Semester: 1 to 8

ALBERTIAN INSTITUTE OF SCIENCE AND TECHNOLOGY
Approved by AICTE , New Delhi, Affiliated to APJAKTU, Thiruvananthapuram
Accredited Programmes in CE, CSE, ECE, EEE, ME ISO 9001:2015 CERTIFIED

DEPARTMENT OF MECHANICAL ENGINEERING

Program: B.Tech (*2019 Regulation)*

Course Handout

Vision

To develop and groom innovative and competent Mechanical Engineers equipped with technical knowledge and ethical values for the betterment of society and beyond.

Mission

- Impart quality and skill based technical education focused on fundamentals and application skills to meet the challenges of the modern society.
- Provide growth-oriented ambience with ample Industry Institute Interactions for bringing out quality professionals.
- Instil creativity and research skills with due emphasis on social, environmental and ethical factors.

Program Educational Objectives (PEOs)

Graduates of Mechanical Engineering shall:

PEO1: Pursue a Mechanical Engineering career with high credentials and social commitment.

PEO2: Adapt to rapid technological changes in Mechanical Engineering domain, through industry institute interaction.

PEO3: Convey and convince innovative ideas in Mechanical Engineering through research, communication and exhibit leadership.

Program Specific Outcomes (PSOs)

Graduates of Mechanical Engineering will be able to:

PSO1: Demonstrate the knowledge of concurrent technologies to solve the practical problems in Mechanical Engineering.

PSO2: Develop Mechanical Engineering projects as a professional team with ethical attitude by applying principles of scientific management and sustainable practices.

PSO3: Apply principles of mathematics, science and engineering to design and analyze multi-disciplinary systems related to Mechanical Engineering.

Program Outcomes (POs)

Engineering Graduates will be able to:

1. **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Semester: 1

Curriculum

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT101	LINEAR ALGEBRA AND CALCULUS	3-1-0	4	4
B	CYT 100	ENGINEERING CHEMISTRY	3-1-0	4	4
C	EST 110	ENGINEERING GRAPHICS	2-1-0	3	3
D	EST 120	BASICS OF CIVIL & MECHANICAL ENGINEERING	4-0-0	4	4
E	HUN 101	LIFE SKILLS	2-0-2	4	-
S	CYL 120	ENGINEERING CHEMISTRY LAB	0-0-2	2	1
T	ESL 120	CIVIL & MECHANICAL WORKSHOP	0-0-2	2	1
TOTAL				23/24	17

Course Code & Name: MAT101 Linear Algebra and Calculus

1. Prescribed Syllabus

Module	Topic	Hours
1	Module 1 (Linear algebra) (Text 2: Relevant topics from sections 7.3, 7.4, 7.5, 8.1,8.3,8.4) Systems of linear equations, Solution by Gauss elimination, row echelon form and rank of a matrix, fundamental theorem for linear systems (homogeneous and non-homogeneous, without proof), Eigen values and eigen vectors. Diagonalization of matrices, orthogonal transformation, quadratic forms and their canonical forms.	**10**
2	Module 2 (multivariable calculus-Differentiation) (Text 1: Relevant topics from sections 13.3, 13.4, 13.5, 13.8) Concept of limit and continuity of functions of two variables, partial derivatives, Differentials, Local Linear approximations, chain rule, total derivative, Relative maxima and minima, Absolute maxima and minima on closed and bounded set.	**8**
3	Module 3(multivariable calculus-Integration) (Text 1: Relevant topics from sections 14.1, 14.2, 14.3, 14.5, 14.6, 14.8) Double integrals (Cartesian), reversing the order of integration, change of coordinates (Cartesian to polar), finding areas and volume using double integrals, mass and centre of gravity of inhomogeneous laminas using double integral. Triple integrals, volume calculated as triple integral, triple integral in cylindrical and spherical coordinates (computations involving spheres, cylinders).	**10**
4	Module 4 (sequences and series) (Text 1: Relevant topics from sections 9.1, 9.3, 9.4, 9.5, 9.6) Convergence of sequences and series, convergence of geometric series and p-series (without proof), test of convergence (comparison, ratio and root tests without proof); Alternating series and Leibnitz test, absolute and conditional convergence.	**8**
5	(Text 1: Relevant topics from sections 9.8, 9.9. Text 2: Relevant topics from sections 11.1, 11.2, 11.6) Taylor series (without proof, assuming the possibility of power series expansion in appropriate domains), Binomial series and series representation of exponential, trigonometric, logarithmic functions (without proofs of convergence); Fourier series, Euler formulas, Convergence of Fourier series (without proof), half range sine and cosine series, Parseval's theorem (without proof).	**9**

2. Text Books (T)

T1. H. Anton, I. Biven,S.Davis, "Calculus", Wiley, 10th edition, 2015
T2. Erwin Kreyszig, Advanced Engineering Mathematics, 10thEdition, John Wiley & Sons, 2016.

3. Reference Books (R)

R1. J. Stewart, Essential Calculus, Cengage, 2nd edition, 2017
R2. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9 th Edition, Pearson, Reprint, 2002.
R3. Peter V. O'Neil, Advanced Engineering Mathematics, Cengage, 7th Edition, 2012
R4. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008. R5. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36 Edition, 2010.

4. Course Objectives

This course introduces students to some basic mathematical ideas and tools which are at the core of any engineering course. A brief course in Linear Algebra familiarises students with some basic techniques in matrix theory which are essential for analysing linear systems. The calculus of functions of one or more variables taught in this course are useful in modelling and analysing physical phenomena involving continuous change of variables or parameters and have applications across all branches of engineering.

5. Course Pre / Co-requisite

A basic course in one-variable calculus and matrix theory.

6. Course Outcomes

After the completion of the course the student will be able to
CO1: Solve systems of linear equations, diagonalize matrices and characterise quadratic forms
CO2: Compute the partial and total derivatives and maxima and minima of multivariable functions CO3: Compute multiple integrals and apply them to find areas and volumes of geometrical shapes, mass and centre of gravity of plane laminas
CO4: Perform various tests to determine whether a given series is convergent, absolutely convergent or conditionally convergent
CO5: Determine the Taylor and Fourier series expansion of functions and learn their applications.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	H	H	M	L			L	M		M
CO2	H	H	H	H	M	L			L	M		M
CO3	H	H	H	H	M	L			L	M		M
CO4	H	M	H	M	L	L			L	M		M
CO5	H	H	H	H	M	L			L	M		M

8. Justification for CO-PO-PSO Correlation

CO1-PO1	Solutions of system of linear equations can be used to solve complex engineering problems including problems related to Astrophysics.
CO1-PO2	The knowledge of linear algebra can be used to analyse complex engineering problems involving electrical circuits.
CO1-PO3	The concept of linear algebra can be to design complex electronic circuits.

CO1-PO4	The concept of linear algebra can be used in the analysis of advanced electrical systems.
CO1-PO5	Linear Algebra can be useful in solving real life problems by modelling those problems and then find the solutions.
CO1-PO6	The concept of linear algebra can be used to assess societal health, safety and legal issues involved in mixing of chemicals.
CO1-PO9	The knowledge of quadratic forms will help to function effectively in diverse terms.
CO1-PO10	The concept of diagonalization of matrices will help to communicate effectively on the solutions of differential and difference equations.
CO1-PO12	The concept of linear algebra will get awareness about the need for lifelong learning and continuous upgradation of technical knowledge.
CO2-PO1	The knowledge of partial differentiation will help to solve problems arising in engineering
CO2-PO2	Fundamental knowledge of partial derivatives of functions will help to formulate problems with high complexity in Engineering
CO2-PO3	Computation of partial and total derivatives and maxima and minima of multivariable functions are used in the development of solutions for complex engineering problems
CO2-PO4	Knowledge of finding extreme and absolute values of multivariable functions will help in the investigations of certain engineering problems.
CO2-PO5	Various methods for computation of partial derivatives will help to select appropriate techniques in complex engineering activities.
CO2-PO6	The concept of partial differential equations will help to assess the issues related to society
CO2-PO9	Partial derivatives and its applications will help to work effectively as a team member.
CO2-PO10	Understanding of partial and total derivatives and maxima and minima of multivariable functions will help to communicate effectively on complex engineering activities.
CO2-PO12	Practical application of partial derivatives such as maxima and minima of multivariable functions will enhance the lifelong learning process.
CO3-PO1	Evaluation of multiple integrals will help to solve complex engineering problems
CO3-PO2	Theory of multiple integrals will help to analyse problems with high complexity in engineering.
CO3-PO3	The concept of finding area and volume using multiple integrals can be used to design solutions for complex engineering problems.
CO3-PO4	Multiple integrals and their applications can be used to conduct investigations of complex problems involving the synthesis of data to provide valid conclusions.
CO3-PO5	The concept of finding area and volume using multiple integrals can be used to create, select and apply appropriate techniques, modern engineering and IT tools including prediction and modelling to complex engineering activities.
CO3-PO6	Geometric applications of multiple integrals such as finding areas and volumes of geometrical shapes, mass and centre of gravity of plane laminas will help to apply

	reasoning to the issues and responsibilities relevant to the professional engineering practice
CO3-PO9	The knowledge of multiple integrals and its practical applications will help to perform better in diverse teams and multi-disciplinary settings
CO3-PO10	The concept of finding area and volume will help to communicate effectively on complex engineering activities with the engineering community.
CO3-PO12	The concept of multiple integrals will help to engage in independent and lifelong learning.
CO4-PO1	Basic knowledge of various tests for convergence of series will help to solve problems arising in engineering
CO4-PO2	Fundamental knowledge of tests for convergence of series will help to analyse problems with high complexity in Engineering.
CO4-PO3	Theory of tests for convergence of series are used to design solutions for complex engineering problems
CO4-PO4	Various tests for convergence of series are used to conduct investigation of complex problems
CO4-PO5	Knowledge of various tests for convergence of series will help to select appropriate techniques in complex engineering activities.
CO4-PO6	The concept of tests for convergence of series will help to assess the issues related to society
CO4-PO9	Knowledge of various tests for convergence will help to function effectively as an individual and a member in diverse teams
CO4-PO10	Application of various tests to determine whether a given series is convergent, absolutely convergent or conditionally convergent will help to communicate effectively on complex engineering activities.
CO4-PO12	The knowledge of various tests for convergence of series will enhance the ability to engage in independent and lifelong learning.
CO5-PO1	Fundamental knowledge of series expansion of functions will help to simplify several problems in Engineering
CO5-PO2	Basic knowledge of Taylor and Fourier series expansion of functions and their applications will help to analyse problems with high complexity in Engineering.
CO5-PO3	Concept of Taylor and Fourier series expansion of functions and their applications are used to design solutions for complex engineering problems
CO5-PO4	Knowledge of Series expansion of functions and their applications are used to conduct investigation of complex problems
CO5-PO5	Concept of series expansion of functions and their applications will help to select appropriate techniques in complex engineering activities with the understanding of the limitations.
CO5-PO6	Understanding of series expansion of functions and their applications can be used to assess the issues related to society
CO5-PO9	Application of Taylor and Fourier series expansion of functions will help to function effectively as an individual and a member in diverse teams
CO5-PO10	Concept of Taylor and Fourier series expansion of functions and their applications will help to communicate effectively on complex engineering activities.
CO5-PO12	Knowledge of Series expansion of functions and their applications will help to engage in independent and lifelong learning.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs*

11. Internal Assessment mark allocation (as per university curriculum)

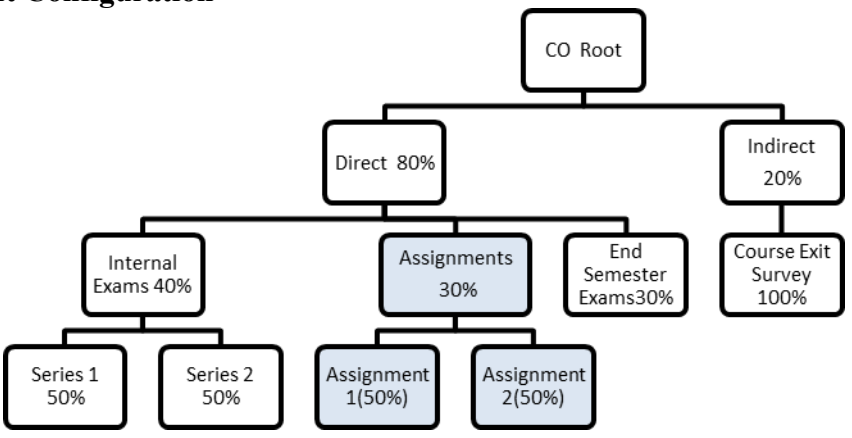
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put' x' if mapping is present)

	Tools		Weightage#	CO1	CO2	CO3	CO4
Direct Assessment Tools**	Internal Exam(s) 40%	Series 1	20%	x	x	x	
		Series 2	20%			x	x
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x	x		
		Assignment 2	15%			x	x
	End Semester Exam		30%	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1	Systems of linear equations, Solution by Gauss elimination	1	Erwin Kreyszig, Advanced Engineering Mathematics, 10thEdit,John Wiley & Sons	Lecture
2	Row echelon form	1	Erwin Kreyszig, Advanced Engineering Mathematics, 10thEdit,John Wiley & Sons	Lecture
3	Finding rank from row echelon form	1	Erwin Kreyszig, Advanced Engineering Mathematics, 10thEdit,John Wiley & Sons	Lecture
4	Fundamental theorem for linear systems	1	Erwin Kreyszig, Advanced Engineering Mathematics, 10thEdit,John Wiley & Sons	Lecture
5	Eigen values and eigen vectors	1	Erwin Kreyszig, Advanced Engineering Mathematics, 10thEdit,John Wiley & Sons	Lecture
6	Eigen values and eigen vectors	1	Erwin Kreyszig, Advanced Engineering Mathematics, 10thEdit,John Wiley & Sons	Tutorial
7	Diagonalization of matrices	1	Erwin Kreyszig, Advanced Engineering Mathematics, 10thEdit,John Wiley & Sons	Lecture
8	Diagonalization of matrices	1	Erwin Kreyszig, Advanced Engineering Mathematics, 10thEdit,John Wiley & Sons	Tutorial
9	Orthogonal transformation, quadratic forms and their canonical forms.	1	Erwin Kreyszig, Advanced Engineering Mathematics, 10thEdit,John Wiley & Sons	Lecture
10	Orthogonal transformation, quadratic forms and their canonical forms.	1	Erwin Kreyszig, Advanced Engineering Mathematics, 10thEdit,John Wiley & Sons	Lecture
11	Concept of limit and continuity of functions of two variables	2	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit, 2015	Lecture
12	partial derivatives	2	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th	Lecture
13	Differentials, Local Linear approximations	2	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Lecture
14	Differentials, Local Linear approximations	2	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Lecture
15	Chain rule, total derivative	2	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Lecture

16	Chain rule, total derivative	2	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Tutorial
17	Maxima and minima	2	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Lecture
18	Maxima and minima	2	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Tutorial
19	Double integrals (Cartesian)-evaluation	3	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Lecture
20	Double integrals (Cartesian)-evaluation	3	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Lecture
21	Change of order of integration in double integrals	3	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Tutorial
22	change of coordinates (Cartesian to polar)	3	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Lecture
23	Finding areas and volumes	3	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Lecture
24	mass and centre of gravity of plane laminas	3	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Lecture
25	mass and centre of gravity of plane laminas	3	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Tutorial
26	Triple integrals	3	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Others
27	Triple integrals	3	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Others
28	Triple integrals	3	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Others
29	Convergence of sequences and series	4	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Lecture
30	geometric and p-series	4	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Lecture
31	Test of convergence(comparison)	4	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Lecture
32	Test of convergence(comparison)	4	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Tutorial

33	Test of convergence(ratio and root	4	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th	Lecture
34	Test of convergence(, ratio and root)	4	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Lecture
35	Alternating series and Leibnitz test,	4	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Lecture
36	absolute and conditional convergence	4	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Tutorial
37	Taylor series, Binomial series and series representation of exponential, trigonometric, logarithmic functions;	5	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Lecture
38	Taylor series, Binomial series and series representation of exponential, trigonometric, logarithmic functions;	5	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Lecture
39	Taylor series, Binomial series and series representation of exponential, trigonometric, logarithmic functions;	5	H. Anton, I. Biven,S.Davis, â€œCalculusâ€, Wiley, 10th edit,	Lecture
40	Fourier series, Euler formulas	5	Erwin Kreyszig, Advanced Engineering Mathematics, 10thEdit,John Wiley & Sons	Lecture
41	Fourier series, Euler formulas	5	Erwin Kreyszig, Advanced Engineering Mathematics, 10thEdit,John Wiley & Sons	Tutorial
42	Convergence of Fourier series(Dirichletâ€™s conditions)	5	Erwin Kreyszig, Advanced Engineering Mathematics, 10thEdit,John Wiley & Sons	Lecture
43	Half range sine and cosine series	5	Erwin Kreyszig, Advanced Engineering Mathematics, 10thEdit,John Wiley & Sons	Lecture
44	Half range sine and cosine series	5	Erwin Kreyszig, Advanced Engineering Mathematics, 10thEdit,John Wiley & Sons	Tutorial
45	Parsevalâ€™s theorem	5	Erwin Kreyszig, Advanced Engineering Mathematics, 10thEdit,John Wiley & Sons	Group Discussion

15. Question Bank

Module 1				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	Determine the rank of the matrix $\begin{bmatrix} 1 & -1 & 0 \\ 5 & 3 & -1 \\ 3 & 3 & -2 \end{bmatrix}$	3	**CO1**	**L1**
2	Write down the spectrum of $\begin{bmatrix} -5 & 2 \\ 2 & -2 \end{bmatrix}$	3	**CO1**	**L1**
3	Find the eigen values and eigen vectors of A= $\begin{bmatrix} 0.8 & -0.6 \\ 0.6 & 0.8 \end{bmatrix}$	3	**CO1**	**L1**
4	Show that the vectors $(1, -1, 0)$, $(1, 3, -1)$ *and* $(5, 3, -2)$ are linearly dependent.	3	**CO1**	**L2**
5	Obtain the matrix of transformation $y_1 = \cos\theta\, x_1 - \sin\theta\, x_2$, $y_2 = \sin\theta\, x_1 + \cos\theta\, x_2$.Prove that it is orthogonal.	3	**CO1**	**L2**
6	Find a matrix C such that $Q = X^T AX$, where $Q = -3x_1^2 + 4x_1x_2 - x_2^2 + 2x_1x_3 - 5x_3^2$	3	**CO1**	**L1**
7	Show that the quadratic form $4x_1^2 + 12x_1x_2 + 13x_2^2 = 16$ is positive definite	3	**CO1**	**L1**
8	What type of conic section the following quadratic form represent? $Q = 17x_1^2 - 30x_1x_2 + 17x_2^2 = 128$	3	**CO1**	**L2**
9	Find the rank of the matrix $\begin{bmatrix} 1 & 2 & -1 & 3 \\ 2 & 2 & 4 & 1 \\ 5 & 6 & 7 & 5 \end{bmatrix}$	3	**CO1**	**L2**
10	Find the Eigen values of the matrix $A = \begin{bmatrix} 1 & 2 \\ 0 & 3 \end{bmatrix}$. What are the Eigen values of A^2, A^{-1} without using its characteristic equation.	3	**CO1**	**L2**
11	Find the rank of the matrix $\begin{bmatrix} 3 & 0 & 2 & 2 \\ -6 & 42 & 24 & 54 \\ 21 & -21 & 0 & -15 \end{bmatrix}$	3	**CO1**	**L2**
12	Show that the quadratic form $3x_1^2 + 22x_1x_2 + 3x_2^2 = 0$ represents a pair of straight lines by transforming it into principal axes form.	3	**CO1**	**L2**

13	Find the rank of the matrix $\begin{bmatrix} 3 & 0 & 2 & 2 \\ -6 & 42 & 42 & 54 \\ 21 & -21 & 0 & -15 \end{bmatrix}$	**7**	**CO1**	**L2**
14	Solve the following system of equation $y + z - 2w = 0$ $2x - 3y - 3z + 6w = 2$ $4x + y + z - 2w = 4$	**7**	**CO1**	**L3**
15	Find the eigen values and eigen vectors of the matrix $A = \begin{bmatrix} -1 & 2 & -2 \\ 2 & 4 & 1 \\ 2 & 1 & 4 \end{bmatrix}$	**7**	**CO1**	**L2**
16	Diagonalize the matrix $A = \begin{bmatrix} -2 & 2 & -3 \\ 2 & 1 & -6 \\ -1 & -2 & 0 \end{bmatrix}$	**7**	**CO1**	**L3**
17	If 2is an eigen value $\begin{bmatrix} 3 & -1 & 1 \\ -1 & 5 & -1 \\ 1 & -1 & 3 \end{bmatrix}$ without using its characteristic equation, find the other eigen values. Also find the eigen values of A^3, A^{-1} , A^T, $5A$, $A - 3I$ & $adjA$	**7**	**CO1**	**L3**
18	What kind of conic section the quadratic form $17x_1^2 - 30x_1x_2 + 17x_2^2 = 128$ represents? Transform it to principal axes.	**7**	**CO1**	**L3**
19	Find the rank, index and signature of the quadratic form $Q = 3x^2 + 5y^2 + 3z^2 - 2xy + 2xz - 2yz$	**7**	**CO1**	**L3**
20	Show that the quadratic form $3x_1^2 + 22x_1x_2 + 3x_2^2 = 0$ represents a pair of straight lines by transforming it into canonical form. Express $X^T = [x_1 \quad x_2]$ in terms of the new coordinate vector $Y^T = [y_1 \quad y_2]$	**7**	**CO1**	**L3**
21	Diagonalize the matrix $A = \begin{bmatrix} 8 & -6 & 2 \\ -6 & 7 & -4 \\ 2 & -4 & 3 \end{bmatrix}$	**7**	**CO1**	**L3**

22	Using Gauss elimination method solve the system of equations $x - y + z = 0$ $-x + y - z = 0$ $10y + 25z =$ 90 $20x + 10y = 80$	**7**	**CO1**	**L3**
23	Reduce to row echelon form and find the rank of the matrix $\begin{matrix} 1 & 2 & 3 & 4 \\ [2 & 1 & 4 & 5\,] \\ 1 & 5 & 5 & 7 \\ 8 & 1 & 14 & 17 \end{matrix}$	**7**	**CO1**	**L2**
24	Check whether the following matrix is diagonalizable $\begin{matrix} 2 & -1 & 3 \\ [-1 & 2 & -1] \\ 1 & -1 & 3 \end{matrix}$	**7**	**CO1**	**L2**
25	What kind of conic section the quadratic form $11x_1^2 + 84x_1x_2 + 24x_2^2 = 156$ represents? Transform it to principal axes.	**7**	**CO1**	**L3**
26	Show that the equations: $x + y + z = a,\quad 3x + 4y + 5z = b,\quad 2x + 3y + 4z = c$ (i)have no solution if $a = b = c = 1$ (ii)have many solutions if $a = \frac{b}{2} = c = 1$	**7**	**CO1**	**L3**
27	Find the matrix of transformation that diagonalize the matrix $A = \begin{bmatrix} 6 & -2 & 2 \\ -2 & 3 & -1 \\ 2 & -1 & 3 \end{bmatrix}$. Also, find the diagonal matrix.	**7**	**CO1**	**L3**
28	Find the value of λ and μ for which the system of equations $2x + 3y + 5z = 9 \quad 7x + 3y - 2z = 8 \quad 2x + 3y + \lambda z = \mu$ has (a) no solution (b) unique solution (c) more than one solution	**7**	**CO1**	**L3**
29	Solve the following linear system of equations using Gauss elimination method $x + 2y - z = 3$ $3x - y + 2z = 1$ $2x - 2y + 3z = 2$	7	**CO1**	**L3**

30	Find the matrix of transformation that diagonalize the matrix $A = \begin{bmatrix} -5 & 2 \\ 2 & -2 \end{bmatrix}$. Also write the diagonal matrix.	**7**	**CO1**	**L3**
31	Solve the following linear system of equations using Gauss elimination method $x + y + z = 2$ $y + z = -2$ $4y + 6z = -12$	**7**	**CO1**	**L3**
32	Find the eigenvalues and eigenvectors of $\begin{bmatrix} 1 & 1 & 2 \\ -1 & 2 & 1 \\ 0 & 1 & 3 \end{bmatrix}$	**7**	**CO1**	**L2**
33	Solve the following linear system of equations using Gauss elimination method. $2x - 3y - 3z + 6w = 2$ $y + z - 2w = 0$ $4x + y + z - 2w = 4$	**7**	**CO1**	**L3**
34	Find the matrix of transformation that diagonalize the matrix $A = \begin{bmatrix} -19 & 7 \\ -42 & 16 \end{bmatrix}$. Also write the diagonal matrix.	**7**	**CO1**	**L2**

Module 2

Sl. No.	Question	Marks	CO	BL
1	Let $f(x, y) = \sqrt{3x + 2y}$, (a) Find the slope of the surface $z = f(x, y)$ in the x – direction at the point (2, 5). (b) Find the slope of the surface $z = f(x, y)$ in the y – direction at the point (2, 5).	**3**	**CO2**	**L1**
2	If $z = \sin(y^2 - 4x)$, (a) Find the rate of change of z $w.r.t$ x at the point (3, 1) with y held fixed. (b) Find the rate of change of z $w.r.t$ y at the point (3, 1) with x held fixed.	**3**	**CO2**	**L1**
3	Show that the function $f(x, y) = e^{-y} \cos x$ satisfies the Laplace equation $f_{xx} + f_{yy} = 0$	**3**	**CO2**	**L2**
4	Find the derivative of $\omega = x^2 + y^2$ w.r.t t along the path	**3**	**CO2**	**L2**

18	Let $L(x, y)$ denote the local linear approximation to the function $f(x, y) = \frac{1}{\sqrt{x2+y2}}$ at the point $P(4,3)$. Compare the error in approximating f by L at the point $Q(3.92,3.01)$ with the distance between the points P and Q.	**7**	**CO2**	**L3**
19	If $\omega = x^2 + y^2 - z^2$, $x = \rho \sin\varphi \cos\theta$, $y = \rho \sin\varphi \sin\theta$, $z = \rho \cos\varphi$. Find $\frac{\partial\omega}{\partial\rho}$, $\frac{\partial\omega}{\partial\theta}$	**7**	**CO2**	**L3**
20	Find the local linear approximation L of $f(x, y) = \ln(xy)$ at the point $(1,2)$. Compare the error in approximating f by L at the point $Q(1.01,2.01)$	**7**	**CO2**	**L3**
21	Locate all relative maxima, relative minima and saddle points of $f(x, y) = 2xy - x^3 - y^2$	**7**	**CO2**	**L3**
22	If $\omega = 4x^2 + 4y^2 + z^2$, $x = \rho \sin\varphi \cos\theta$, $y = \rho \sin\varphi \sin\theta$, $z = \rho \cos\varphi$. Find $\frac{\partial\omega}{\partial\rho}$, $\frac{\partial\omega}{\partial\theta}$, $\frac{\partial\omega}{\partial\varphi}$	**7**	**CO2**	**L3**
23	Find the second order partial derivatives of $f(x, y) = x^2y^3 + x^4y$	**7**	**CO2**	**L2**
24	Find the local linear approximation L of $f(x, y) = xyz$ at the point $(1,2,3)$. Compare the error in approximating f by L at the point $Q(1.001,2.002,3.003)$	**7**	**CO2**	**L3**
25	A function $f(x, y) = x^2 + y^2$ is differentiable at the point $P(x, y)$ .If $L(x, y) = 2x + 4y - 5$ be the local linear approximation to f at P, determine P.	**7**	**CO2**	**L3**
26	Determine the dimensions of a rectangular box, open at the top having a volume of 32 ft^3 and requiring the least amount of material for its construction.	**7**	**CO2**	**L3**
27	Find the local linear approximation of $\frac{4y}{x+z}$ at $(1,1,1)$	**7**	**CO2**	**L3**
28	Find the absolute extrema of the function $f(x, y) = x^2 - 3y^2 - 2x + 6y$ over the square region with vertices $(0,0), (0,2)$ $(2,2)$ and $(2,0)$.	**7**	**CO2**	**L3**
29	Locate all relative extrema of $f(x,y) = x^3y^2(12 - x - y)$	**7**	**CO2**	**L3**
30	Locate all relative extrema and saddle points of $f(x, y) = 4xy - x^4 - y^4$	**7**	**CO2**	**L3**

31	The length and width of a rectangle are measured with errors of at most 3% and 4% respectively. Use differentials to approximate the maximum percentage error in the calculated area.	**7**	**CO2**	**L3**
32	If $w = f(P,Q,R)$ where $P = \frac{x}{y},\ Q = \frac{y}{z},\ R = \frac{z}{x}$ prove that $x\frac{\partial w}{\partial x} + y\frac{\partial w}{\partial y} + z\frac{\partial w}{\partial z} = 0.$	**7**	**CO2**	**L2**
33	Locate all relative extrema and saddle points of $f(x,y) = 2xy - x^3 - y^2.$	**7**	**CO2**	**L2**
34	The length and width of a rectangle are measured with errors of at most r%, where r is small. Use differentials to approximate the maximum percentage error in the calculated length of the diagonal.	**7**	**CO2**	**L3**
35	Find the local linear approximation L of $f(x,y) = \sqrt{x^2+y^2}$ at the point $P(3,4)$. Compute the error in approximation f by L at the point $Q(3.04, 3.98)$.	**7**	**CO2**	**L3**
	Module 3			
1	Evaluate $\int_0^1 \int_0^y \int_{-1}^{z} z\, dx\, dz\, dy$	**3**	**CO3**	**L2**
2	Use polar coordinates to evaluate the area of the circle $x^2 + y^2 = 4$	**3**	**CO3**	**L2**
3	Find the mass of the square lamina with vertices (0,0) (1,0) (1,1) and (0,1) and density function x^2y	**3**	**CO3**	**L1**
4	Evaluate $\int_0^{\infty}\int_0^{\infty} e^{-(x^2+y^2)}\, dx\, dy$ by changing to polar coordinates.	**3**	**CO3**	**L2**
5	Evaluate $\int_0^{ln3}\int_0^{ln2} e^{x+2y}\, dy\, dx$	**3**	**CO3**	**L2**
6	Find the mass of the lamina with density function x^2 which is bounded by $y = x$ and $y = x^2$.	**3**	**CO3**	**L2**
7	Evaluate $\iint_R y^2 x\, dA$ over the region $R = \{(x,y),\ -3 \le x \le 2, 0 \le y \le 1\}$	**3**	**CO3**	**L2**
8	Use double integrals to find the volume of the solid enclosed below the plane $z = 4 - x - y$ and above the rectangle $R = \{(x,y);\ 0 \le x \le 1,\ 0 \le y \le 2\}$.	**3**	**CO3**	**L2**

9	Evaluate $\int_0^3 \int_0^2 \int_0^1 xyz\,dx\,dy\,dz$	**3**	**CO3**	**L2**
11	Find the mass of the square lamina with vertices (0,0) (1,0) (1,1) and (0,1) and density function x^2y	**3**	**CO3**	**L1**
12	Evaluate $\int_0^\infty \int_0^\infty e^{-(x^2+y^2)}\,dx\,dy$ by changing to polar coordinates.	**3**	**CO3**	**L2**
13	Evaluate $\int_0^{ln3} \int_0^{ln2} e^{x+2y}\,dy\,dx$	**3**	**CO3**	**L2**
14	Find the mass of the lamina with density function x^2 which is bounded by $y = x$ and $y = x^2$.	**3**	**CO3**	**L2**
15	Evaluate $\iint_R y^2x\,dA$ over the region $R = \{(x,y),\ -3 \le x \le 2, 0 \le y \le 1\}$	**3**	**CO3**	**L2**
16	Evaluate $\int_1^a \int_1^b x^2y\,dxdy$.	**3**	**CO3**	**L2**
17	Use double integral to find the area of the plane region enclosed by the curves $y = \sin x$ and $y = \cos x$ for $0 \le x \le \frac{\pi}{4}$.	**3**	**CO3**	**L3**
18	Use double integral to find the area of the region enclosed between the parabola $y = \frac{x^2}{2}$ and the line y = 2x.	**7**	**CO3**	**L2**
19	Evaluate $\int_0^\infty \int_x^\infty e^{\frac{-y}{y}}\,dy\,dx$ by reversing the order of integration	**7**	**CO3**	**L3**
20	Find the mass and center of gravity of the triangular lamina with vertices (0,0), (0,1) and (1,0) and density function $\delta(x, y) = xy$	**7**	**CO3**	**L2**
21	Evaluate $\int_0^2 \int_{y/2}^1 e^{x^2}\,dx\,dy$ by changing the order of integration.	**7**	**CO3**	**L3**
22	Using double integrals prove that the area bounded between the parabolas $y^2 = 4ax$ and $x^2 = 4ay$ is $\frac{16}{3}a^2$.	**7**	**CO3**	**L3**
23	Change the order of integration and hence evaluate $\int_0^4 \int_{\frac{x^2}{4}}^{2\sqrt{x}} dydx$	**7**	**CO3**	**L3**

24	Evaluate $\iiint_G z\,dV$, where G is the wedge in the first octant cut off from the cylindrical solid $y^2 + z^2 \leq 1$ and the planes $y = x$ and $x = 0$.	**7**	**CO3**	**L3**
25	Evaluate $\iint_R y\,dA$ where R is the region in the first quadrant enclosed between the circle $x^2 + y^2 = 25$ and the line $x + y = 5$.	**7**	**CO3**	**L3**
26	Find the volume of the solid bounded by the cylinder $x^2 + y^2 = 4$ and the planes $y + z = 4$ *and* $z = 0$.	**7**	**CO3**	**L3**
27	Find the area bounded by the x-axis, $y = 2x$ *and* $x + y = 1$ using double integration.	**7**	**CO3**	**L2**
28	Evaluate $\int_0^a \int_{\frac{y}{2}}^{a} \frac{x}{x^2+y^2}\,dx\,dy$ by changing the order of integration.	**7**	**CO3**	**L3**
29	Use spherical coordinates to find the volume of the solid bounded above by the sphere $x^2 + y^2 + z^2 = 16$ and below by the cone $z = \sqrt{x^2 + y^2}$	**7**	**CO3**	**L3**
30	Find the volume of the solid in the first octant bounded by the coordinate planes and the plane $x + 2y + z = 6$.	**7**	**CO3**	**L2**
31	Find the mass and centre of gravity of the lamina in the first quadrant bounded by the circle $x^2 + y^2 = 1$ and the coordinate planes with density function xy.	**7**	**CO3**	**L3**
32	Change the order of integration and hence evaluate $\int_0^1 \int_{x^2}^{2-x} dy\,dx$	**7**	**CO3**	**L3**
33	Evaluate $\iint_R \frac{\sin y}{y}\,dA$, where R is the triangular region bounded by the y −axis, $y = x$ and $y = \pi$.	**7**	**CO3**	**L3**
34	Evaluate $\int_0^2 \int_{\frac{y}{2}}^{1} e^{x^2}\,dx\,dy$ by reversing the order of integration.	**7**	**CO3**	**L3**
35	By converting into polar coordinates evaluate $\int_{-1}^{1} \int_0^{\sqrt{1-x^2}} (x^2 + y^2)^{\frac{3}{2}}\,dy\,dx$.	**7**	**CO3**	**L3**

36	Find the volume of the solid in the first octant bounded by the coordinate planes and the plane $x + y + z = 1$.	**7**	**CO3**	**L3**
	Module 4			
1	Test the convergence of the series $\sum_{k=1}^{\infty} \frac{k}{k!3}$	**3**	**CO4**	**L1**
2	Test the convergence of the alternating series $\sum_{k=1}^{\infty} (-1)^{k+1} \frac{1}{k}$ using Leibnitz Test	**3**	**CO4**	**L2**
3	Test the convergence of the series $\sum_{k=1}^{\infty} \frac{k^2}{2k^2-1}$	**3**	**CO4**	**L1**
4	Test the convergence of $\sum_{k=1}^{\infty} \frac{k}{2k+1}$	**3**	**CO4**	**L1**
5	Test the convergence of $\sum_{k=2}^{\infty} \frac{1}{\frac{k}{k2}}$	**3**	**CO4**	**L2**
6	Examine the convergence of $\sum_{k=1}^{\infty} \frac{k}{k+1}(__)^{k2}$	**3**	**CO4**	**L2**
7	Test the convergence of the series $\sum_{k=1}^{\infty} \left(\frac{k}{100}\right)^k$	**3**	**CO4**	**L1**
8	Does the series $\sum_{k=1}^{\infty} \left(\frac{-3}{4}\right)^k$ converge? If so, find the sum.	**3**	**CO4**	**L1**
9	Examine the convergence of $\sum_{k=1}^{\infty} \frac{1}{k!}$	**3**	**CO4**	**L1**
10	Determine whether the series $\sum_{k=1}^{\infty} \frac{4^{k+2}}{7^{k-1}}$ converges and if so find its sum	**3**	**CO4**	**L2**
11	Determine whether the series $\sum_{k=1}^{2k-1} (-1)^{k+1} 3 \frac{}{k2+1}$ is absolutely convergent.	**3**	**CO4**	**L2**
12	Test the convergence of the series $1+ \frac{1.3}{3!} + \frac{1.3.5}{5!} + \frac{1.3.5.7}{7!} + \ldots\ldots\ldots\ldots\ldots\ldots$	**7**	**CO4**	**L3**
13	Test the convergence of $\frac{x}{1.2} + \frac{x^2}{2.3} + \frac{x^3}{3.4} + \ldots\ldots\ldots \frac{x^k}{k(k+1)} + \text{--------}$	**7**	**CO4**	**L3**

14	Test whether the following series is absolutely convergent or conditionally convergent $\sum_{k=1}^{\infty} \frac{(-1)^k}{\sqrt{k(k+1)}}$	**7**	**CO4**	**L3**
15	Prove that the series $\sum_{k=1}^{\infty} (-1)^{k+1} \frac{(k-2)}{k(k+1)}$ is conditionally convergent.	**7**	**CO4**	**L2**
16	Find the sum of the series $\sum_{k=1}^{\infty} \frac{1}{k(k+1)}$	**7**	**CO4**	**L2**
17	Test the absolute or conditional convergence of $\sum_{k=1}^{\infty} \frac{(-1)^{k+1} k^2}{k^3+1}$	**7**	**CO4**	**L3**
18	Test the convergence of the series $1+\frac{1.3}{1.2}+\frac{1.3.5}{1.2.3}+\frac{1.3.5.7}{1.2.3.4}+\ldots$	**7**	**CO4**	**L3**
19	Test the convergence $i)\sum_{k=1}^{\infty} \frac{k(k-1)}{(k+1)(k+2)(k+3)}$ $ii)\sum_{k=1}^{\infty} \left(\frac{k+2}{2k-1}\right)^k$	**7**	**CO4**	**L2**
20	Test the convergence: $(i)\sum_{k=1}^{\infty} \frac{2}{3^k+5}$ $(ii)\sum_{k=1}^{\infty} (-1)^{k+1} \left(\frac{k}{2k+3}\right)$	**7**	**CO4**	**L3**
21	Test the convergence of the series $\sum_{k=1}^{\infty} \frac{k(k+3)}{(k+1)(k+2)(k+5)}$	**7**	**CO4**	**L2**
22	Test the convergence of the series $(i)\sum_{k=1}^{\infty} \frac{k}{k!}$ $(ii)\sum_{k=2}^{\infty} \frac{(4k-5)^k}{2k+1}$	**7**	**CO4**	**L1**
23	Test the convergence of the series $\sum_{k=1}^{\infty} \frac{1}{3\sqrt{2k-1}}$	**7**	**CO4**	**L2**
24	Use ratio test for absolute convergence to determine the convergence of the series $\sum_{k=1}^{\infty} (-1)^k \frac{2^k}{k!}$	**7**	**CO4**	**L2**
25	Test the convergence of the series $1+\frac{1.2}{1.3}+\frac{1.2.3}{1.3.5}+\frac{1.2.3.4}{1.3.5.7}+\ldots\ldots\ldots\ldots\ldots$	**7**	**CO4**	**L3**
26	Test the convergence of $\sum_{k=1}^{\infty} \frac{(k+4)!}{4!\, k!\, 4^k}$	**7**	**CO4**	**L2**
27	Test the convergence of (i) $\sum_{k=1}^{\infty} \frac{k(k+1)}{(k+3)(k+2)(k+5)}$ (ii) $\sum_{k=1}^{\infty} k^{50} e^{-k}$	**7**	**CO4**	**L2**

28	Test the convergence of the series $1+\frac{1.3}{3!}+\frac{1.3.5}{5!}+\frac{1.3.5.7}{7!}+\cdots\cdots\cdots$	**7**	**CO4**	**L2**
29	Determine whether the alternating series $\sum_{k=1}^{\infty}(-1)^{k+1}\frac{k+7}{k(k+4)}$ is conditionally convergent or not.	**7**	**CO4**	**L3**
30	Test the convergence of (i) $\sum_{k=1}^{\infty}\frac{[\pi(k+1)]^k}{k^{k+1}}$ (ii) $\sum_{k=1}^{\infty}\frac{1}{(2k+5)^{17}}$	**7**	**CO4**	**L2**
	Module 5			
1	Find the binomial series expansion of $\frac{1}{\sqrt{1+x}}$	**3**	**CO5**	**L1**
2	Find the Maclaurin's series expansion of $f(x)=xsin\,x$	**3**	**CO5**	**L2**
3	Find the Fourier series expansion of $f(x)=x$ for $-\pi<x<\pi$	**3**	**CO5**	**L2**
4	Find the Fourier half range sine series of $f\,(x)=ex$ in $0<x<1$	**3**	**CO5**	**L2**
5	Find the half range sine series for the function $f(x)=x\ \ 0\le x\le\pi$	**3**	**CO5**	**L2**
6	Find the binomial series for $f(x)=(1+x)^{1/3}$ up to third degree term.	**3**	**CO5**	**L1**
7	Find the Maclaurin's series of $f(x)=\log(1+x)$ up to third degree term.	**3**	**CO5**	**L2**
8	Find the Fourier series $f(x)=x^2-2$ in the interval $(-2,2)$	**3**	**CO5**	**L2**
9	Find the Taylor series expansion of $f(x)=cosx$ about $x=\pi$ up to third degree terms.	**3**	**CO5**	**L2**
10	Find the half range sine series expansion of $f(x)=\pi x-x^2$ in $(0,\pi)$	**3**	**CO5**	**L3**
11	Find the Taylors series for $f(x)=cosx$ about $x=\pi$ up to third degree terms	**7**	**CO5**	**L2**
12	Find a Fourier series with period 3 to represent $f(x)=2x-x^2$ in (0,3)	**7**	**CO5**	**L2**

13	Obtain the Fourier series for the function $f(x) = \|x\|, -\pi < x < \pi$	**7**	**CO5**	**L2**
14	Find the half range sine series of $f(x) = x$ in the interval $0 < x < \pi$. Hence show that $\frac{1}{1^2} + \frac{1}{3^2} + \frac{1}{5^2} + \cdots \ldots = \frac{\pi^2}{8}$.	**7**	**CO5**	**L2**
15	Expand $f(x) = e^{ax}$ in a Fourier series in the range $(0,2\pi)$	**7**	**CO5**	**L2**
16	Find the Fourier series of periodic function with period 2 which is given below: $f(x)) = \{-x \quad , -1 \le x \le 0$ $\quad\quad x \quad , 0 \le x \le 1$ Hence prove that $1 + \frac{1}{3^2} + \frac{1}{5^2} + \cdots = \frac{\pi^2}{8}$	**7**	**CO5**	**L2**
17	Find the Fourier series for the function $f(x) = \{ x \quad , 0 < x < 1$ $1 - x \ , \quad 1 < x < 2$	**7**	**CO5**	**L2**
18	Find the Fourier series of $f(x) = -1 + x \quad , -\pi < x < 0$ $\{ 1 + x \quad , \quad 0 < x < \pi$	**7**	**CO5**	**L3**
19	Find the half range cosine series for the function $f(x) = (x-1)^2$ $0 \le x \le 1$	**7**	**CO5**	**L2**
20	Find the half range cosine series for $f(x) = \{ kx \quad 0 \le x \le L/2$ $k(L-x) \quad L/2 \le x \le L$	**7**	**CO5**	**L3**
21	Find the Fourier series for $f(x) = x^2$ in the interval $-\pi < x < \pi$. Hence show that $\frac{1}{1^4} + \frac{1}{2^4} + \frac{1}{3^4} + \cdots \ldots = \frac{\pi^4}{90}$	**7**	**CO5**	**L3**
22	Find the Fourier series of the function $f(x) = \|x\|$ in $-1 \le x \le 1$	**7**	**CO5**	**L2**
23	Find the Fourier sine series of $f(x) = x \cos x$ in $0 < x < \pi$	**7**	**CO5**	**L2**
24	Find the Fourier series of $f(x) = \begin{cases} 1 + \frac{2x}{\pi}, -\pi < x < 0 \\ 1 - \frac{2x}{\pi}, 0 < x < \pi \end{cases}$	**7**	**CO5**	**L3**

25	Obtain Fourier series of e^x the interval $(-1,1)$	**7**	**CO5**	**L2**
26	Find the Fourier cosine series of $f(x) = x^2$ in $0 < x < \pi$.	**7**	**CO5**	**L2**
27	Find the Fourier series expansion of $f(x) = \frac{1}{2}(\pi - x)$ in $0 < x < 2\pi$	**7**	**CO5**	**L2**
28	Find the half range Fourier sine and cosine series of $f(x) = x$ in $(0,\pi)$	**7**	**CO5**	**L2**
29	Find the Fourier series expansion of $f(x) = \begin{cases} \frac{\pi}{2} + x & for -\pi \le x \le 0 \\ \frac{\pi}{2} - x & for \ 0 \le x \le \pi \end{cases}$. Hence show that $1 + \frac{1}{3^2} + \frac{1}{5^2} + \frac{1}{7^2} + \cdots = \frac{\pi^2}{8}$	**7**	**CO5**	**L2**
30	Obtain the half range Fourier sine series of $f(x) = \begin{cases} x, & 0 < x < 1 \\ 2 - x, & 1 < x < 2 \end{cases}$	**7**	**CO5**	**L2**

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Course Code & Name: CYT 100 ENGINEERING CHEMISTRY

1. Prescribed Syllabus

Module	Topic	Hours
1	**Electrochemistry and Corrosion** Introduction – Differences between electrolytic and electrochemical cells – Daniel cell – redox reactions – cell representation. Different types of electrodes (brief) – Reference electrodes – SHE – Calomel electrode – Glass Electrode - Construction and Working. Single electrode potential - definition - Helmholtz electrical double layer - Determination of E0 using calomel electrode. Determination of pH using glass electrode. Electrochemical series and its applications. Free energy and EMF - Nernst Equation - Derivation - single electrode and cell (Numericals) -Application - Variation of emf with temperature. Potentiometric titration - Introduction -Redox titration only. Lithium-ion cell – construction and working. Conductivity – Measurement of conductivity of a solution (Numericals).Corrosion – Electrochemical corrosion – mechanism. Galvanic series – cathodic protection – electroless plating – Copper and Nickel plating.	9
2	**Module 2 Spectroscopic Techniques and Applications** Introduction- Types of spectrum - electromagnetic spectrum - molecular energy levels - Beer Lambert's law (Numericals). UV-Visible Spectroscopy – Principle Types of electronic transitions - Energy level diagram of ethane, butadiene, benzene and hexatriene. Instrumentation of UV-Visible spectrometer and applications.IR-Spectroscopy – Principle - Number of vibrational modes - Vibrational energy states of a diatomic molecule and -Determination of force constant of diatomic molecule (Numericals) –Applications. ^{1}H NMR spectroscopy – Principle – Relation between field strength and frequency – chemical shift – spin-spin splitting (spectral problems) – coupling constant (definition) – applications of NMR – including MRI (brief).	9
3	**Module 3 Instrumental Methods and Nanomaterials** Thermal analysis – TGA – Principle, instrumentation (block diagram) and applications – TGA of $CaC_2O_4.H_2O$ and polymers. DTA-Principle, instrumentation (block diagram) and applications - DTA of $CaC_2O_4.H_2O$. Chromatographic methods - Basic principles and applications of column and TLCRetention factor. GC and HPLC – Principle, 9instrumentation (block diagram) - retention time and applications. Nanomaterials - Definition - Classification - Chemical methods of preparation - Hydrolysis and Reduction - Applications of nanomaterials - Surface characterisation – SEM – Principle and instrumentation (block diagram).	9
4	**Module 4 Stereochemistry and Polymer Chemistry**	9

	Isomerism-Structural, chain, position, functional, tautomerism and metamerism - Definition with examples - Representation of 3D structures-Newman, Sawhorse, Wedge and Fischer projection of substituted methane and ethane. Stereoisomerism - Geometrical isomerism in double bonds and cycloalkanes (cis- trans and E-Z notations). R-S Notation – Rules and examples - Optical isomerism, Chirality, Enantiomers and Diastereoisomers-Definition with examples. Conformational analysis of ethane, butane, cyclohexane, mono and di methyl substituted cyclohexane. Copolymers - Definition - Types - Random, Alternating, Block and Graft copolymers - ABS - preparation, properties and applications. Kevlar-preparation, properties and applications. Conducting polymers - Doping -Polyaniline and Polypyrrole - preparation properties and applications. OLED - Principle, construction and advantages.	
5	**Module 5 Water Chemistry and Sewage Water Treatment** Water characteristics - Hardness - Types of hardness- Temporary and Permanent- Disadvantages of hard water -Units of hardness- ppm and mg/L -Degree of hardness (Numericals) - Estimation of hardness-EDTA method (Numericals). Water softening methods-Ion exchange process-Principle, procedure advantages. Reverse osmosis – principle, process and advantages. Municipal water treatment (brief) - Disinfection methods - chlorination, ozone and UV irradiation.Dissolved oxygen (DO) -Estimation (only brief procedure-Winkler's method), BOD and COD – definition, estimation (only brief procedure) and significance (Numericals). Sewage water treatment - Primary, Secondary and Tertiary - Flow diagram -Trickling filter and UASB process.	**9**

2. Text Books (T)

T1. B. L. Tembe, Kamaluddin, M. S. Krishnan, "Engineering Chemistry (NPTEL Web-book)", 2018.

T2. P. W. Atkins, "Physical Chemistry", Oxford University Press, 10th edn., 2014.

3. Reference Books (R)

R1. C. N. Banwell, "Fundamentals of Molecular Spectroscopy", McGraw-Hill, 4thedn., 1995.

R2. Donald L. Pavia, "Introduction to Spectroscopy", Cengage Learning India Pvt. Ltd., 2015.

R3. B. R. Puri, L. R. Sharma, M. S. Pathania, "Principles of Physical Chemistry", Vishal Publishing Co., 47th Edition, 2017.

R4. H. H. Willard, L. L. Merritt, “Instrumental Methods of Analysis”, CBS Publishers, 7th Edition, 2005.

R5. Ernest L. Eliel, Samuel H. Wilen, “Stereo-chemistry of Organic Compounds”, WILEY, 2008.

R6. Raymond B. Seymour, Charles E. Carraher, “Polymer Chemistry: An Introduction”, Marcel Dekker Inc; 4th Revised Edition, 1996.

R7. MuhammedArif, Annette Fernandez, Kavitha P. Nair “Engineering Chemistry”, Owl Books, 2019.

R8. Ahad J., “Engineering Chemistry”, Jai Publication, 2019.

R9. Roy K. Varghese, “Engineering Chemistry”, Crownplus Publishers, 2019. R10. Soney C. George, Rino Laly Jose, “Text Book of Engineering Chemistry”,

S. Chand & Company Pvt Ltd, 2019.

4. Course Objectives

To enable the students to acquire knowledge in the concepts of chemistry for engineering applications and to familiarize the students with different application-oriented topics like spectroscopy, electrochemistry, instrumental methods etc. Also familiarize the students with topics like mechanism of corrosion, corrosion prevention methods, SEM, stereochemistry, polymers, desalination etc., which enable them to develop abilities and skills that are relevant to the study and practice of chemistry.

5. Course Pre / Co-requisite

Concepts of chemistry introduced at the plus two levels in schools.

6. Course Outcomes

CO 1. Apply the basic concepts of electrochemistry and corrosion to explore its possible applications in various engineering fields.

CO 2. Understand various spectroscopic techniques like UV-Visible, IR, NMR and its applications.

CO 3. Apply the knowledge of analytical method for characterizing a chemical mixture or a compound. Understand the basic concept of SEM for surface characterisation of nanomaterials.

CO 4. Learn about the basics of stereochemistry and its application. Apply the knowledge of conducting polymers and advanced polymers in engineering.

CO 5. Study various types of water treatment methods to develop skills for treating wastewater.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2	1									
CO2	1	1		1	2							
CO3	1	1		1	2							
CO4	2	1										
CO5	1			1			3					

8. Justification for CO-PO-PSO Correlation

CO1	**PO 1** The student will gain awareness about the fundamental concepts of electrochemical techniques that helps to solve engineering problems and an ability to design and construct engineering products like cells and batteries. **PO 2** The study of Galvanic Series and Corrosion will be helpful for the student to choose appropriate materials for various engineering purposes. **PO 3** Knowledge on Electrochemistry and Corrosion helps to design and construct various engineering products, system components etc by proper material selection.
CO2	**PO 1** The student can acquire an ability to apply modern techniques of analysis like spectroscopy to solve complex engineering problems. **PO 2** Knowledge on spectroscopic techniques will help the student to analyse engineering problems like structure analysis and material applications. **PO 4** Knowledge on modern tools like spectroscopy will help the student in the prediction of structure, synthesis and characterization of new engineering materials. **PO 5** An awareness about the fundamental concepts of spectroscopic techniques helps to gain ability to use modern instrumental techniques for engineering practice.
CO3	**PO 1** The student will acquire the knowledge of Thermal Analysis & SEM to solve engineering problems. **PO 2** Knowledge on Thermal Analysis & SEM will help the student to identify and find solution to engineering problems like stability of materials and structure analysis. **PO 4** The study of the structural features of materials using SEM will help the student in synthesis and characterization of new engineering materials. **PO 5** An awareness about the fundamental concepts of Thermal Analysis and SEM will help the student to gain the ability to use modern instrumental techniques.
CO4	**PO 1** Study of Engineering Polymers and Conducting Polymers will help the student to solve many industrial problems. **PO 2** Knowledge on Engineering Polymers and Conducting Polymers will help the student to analyse various system components by using appropriate techniques.

CO5	**PO 1** The student with the knowledge of Water Chemistry and treatment methods will be able to solve environmental problems. **PO 4** Knowledge of water treatment methods will help the student to design various system components by using appropriate materials for setting up water treatment plants and recycling plants, Sewage removal from waste water etc. **PO 7** Knowledge about water treatment methods will help the student to meet the specifications of public health and safety measurements and Societal considerations.

9. Curricular gaps (if any)

Modules 2 and 3 requires some foundation work - Electromagnetic spectrum, Interaction between matter and radiation, Thermal analysis.

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs*

** Proposed Actions: Webinar/Industry Visit/Expert talks /NPTEL/project/training Etc

* To better attain POs and PSOs and to bridge the gap between industry academia

11. Internal Assessment mark allocation (as per university curriculum)

(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

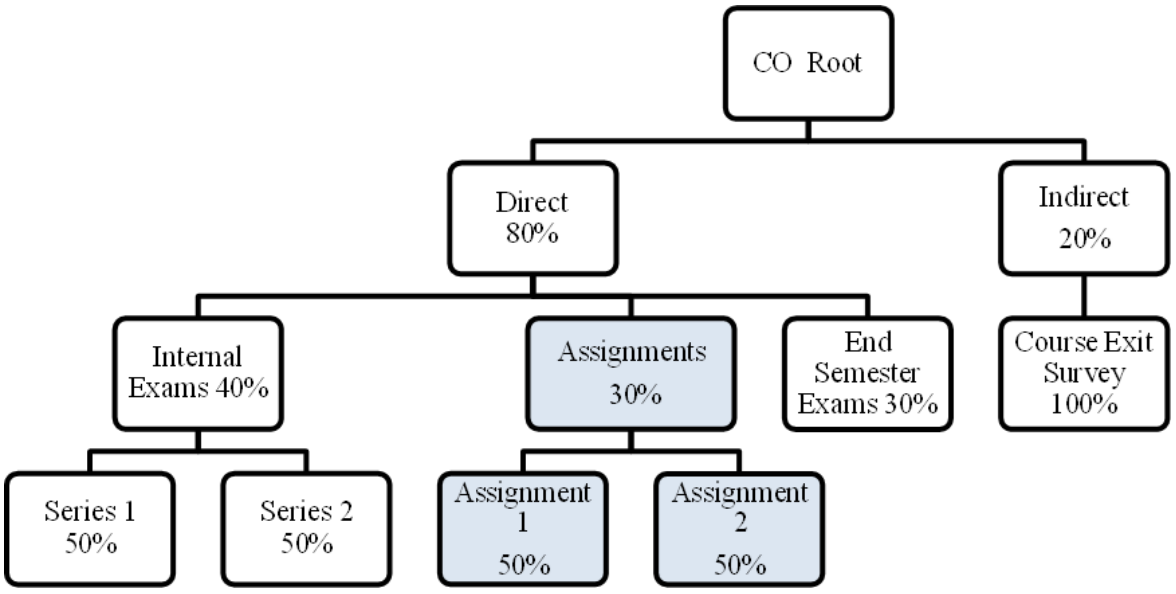
12. Assessment – CO Mapping (Put‘ x’ if mapping is present)

	Tools		Weightage#	CO1	CO2	CO3	CO4	CO5
Direct Assessment Tools**	Internal Exam(s) 40%	Series 1	20%	x				x
		Series 2	20%		x	x		
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x				x
		Assignment 2	15%		x	x	x	
	End Semester Exam		30%	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x

**Fill appropriate course specific Direct Assessment tools

Fill appropriate weights such that total weight for direct assessment tools is 100%

13. Assessment Configuration



14. Course Plan

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1	Differences between electrolytic and electrochemical cells â€“ Daniel cell â€“ redox reactions â€“ cell representation.	1	B. R. Puri, L. R. Sharma, M. S. Pathania, â€œPrinciples of Physical Chemistryâ€,•	Lecture
2	Different types of electrodes (brief) â€“ Reference electrodes â€“ SHE â€“ Calomel electrode â€“ Glass Electrode - Construction and Working.	1	Vishal Publishing Co., 47th Edition, 2017.	Lecture
3	Single electrode potential - definition - Helmholtz electrical double layer - Determination of E0 using calomel electrode.	1	B. R. Puri, L. R. Sharma, M. S. Pathania, â€œPrinciples of Physical Chemistryâ€,•	Lecture
4	Determination of pH using glass electrode. Electrochemical series and its applications.	1	Vishal Publishing Co., 47th Edition, 2017.	Lecture
5	Free energy and EMF - Nernst Equation - Derivation - single electrode and cell (Numericals) -Applications	1	B. R. Puri, L. R. Sharma, M. S. Pathania,	Lecture

			â€œPrinciples of Physical Chemistryâ€•	
6	Variation of emf with temperature. Potentiometric titration - Introduction - Redox titration only.	1	Vishal Publishing Co., 47th Edition, 2017.	Lecture
7	Lithium-ion cell â€“ construction and working. Conductivity â€“ Measurement of conductivity of a solution (Numericals).	1	B. R. Puri, L. R. Sharma, M. S. Pathania, â€œPrinciples of Physical Chemistryâ€•	Lecture
8	Corrosion â€“ Electrochemical corrosion â€“ mechanism. cathodic protection	1	Vishal Publishing Co., 47th Edition, 2017.	Lecture
9	Module 1			Lecture
10	Galvanic series â€“ electroless plating â€“ Copper and Nickel plating.	1	B. R. Puri, L. R. Sharma, M. S. Pathania, â€œPrinciples of Physical Chemistryâ€• Vishal Publishing Co., 47th Edition, 2017.	Lecture
11	Types of spectrum - electromagnetic spectrum - molecular energy levels - Beer Lambertâ€™s law (Numericals).	2	C. N. Banwell, â€œFundamentals of Molecular Spectroscopyâ€•McGraw-Hill, 4th edn., 1995.	Lecture
12	UV-Visible Spectroscopy â€“ Principle â€“ Types of electronic transitions Instrumentation of UV-Visible spectromete	2	C. N. Banwell, â€œFundamentals of	Lecture
13	Energy level diagram of ethane, butadiene, benzene and hexatriene. and applications.	2	Molecular Spectroscopyâ€•McGraw-Hill, 4th edn., 1995.	Lecture
14	IR-Spectroscopy â€“ Principle - Number of vibrational modes	2	C. N. Banwell, â€œFundamentals of	Lecture

15	Vibrational energy states of a diatomic molecule and Determination of force constant of diatomic molecule (Numericals)	2	Molecular Spectroscopyâ €,•McGraw-Hill, 4th edn., 1995.	Lecture
16	1H NMR spectroscopy â€“ Principle â€“ Relation between field strength and frequency	2	C. N. Banwell, â€œFundamentals of	Lecture
17	Chemical shift â€“ spin-spin splitting (spectral problems) â€“ coupling constant (definition)	2	Molecular Spectroscopyâ €,•McGraw-Hill, 4th edn., 1995.	Lecture
18	Applications of NMR â€“ including MRI (brief).	2	C. N. Banwell, â€œFundamentals of	Lecture
19	TUTORIAL MODULE 2	2	Molecular Spectroscopyâ €,•McGraw-Hill, 4th edn., 1995.	Lecture
20	Thermal analysis â€“ TGA â€“ Principle, instrumentation (block diagram) and applications	3	H. H. Willard, L. L. Merritt, â€œInstrumental Methods of Analysisâ€,•CBS Publishers, 7th Edition, 2005.	Lecture
21	TGA of CaC2O4.H2O and polymers.	3	H. H. Willard, L. L. Merritt, â€œInstrumental Methods of Analysisâ€,•CBS Publishers, 7th Edition, 2005.	Lecture
22	DTA-Principle, instrumentation (block diagram) and applications - DTA of CaC2O4.H2O.	3	H. H. Willard, L. L. Merritt, â€œInstrumental Methods of Analysisâ€,•CBS Publishers, 7th Edition, 2005.	Lecture
23	Chromatographic methods - Basic principles and applications of column and TLC â€“ Retention factor.	3	H. H. Willard, L. L. Merritt, â€œInstrument	Lecture

			al Methods of Analysisâ€,•C BS Publishers, 7th Edition, 2005.	
24	GC â€“ Principle, instrumentation (block diagram) - retention time and applications.	3	H. H. Willard, L. L. Merritt, â€œInstrumental Methods of Analysisâ€,•C BS Publishers, 7th Edition, 2005.	Lecture
25	HPLC â€“ Principle, instrumentation (block diagram) - retention time and applications.	3	H. H. Willard, L. L. Merritt, â€œInstrumental Methods of Analysisâ€,•C BS Publishers, 7th Edition, 2005.	Lecture
26	Nanomaterials - Definition - Classification - Chemical methods of preparation - Hydrolysis and Reduction	3	H. H. Willard, L. L. Merritt, â€œInstrumental Methods of Analysisâ€,•C BS Publishers, 7th Edition, 2005.	Lecture
27	Applications of nanomaterials - Surface characterisation	3	H. H. Willard, L. L. Merritt, â€œInstrumental Methods of Analysisâ€,•C BS Publishers, 7th Edition, 2005.	Lecture
28	SEM â€“ Principle and instrumentation (block diagram).	3	H. H. Willard, L. L. Merritt, â€œInstrumental Methods of Analysisâ€,•C BS Publishers, 7th Edition, 2005.	Lecture
29	Isomerism-Structural, chain, position, functional, tautomerism and metamerism - Definition with examples	4	Ernest L. Eliel, Samuel H. Wilen, â€œStereo-	Lecture

			chemistry of Organic Compoundsâ€, •WILEY, 2008.	
30	Representation of 3D structures- Newman, Sawhorse, Wedge and Fischer projection of substituted methane and ethane.	4	Ernest L. Eliel, Samuel H. Wilen, â€œStereo-chemistry of Organic Compoundsâ€, •WILEY, 2008.	Lecture
31	Stereoisomerism - Geometrical isomerism in double bonds and cycloalkanes (cis-trans and E-Z notations). R-S Notation â€“ Rules and examples	4	Ernest L. Eliel, Samuel H. Wilen, â€œStereo-chemistry of Organic Compoundsâ€, •WILEY, 2008.	Lecture
32	Optical isomerism, Chirality, Enantiomers and Diastereoisomers-Definition with examples.	4	Ernest L. Eliel, Samuel H. Wilen, â€œStereo-chemistry of Organic Compoundsâ€, •WILEY, 2008.	Lecture
33	Conformational analysis of ethane, butane, cyclohexane, mono and di methyl substituted cyclohexane.	4	Ernest L. Eliel, Samuel H. Wilen, â€œStereo-chemistry of Organic Compoundsâ€, •WILEY, 2008.	Lecture
34	Copolymers - Definition - Types - Random, Alternating, Block and Graft copolymers	4	Ernest L. Eliel, Samuel H. Wilen, â€œStereo-chemistry of Organic Compoundsâ€,	Lecture

			•WILEY, 2008.	
35	ABS - preparation, properties and applications. Kevlar-preparation, properties and applications.	4	Ernest L. Eliel, Samuel H. Wilen, â€œStereo-chemistry of Organic Compoundsâ€, •WILEY, 2008.	Lecture
36	Conducting polymers - Doping - Polyaniline and Polypyrrole - preparation properties and applications.	4	Ernest L. Eliel, Samuel H. Wilen, â€œStereo-chemistry of Organic Compoundsâ€, •WILEY, 2008.	Lecture
37	OLED - Principle, construction and advantages.	4	Ernest L. Eliel, Samuel H. Wilen, â€œStereo-chemistry of Organic Compoundsâ€, •WILEY, 2008.	Lecture
38	Water characteristics - Hardness - Types of hardness- Temporary and Permanent - Disadvantages of hard water.	5	Roy K. Varghese, â€œEngineering Chemistryâ€,• Crownplus Publishers, 2019.	Lecture
39	Units of hardness- ppm and mg/L - Degree of hardness (Numericals) - Estimation of hardness-EDTA method (Numericals).	5	Roy K. Varghese, â€œEngineering	Lecture
40	Water softening methods-Ion exchange process-Principle, procedure and advantages.	5	Chemistryâ€,• Crownplus Publishers, 2019.	Lecture
41	Reverse osmosis â€“ principle, process and advantages. Municipal water treatment (brief).	5	Roy K. Varghese, â€œEngineering	Lecture

42	Reverse osmosis â€“ principle, process and advantages. Municipal water treatment (brief).	5	Chemistryâ€,• Crownplus Publishers, 2019.	Lecture
43	Dissolved oxygen (DO) -Estimation (only brief procedure-Winklerâ€™s method).	5	Roy K. Varghese, â€œEngineering	Lecture
44	BOD and COD â€“ definition, estimation (only brief procedure) and significance (Numericals).	5	Chemistryâ€,• Crownplus Publishers, 2019.	Lecture
45	Sewage water treatment - Primary, Secondary and Tertiary - Flow diagram	5	Roy K. Varghese, â€œEngineering	Lecture
46	Trickling filter and UASB process.	5	Chemistryâ€,• Crownplus Publishers, 2019.	Lecture

15. Question Bank

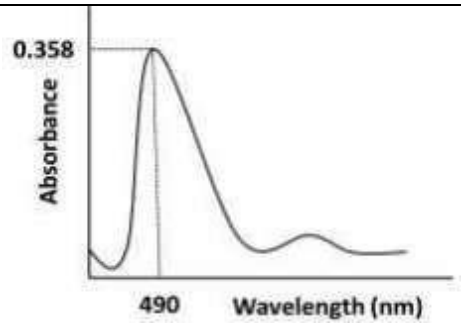
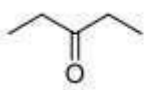
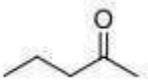
Module 1 ELECTROCHEMISTRY AND CORROSION				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1.	Outline the differences between the Electrolytic cell and Electrochemical cell.	**3**	**CO1**	**L1**
2.	Define single electrode potential? Recall how it is determined.	**3**	**CO1**	**L1**
3.	Explain the construction of a Galvanic cell? Represent the cell using notations.	**3**	**CO1**	**L2**
4.	Potentiometric titrations can be employed to find the end point of a redox titration. Explain with a suitable example.	**3**	**CO1**	**L2**
5.	Explain the construction and working of a glass electrode.	**3**	**CO1**	**L2**
6.	Explain the process of Cathodic Protection?	**3**	**CO1**	**L2**
7	Discuss the electrochemical reactions taking place during corrosion of iron?	**3**	**CO1**	**L2**
8	Describe the electroless plating using Copper?	**3**	**CO1**	**L2**
9	Explain the process - electroless plating using Nickel?	**3**	**CO1**	**L2**
10	Discuss Helmholtz Electric Double Layer.	**3**	**CO1**	**L2**
11	Demonstrate how a glass electrode can be used to determine the pH of a solution?	**3**	**CO1**	**L3**
12	Illustrate that the Calomel electrode can act as a reversible electrode. How can you construct a saturated Calomel Electrode.	**3**	**CO1**	**L3**
13	Illustrate Impressed Current Anodic protection.	**3**	**CO1**	**L4**
	a) Explain the construction, working and cell reaction for a Lithium-ion cell. b) What is Nernst Equation? What are the terms involved?	**10** **4**		

15.	**a)** Define is a reference electrode? How is SHE constructed? **b)** Describe the electrode reactions, cell reaction and calculate the emf of the given cell – $Ag(s) / Ag^{+}(1M) \parallel Zn^{2+}(1M) / Zn(s)$, given $E^{\circ} Ag/Ag^{+} = 0.799$ V and $E^{\circ} Zn^{2+}/Zn = -0.763$ V. Is the reaction spontaneous?	**4** **10**	**CO1**	**L2**
16	**a)** What is an electrochemical series? **b)** Explain its applications? **c)** Explain the charge on anode and cathode in an electrochemical cell?	**4** **6** **4**	**CO1**	**L4**
	PREVIOUS UNIVERSITY QUESTIONS			
1	How is Helmholtz electrical double layer formed?	3	DEC21	
2	Calculate the single electrode potential of dichromate electrode at 25^0C when $[Cr2O^{2-}]$ is 0.3M, $[Cr^{3+}]$ is 0.02M and $[H^{+}]$ is 1M. Given: $Cr_2O_7^{-} + 14\,H^{+} + 6e \rightarrow 2Cr^{3+} + 7H2O$; E0 = 1.33 V	3		
3	) How is glass electrode used in determining the pH of a solution? What are the advantages and limitations of a glass electrode? b) Describe the principle and applications of Electroless copper plating.	8 6		
	a) Write the principle and procedure for the estimation of ferrous ion using dichromate solution potentiometrically. E0 Fe^{3+}/Fe^{2+}= 0.77 V b) Emf of an electrochemical cell is 1.5175 V at 20^0C and 1.5213 V at 350C.If the cell reaction involve 2 electrons, find the standard	8 6		
	emf of the cell and the reaction quotient.			
5	What is galvanic series? How is galvanic series advantageous over electrochemical series in corrosion chemistry?	3	JAN21	
6	Why full charging is not allowed in Li-ion cell?	3		
7	a) Derive Nernst equation and apply it for the emf of Daniel cell. b) How is electroless nickel plating done? Write the reactions involved. Give any two applications of it.	(8)		
8	a) With the help of electrochemical equations, show that rusting of iron is more severe in oxygen rich acidic medium than alkaline medium. b) A glass electrode – calomel electrode assembly shows an emf of 212 mV with pH = 4 buffer solution and -30 mV with pH = 9.2 buffer solution. Find the pH of the test solution if it shows an emf of 120 mV. Also find E0 G if ESCE = 0.2422 V	(8) (6)		
9	What will be the standard electrode potential of Ni^{2+}/ Ni electrode if the cell potential of the cell $Ni/Ni^{2+}(1M)$ // $Cu^{2+}(0.1M)$/ Cu is 0.59V at 25°C? E0 Cu^{2+}/Cu= 0.34 V	3	DEC20	S1

10	Briefly explain the principle of electroless plating.	3		
	a) Explain the mechanism of electrochemical corrosion in different environmental conditions. b) How is the cell constant of a conductivity cell measured?	(10) (4)		
	a) Describe the construction and working of Li-ion battery. What are the major advantages of it? (0.01M) E0 Al^{3+}/Al= -1.66 V, E0 Sn^{4+} / Sn^{2+} = 0.15 V	(10)		

Module 2. Spectroscopic Techniques and applications				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1.	Give the applications of U.V Spectroscopy	3	CO 2	L1
2.	Illustrate HOMO – LUMO concept with a suitable example?	3	CO 2	L1
3.	Recall what you mean by electromagnetic radiation and electromagnetic spectrum.	3	CO 2	L1
4.	List out the requirements of a molecule to be IR active	3	CO 2	L1
5.	Recall on the advantages of Spectroscopic analysis.	3	CO 2	L1
6	What are the three regions of IR spectrum? Describe why the region 1300 - 900 cm^{-1} is called the finger print region of the compound?	3	C0 2	L2
7	Tetramethylsilane is the customary standard used in NMR spectroscopy. Explain?	3	CO 2	L2
8	Discuss the difference between NMR spectroscopy and UV or IR spectroscopy?	3	CO 2	L2
9	Explain what are stretching and bending vibrations?	3	CO 2	L2
10	Explain various modes of vibration possible for CO_2 molecule?	3	CO 2	L2
11	Explain various modes of vibration possible for H_2O molecule?	3	CO 2	L2
12	IR Spectroscopy can be used to identify functional groups. Explain?	3	CO 2	L2
13	Calculate the number of modes of vibrations available for a linear and a non-linear molecule.	3	CO 2	L3
14	Represent the normal NMR spectrum and splitting pattern of ethyl alcohol ($CH_3 - CH_2 - OH$)	3	CO 2	L1
15	a) Explain the principle of UV and IR Spectroscopy. b) A dye solution of concentration 0.08M shows absorbance of .012 at 600mm. While a test solution of same dye shows absorbance of 0.084 under same conditions. Find the concentration of test solution	10 4	CO 2	L3

16	a) Why is TMS taken as a standard in NMR Spectroscopy? b) Illustrate the normal spectrum and splitting pattern of ethyl alcohol ($CH_3 - CH_2 - OH$) c) Compare U.V and IR spectrum	6 4 4	CO 2	L3
17	a) What is chemical shift in NMR spectroscopy? What	10	CO 2	
	are the factors that affect chemical shift? b) Sketch the vibrational modes of CO_2 and H_2O	4		L4
18	a) Define Beer Lamberts law and the mathematical form of the law. b) Explain the instrumentation and working of U.V Spectrometer. c) What are the applications of U.V Spectroscopy?	4 6 4	CO 2	L3 L4
19	a) An organic compound C_7H_7Cl shows a strong IR band around 800 cm^{-1} , two bands at 1800 cm^{-1} and 1900 cm^{-1} (the band at 1900 cm^{-1} being stronger) and three IR bands at 3100, 2930 and 2860 cm^{-1}. Suggest a suitable structure for the compound. b) What are the factors affecting chemical shift? Explain?	10 4	CO 2	L4
20.	a) A compound having molecular formula C_9H_{12} gives two signals at δ = 2.27 (9H) and 6.7 (3H) respectively in NMR spectra. The area under the two peaks is 3:1. Assign structure to the compound. b) Draw the MO representation of 1, 3, 5 – Hexatriene and indicate HOMO and LUMO.	10 4	CO 2	L4
PREVIOUS UNIVERSITY QUESTIONS				
1.	Recognize the atoms showing NMR phenomenon among the following. Give reason. a) $^{1}_{1}H$ b) $^{2}_{1}H$ c) $^{3}_{1}H$ d) $^{16}_{8}O$ e) $^{18}_{8}O$ f) $^{14}_{7}N$	3	**DEC 21**	
2.	IR spectroscopy can be used to differentiate intra molecular and inter molecular hydrogen bonds. Explain with an example.	3		
3.	a) What are the various types of electronic transitions possible in organic molecules? Give examples of each. Also give the instrumentation of UV Visible spectrophotometer. b) Suggest structural formula for the following compounds such that they give a single signal in proton NMR spectroscopy. a) $C_9H_{18}O$ and b) $C_{12}H_{18}$	8 6		

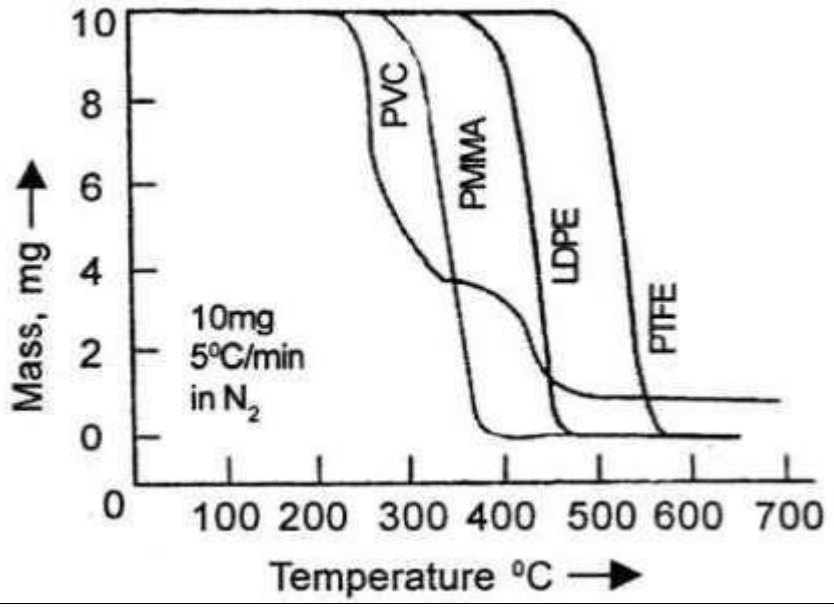
4.	a) Write the various modes of vibration possible for HCl, CO_2 and H_2O and state which of these modes are IR active. Write reason for their IR activity. b) State Beer- Lambert's law and explain the term molar extinction co-efficient. Given is the absorption spectrum of a compound A of 2.5 x 10^{-6} M concentration, when measured using 1 cm cuvette in a UV- Vis spectrometer. Calculate the unknown concentration of a test sample of compound A if the absorbance is 0.518, when measured in the same condition.	8 6		
				
5.	What is the requirement for a molecule to be IR active? Write two examples for IR active and inactive molecules.	3	**JAN 2021**	
6.	Predict number of signals for the following and justify your answer. a)  b) 	3.		
7.	a) Draw the expected NMR spectrum of methyl propanoate and point out how it differs from ethyl acetate b) Write the mathematical representation of the law governing absorption of light by molecules of a solution. Also calculate the concentration of a solution if it shows a transmittance of 20% when taken in a cell of 2.5 cm thickness (Molar absorption coefficient is 12000 dm^2 mol^{-1}).	10 4		
8.	a) How can you differentiate NMR spectrum of CH_3CH_2Cl and CH_3CHCl_2 using the concept of spin-spin splitting? b) Comment on the various electronic transitions that are possible in the following molecules (i) C_2H_6 (ii) CH_3CH_2OH and (iii) 1,3 butadiene.	8 6		
9.	$CHCl_3$ gives a singlet at 7.26 ppm, while CH_3Cl shows singlet at 3.06 ppm in the ^1H NMR spectrum. Give reason.	3	**JULY 2021**	
10.	Explain the reason for broadening of UV-Visible (electronic) spectrum.	3		

11.	a) Draw the molecular orbital energy diagram of i) Ethene, ii) 1, 3- butadiene iii) 1,3,5 hexatriene and iv) benzene to explain their UV-Vis absorption. b) Explain the origin of spin-spin splitting and draw the splitting pattern in CH_3- CH_2-CH_2-Cl.	8 6		
12	a) Discuss the principle of IR spectroscopy. Arrive at the expression for vibrational energy states of a diatomic molecule. Draw the potential energy diagram. b) An organic compound C_3H_6O contains a carbonyl group. How will its NMR spectrum decide whether it is an aldehyde or a ketone?	8 6		
13	Which of the following molecules can give UV visible spectrum (200nm - 800nm)? a) CH_4 b) N_2 c) Butadiene d) Benzene	3	**JUNE 2022**	
14	How many vibrational modes are possible for CO_2 molecule? Sketch the vibrational modes	3		
15.	a) Write a note on magnetic resonance imaging (MRI). List applications of it in medical diagnosis b) Predict high resolution 1H NMR spectra of 1-Chloroethane and 2- Chloropropane	8 6		

Module 3 INSTRUMENTAL METHODS AND NANOMATERIALS

Sl. No.	Question	Marks	CO	BL
1.	List two examples each for (i) adsorbent (ii) Eluents.	3	CO 3	L1
2.	Recall any three applications of TGA?	3	CO 3	L1
3.	Name any three applications of DTA?	3	CO 3	L1
4.	Label the chromatographic methods based on physical nature of adsorbent.	3	CO 3	L1
5.	Summerize the differences between DTA and TGA.	3	CO 3	L2
6	Discuss on the visualization techniques used in TLC.	3	CO 3	L2
7.	Explain the instrumentation of TGA	3	CO 3	L2
8	Describe any three applications of TLC?	3	CO 3	L2
9	Illustrate the basic principles of Gas Chromatography.	3	CO 3	L3
10	Illustrate the basic principles of HPLC.	3	CO 3	L3

11.	Explain the principle, instrumentation and procedure of gas chromatography. Differentiate between Retention Factor (Rf Value) and Retention time (TR) in chromatography.	10 4	CO 3	L2
12.	Discuss the importance of nano materials? Classify the nano materials based on raw materials? Explain any two chemical methods for the synthesis of nanomaterials?	4 4 6	CO 3	L2
13.	Explain the principle, instrumentation and procedure of gas chromatography Differentiate between Retention Factor (Rf Value) and Retention time (TR) in chromatography	10 4	CO 3	L2
14.	a) Explain the instrumentation of TGA? b) Draw the TGA thermogram of $CaC_2O_4.H_2O$.	10 4	CO 3	L2
	PREVIOUS UNIVERSITY QUESTIONS			
1	Write any three differences of TGA and DTA. (3)	**December 2020**		
2	Explain sol-gel method for the synthesis of nano particles (3)			
3	a) Define chemical shift in NMR and explain the factors affecting chemical shift with examples. (8) b) Calculate the force constant of H-F molecule that is showing IR			
	absorption signal at 4000 cm-1. By what factor do you expect this frequency to shift if Deuterium is substituted for Hydrogen in this molecule? Given that atomic masses of H and F are 1u and 19 u, respectively. (6)			
4	How many vibrational modes are possible for the molecules CO, NO, CO2 and H2O? Draw the vibrational modes of CO2 and H2O and explain their IR active modes. (8) Each compound gives only one signal in its 1H-NMR Spectrum. Propose a structural formula for each. a) C8H18 and b) C8H18O (6)			
5	TGA will not give information regarding phase changes .Give reason.(3)	**January 2021**		
6	Mention any three applications of SEM. (3)			
7	Explain the principle and instrumentation of DTA with a neat diagram. Interpret the DTA thermogram of CaC2O4.H2O. (10) Discuss the classification of nanomaterials based on Materials. (4)			
8	Describe the principle, instrumentation, procedure and applications of GC. (10) Explain hydrothermal method of synthesis of nanomaterials. (4)			

9	Compare the thermal stability of PVC, PMMA, LDPE and PTFE using TG given below. Justify your answer. (3)  	**December 2021**		
10	Give the principle of TLC. Mention two applications of TLC. (3)			
11	Describe the principle and steps to be followed in column chromatography. (10) How are nanomaterials classified on the basis of dimension? (4)			
12	Sketch the instrumentation of DTA and explain the principle. Explain the DTA of CaC2O4.H2O. (8) Briefly explain the principle and instrumentation of SEM with the help of a diagram. (6)			

Module 4 STEREOCHEMISTRY AND POLYMER CHEMISTRY

Sl. No.	Question	Marks	CO	BL
1	Outline the reason for Geometrical isomerism?	3	CO4	L1
2	What is a meso compound? Give an example.	3	CO4	L1
3	List the information that you get from Fischer projections?	3	CO4	L1
4	Define conducting Polymers? Give examples.	3	CO4	L1
5	Write a note on the applications of OLED's.	3	CO4	L1
6	Describe the properties of Polyaniline?	3	CO4	L2
7	Explain the preparation of the polymer ABS.	3	CO4	L2
8	Explain the working of OLED's.	3	CO4	L2
9	Discuss the synthesis of polyaniline.	3	CO4	L2
10	Describe the applications of Polyaniline?	3	CO4	L2

11	Describe the applications of Polypyrrole?	3	CO4	L2
12	Illustrate the general properties of conducting polymers?	3	CO4	L3
13	Differentiate between Enantiomers and Diastereoisomers.	3	CO4	L4
14	Classify the polymers can be formed by 2 or more different monomers.	3	CO4	L4
15	a) Explain the synthesis, properties and uses of Kevlar? b) Explain the uses of ABS?	10 4	CO4	L2
16	a) Explain the synthesis, properties and uses of ABS? b) Explain the uses of Kevlar?	10 4	CO4	L2
17	a) Taking Glyceraldehyde as example, explain R – S system of Nomenclature. b) Draw the conformational isomers of Butane taking C2 – C3 axis as the axis of rotation.	10 4	CO4	L2
18	a) Describe the conformational Isomerism of cyclohexane. Draw the energy diagram of the conformers. b) Draw Sawhorse projection of staggered and eclipsed conformers of Butane.	10 4	CO4	L2
19	a) Illustrate the stereochemistry of monosubstituted and 1,2- disubstituted cyclohexane. b) Draw Fischer projection formulae of the isomers of Lactic acid and name them using R-S system.	10 4	CO4	L4
20	Explain the following – a) Conducting polymers with conjugated π – electrons. b) Doped conducting polymers.	6 4	CO4	L2

Module 5 WATER CHEMISTRY & WASTE WATER TREATMENT

Sl. No.	Question	Marks	CO	BL
1	Illustrate the advantages of water softening by Zeolite process?	3	CO 5	L3
2	Explain water purification by chlorination?	3	CO 5	L2
3	Outline the disinfection of water by UV radiation?	3	CO 5	L1
4	Explain DO determination by Winkler's method?	3	CO 5	L2
5	What is BOD? Describe the importance of BOD?	3	CO 5	L2
6	What is COD? Describe the significance of COD?	3	CO 5	L2
7	Write notes on Trickling Filter.	3	CO 5	L2

8	Explain what do you mean by UASB process?	3	CO 5	L2
9	Explain sewage water treatment process.	3	CO 5	L2
10	Differentiate between temporary hardness and permanent hardness.	3	CO 5	L2
11	Name the six types of salts that cause hardness in water?	3	CO 5	L1
12	Summarize the defects of using hard water in boilers?	3	CO 5	L2
13	Explain carbonate treatment process for removal of hardness of water.	3	CO 5	L2
14	Explain phosphate treatment process for removal of hardness of water.	3	CO 5	L2
15	Define hardness of water. What are the different types of hardness of water?	3	CO 5	L1
16	a) Illustrate two methods each for the removal of temporary and permanent hardness from water. b) A sample of water contains the following dissolved Salts $Ca(HCO_3)_2$ = 20 Mg/litre, $MgSO_4$ = 30 mg/litre and $CaCl_2$ = 55.5mg/litre. Calculate the total and permanent hardness.	10 4	CO 5	L4
17	a) Illustrate the preparation of deionized water? b) Classify the differences between BOD and COD	10 4	CO 5	L4 L4
18	a) Demonstrate the different steps in the preparation of water for domestic supply? b) Explain the term reverse osmosis and give its	10 4	CO 5	L3 L2

	Applications			
19	a) Describe the estimation of hardness of a sample of water by EDTA method. b) Illustrate the structure of EDTA	10 4	CO 5	L2
20	a) What do you mean by BOD and COD? Illustrate their significance. b) A water sample contains 204 mg of $CaSO_4$ per litre. Calculate the hardness of the sample.	10 4	CO 5	L4 L3
UNIVERSITY QUESTIONS				
21	Explain disinfection by chlorination. (3)	DEC 2020		
22	Compare BOD and COD	3		

23	a) Describe the steps involved in municipal water treatment. b) The following data are obtained for a hard water sample from an EDTA experiment i) 20 mL standard hard water (5 g/L CaCO3) = 25 mL EDTA solution ii) 100 mL of hard water sample = 24 mL EDTA solution iii) 100 mL of boiled hard water sample = 18 mL EDTA solution Calculate the temporary and permanent hardness.	10 4		
24	a) With the help of a flow diagram explain the steps involved in sewage treatment. b) Calculate the temporary and permanent hardness of water sample containing the following dissolved salts. Ca(HCO3)2 = 28 mg/L; CaSO4 = 18 mg/L; Mg(HCO3)2 = 32 mg/L; MgCl2 = 30 mg/L; NaCl =58 mg/L	10 4		
25	A sample of water on analysis gives the following results. Ca2+ = 200 mg/L, Mg2+ = 180 mg/L, HCO_3 - = 360 mg/L, Cl- = 200 mg/L and Na+ = 80 mg/L. Calculate temporary and permanent hardness. (3)	3	DEC 2021	
26	Differentiate between aerobic and anaerobic oxidation. (3)	3		
27	a) Explain the EDTA method for the estimation of hardness of water with calculation steps. b) Write the procedure for estimating COD of a sample of waste water.	10 4		
28	a) Discuss the action of chlorine as a disinfectant. How is it applied? What is break point chlorination? Write any two advantages of breakpoint chlorination. b) A pure water sample is added with 90 mg carbohydrate (CH_2O) per litre find the maximum BOD possible for the water sample.	10 4		
29	What is the chemistry behind the removal of temporary hardness by boiling?	3	JAN 2021	
30	What are the factors that affect DO level in water?	3		

31	a) Explain aerobic and anaerobic methods for the waste water treatment. b) A water sample contains 16.2 mg/L $Ca(HCO_3)_2$, 7.3 mg/L $Mg(HCO_3)_2$, 9.5 mg/L $MgCl_2$ and 13.6 mg/L $CaSO_4$. Calculate the temporary and permanent hardness of water and what will happen if 10.6 mg/L $NaHCO_3$ is added?	10 4		
32	a) Explain the complexometric titration method for the estimation of hardness of water. Write necessary calculation steps. b) Write any four disadvantages of hard water.	10 4		
33	What is galvanic series? How is galvanic series advantageous over electrochemical series in corrosion chemistry? (3) 2	3	JULY 2021	
34	Why full charging is not allowed in Li-ion cell	3		
35	a) Explain trickling filter and UASB processes in waste water treatment. b) Discuss the procedure for the determination of DO in water.	10 4		
36	a) Define reverse osmosis. Explain the method for the desalination of water using reverse osmosis. Give its advantages. b) Explain the ion exchange process in water treatment. How is the exhausted resin regenerated?	8 6		

Prepared By: Dr. Shybi AA

Checked By: Dr. Jude Martin Mendez

Course Code & Name: EST110 Engineering Graphics

1. Prescribed Syllabus

Module	Topic	Hours
	Section A	
1	Introduction: Relevance of technical drawing in engineering field. Types of lines, Dimensioning, BIS code of practice for technical drawing. Orthographic projection of Points and Lines: Projection of points in different quadrants, Projection of straight lines inclined to one plane and inclined to both planes. Trace of line. Inclination of lines with reference planes True length of line inclined to both the reference planes.	**9**
2	Orthographic projection of Solids: Projection of Simple solids such as Triangular, Rectangle, Square, Pentagonal and Hexagonal Prisms, Pyramids, Cone and Cylinder. Projection of solids in simple position including profile view. Projection of solids with axis inclined to one of the reference planes and with axis inclined to both reference planes.	**8**
3	Sections of Solids: Sections of Prisms, Pyramids, Cone, Cylinder with axis in vertical position and cut by different section planes. True shape of the sections. Also locating the section plane when the true shape of the section is given. Development of Surfaces: Development of surfaces of the above solids and solids cut by different section planes. Also finding the shortest distance between two points on the surface.	**8**
4	Isometric Projection: Isometric View and Projections of Prisms, Pyramids, Cone , Cylinder, Frustum of Pyramid, Frustum of Cone, Sphere, Hemisphere and their combinations.	**6**
5	Perspective Projection: Perspective projection of Prisms and Pyramids with axis perpendicular to the ground plane, axis perpendicular to picture plane. Conversion of Pictorial Views: Conversion of pictorial views into orthographic views.	**6**
	Section B	
	Introduction to Computer Aided Drawing: Role of CAD in design and development of new products, Advantages of CAD. Creating two dimensional drawing with dimensions using suitable software. (Minimum 2 exercises mandatory) Introduction to Solid Modelling: Creating 3D models of various components using suitable modelling software. (Minimum 2 exercises mandatory)	**8**

2. Text Books (T)

T1. Bhatt, N.D., Engineering Drawing, Charotar Publishing House Pvt. Ltd.

T2. John, K.C. Engineering Graphics, Prentice Hall India Publishers.

T3. P. I. Varghese, Engineering Drawing and Graphic, New Age International Publishers.

3. Reference Books (R)

R1. Anilkumar, K.N., Engineering Graphics, Adhyuth narayan Publishers

R2. Benjamin, J., Engineering Graphics, Pentex Publishers- 3rd Edition, 2017

R3. Varghese, P.I., Engineering Graphics, V I P Publishers

4. Course Objectives

To enable the student to effectively perform technical communication through graphical representation as per global standards.

5. Course Pre / Co-requisite

Nil

6. Course Outcomes

After completion of the course, student will be able to
CO1: Draw the projections of points and line in different quadrants
CO2: Prepare multi-view orthographic projections of objects by visualizing them in different positions
CO3: Draw sectional view and develop surface of given object
CO4:Prepare pictorial drawings using principles of isometric and perspective projections to visualise object in three dimensions
CO5: Convert 3D views to orthographic views
CO6: Obtain multi-view projections and solid models of objects using CAD tools

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO 3
CO1	H														
CO2	H														
CO3	H	L													
CO4	H									L					
CO5	H									M					
CO6	H				H					H					

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	PO1	Students will be able to apply knowledge on projections of points and

		lines in different quadrants to aid in creating complex engineering drawings. Student will attain in depth knowledge in creating projections of lines required to communicate effectively with use of drawings.
CO2	PO1	Students will be able to prepare multi-view orthographic projections of objects to aid in drawing complex engineering drawings. Student will attain in depth knowledge in creating multi-view orthographic projection required to communicate effectively with use of drawings and solve problems.
CO3	PO1	Students will be able to create and interpret sectional view and develop surface of required object. Student will attain in depth knowledge in creating sectional view and develop surface of given object.
	PO2	Students will be able to draw sectional view and develop surface of a given object for better analysis of an object. Student will attain intermediate knowledge in analysis of inner features of object with the aid of sectional views.
CO4	PO1	Students will be able to apply principles of isometric and perspective projections to aid in drawing and interpreting complex engineering figures. Student will attain in depth knowledge in creating isometric and perspective projections to create easy to understand 3D solutions
	PO10	Students will be able to apply principles of isometric and perspective projections to communicate complex engineering structures with the engineering community and with society at large.
CO5	PO1	Students will be able to convert 3D views to orthographic views to aid in solving complex engineering problems. Student will attain in depth knowledge on 3D views and orthographic views required to effectively interpret drawings.
	PO10	Students will be able to convert 3D views to orthographic views and communicate effectively with complex engineering drawings with the engineering community. Student will attain intermediate knowledge required design documentation
CO6	PO1	Students will attain in depth knowledge to apply CAD tools to create complex engineering drawings and obtain design solutions.
	PO5	Students will attain in depth knowledge to use CAD tools to create, select, and apply appropriate techniques for modelling complex engineering drawings.
	PO10	Students attain in depth know how on CAD tools to create and communicate effectively using engineering drawings with the engineering community, society at large and create design reports and effective presentations.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	Solid model	Familiarise different simple solids with actual models	PO1, PO2

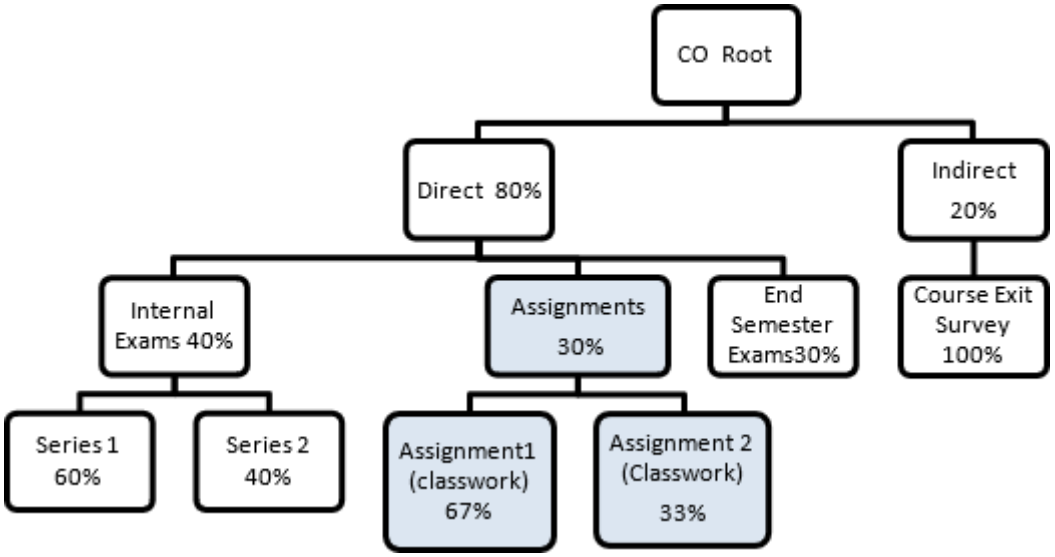
11. Internal Assessment mark allocation (as per university curriculum)
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Class work	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put' x' if mapping is present)

	Tools		Weightage#	CO1	CO2	CO3	CO4	CO5	CO6
Direct Assessment Tools**	Internal Exam(s) 40%	Series 1	20%	x	x				
		Series 2	20%			x	x	x	x
	Assignment (s)/ Course Project /Quiz etc. 30%	Class work 1	15%	x	x	x			
		Class work 2	15%				x	x	x
	End Semester Exam		30%	x	x	x	x	x	
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1	Introduction: Relevance of technical drawing in engineering field. Types of lines	1	T1	Lecture

2	Dimensioning, BIS code of practice for technical drawing. (No questions for the end semester examination)	1	T1	Lecture
3	Projection of points in different quadrants	1	T1	Practical
4	Projection of straight lines inclined to one plane and inclined to both planes	1	T1	Practical
5	Projection of straight lines inclined to one plane and inclined to both planes	1	T1	Practical
6	Trace of a line	1	T1	Lecture
7	Inclination of lines with reference planes.	1	T1	Practical
8	True length and true inclinations of line inclined to both the reference planes	1	T1	Lecture
9	True length and true inclinations of line inclined to both the reference planes	1	T1	Practical
10	Projection of Simple solids such as Triangular, Rectangle Prisms.	2	T1	Practical
11	Projection of Simple solids such as Square, Pentagonal and Hexagonal Prisms.	2	T1	Lecture
12	Projection of Simple solids such as Triangular, Rectangle, Pyramids.	2	T1	Practical
13	Projection of Simple solids such as Square, Pentagonal and Hexagonal Pyramids.	2	T1	Practical
14	Projection of Simple solids such as Cone and Cylinder only.	2	T1	Lecture
15	Projection of solids in simple position including profile view.	2	T1	Practical
16	Projection of solids with axis inclined to one of the reference planes.	2	T1	Lecture
17	Projection of solids with axis inclined to both reference planes.	2	T1	Practical
18	Projection of solids with axis inclined to both reference planes.	2	T1	Practical
19	Sections of Solids: Sections of Prisms.	3	T1	Lecture,
20	Sections of Solids: Sections of Pyramids.	3	T1	Lecture
21	Sections of Cone and Cylinder only	3	T1	Lecture
22	Sections of Solids with axis in vertical position and cut by different section planes.	3	T1	Practical
23	True shape of the sections. (Exclude true shape given problems)	3	T1	Practical
24	Development of Surfaces: Development of surfaces of the solids and solids cut by different section planes.	3	T1	Lecture
25	Development of Surfaces: Development of surfaces of the solids and solids cut by different section planes.	3	T1	Practical
26	Development of Surfaces: Development of surfaces of the solids and solids cut by different section planes.	3	T1	Practical
27	Isometric Projection: Isometric scale	4	T1	Lecture
28	Isometric View and Projections of Prisms	4	T1	Lecture

29	Isometric View and Projections of Prisms	4	T1	Practical
30	Isometric View and Projections of Pyramids	4	T1	Lecture
31	Isometric View and Projections of Pyramids	4	T1	Practical
32	Isometric View and Projections of Cone, Cylinder	4	T1	Practical
33	Isometric View and Projections of Hemisphere.	4	T1	Practical
34	Isometric View and Projections of Prisms, Pyramids, Cone, Cylinder, Sphere, Hemisphere and their combinations.	4	T1	Lecture
35	Isometric View and Projections of Prisms, Pyramids, Cone, Cylinder, Sphere, Hemisphere and their combinations.	4	T1	Practical
36	Introduction to perspective projection, different planes, station point etc.	5	T1	Lecture
37	Perspective problems on pyramids	5	T1	Practical
38	Perspective problems on prisms	5	T1	Practical
39	Perspective problems on prisms	5	T1	Practical
40	Practice on conversion of pictorial views into orthographic views	5	T1	Practical
41	Practice on conversion of pictorial views into orthographic views	5	T1	Practical

15. Question Bank

SECTION A				
Module 1				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1.	A line AB 70mm long has its end A 15mm in front of VP & 20mm above HP. Other end B is 60mm in front of VP & 50mm above HP. Draw the projections of the line AB & finds its inclinations with both the reference planes. Also locate its traces.	20	CO1	L2
2.	Draw the projections of line PQ 75mm long lying 30° to VP & 45° to HP. End P of the line is 15mm above HP & 20mm in front of VP. Locate the traces of line.	20	CO1	L2
3.	The end projectors of a line AB is 60mm apart. End A is 20mm above HP & 30mm in front of VP. Other end B is 70mm above HP & 45mm behind VP. Draw the projections and find its true length and true inclinations. Also locate its traces.	20	CO1	L3
4.	The end A of a line AB, 80mm long is 10mm above HP & 20mm in front of VP. The end B is 35mm below HP & 30mm behind VP. Draw the projections of the line AB & find its inclinations with reference planes. Also locate its traces.	20	CO1	L3
5.	Point A is 20mm above HP and 65mm in front of VP. Point B is 70mm above HP and 30mm in front of VP. The distance between the projectors is 65mm. Draw the projections of the line and hence find its true length, inclinations with coordinate planes and projections of the traces.	20	CO1	L3

6.	Point A is 20mm above HP and 30mm in front of VP. The front view is inclined 45° to ground line and measures 70mm. The end B is 75mm in front of VP. Draw the projections of the line and its traces. Also find its true length and inclinations with HP and VP..	20	CO1	L3
7.	Point M is 25mm in front of VP and 30mm above HP. The distance between the end projectors of line MN is 50mm The top view and front view measures 70mm and 65mm respectively. Draw the projections of the line and true length and its traces.	20	CO1	L3
8.	A line AB 65mm long has its end 20mm above HP and 25mm in front of VP. The end B is 50mm above HP and 65mm in front of VP. Draw projections of line AB and show its inclination with HP and VP.	20	CO1	L2
9.	The top view of a line makes 30° with ground line. The horizontal trace is 60mm in front of VP and vertical trace is 70mm above HP. One end point of the line is 10mm behind VP while the other end is 30mm above HP. Draw the projections.	20	CO1	L3
10.	A line AB , 80mm long, is inclined 30° to HP and 45° to VP. Draw its projections when end A lies on HP and end B lies on VP.	20	CO1	L2
11.	The FV of a line AB measures 75mm & makes an angle of 500 with XY. The end A is in horizontal plane & VT of the line is 25mm above HP. The line is inclined at 350 to the VP. Draw the projections of the line & find its true length & inclination with HP.	20	CO1	L3
12.	The FV of a line AB makes an angle of 300 with XY line. The HT of the line is 36mm behind VP & the VT is 30mm above HP. One end of the line is 10mm below HP, while the other end is 20mm in front of VP. Draw the projections of the line determine the true inclinations.	20	CO1	L3
13	The projectors through traces of a line are 110mm apart & those through the ends of the line are 50mm apart. The end A of the line is 20mm below HP & is in front of VP. The TV & FV of the line make 30° & 45° with the XY line respectively. Draw the projections of the line determine the true inclinations.	20	CO1	L3
14	A line AB, 70mm long is inclined at 45^0 to HP & 30^0 to VP. A point M on the line is at a distance of 30mm from B is 50mm above HP & 60mm in front of VP. Draw the projections of the line and mark its traces.	20	CO1	L3
15.	A line AB 90mm long is inclined 30° to HP. Its end A is 10mm above HP & 20mm in front of VP. Its FV measures 65mm. Draw the TV of the line AB & measure its length. Determine the inclination of the line with VP & locate its traces.	20	CO1	L3
16.	One end point of a line AB is 12 mm above HP and is 15 mm in-front of VP. Other end point is 50 mm above HP and is 42 mm in front of VP. Draw the projections of the line AB if its elevation measures 70 mm. Find out its true length and the true inclinations with respect to the reference planes.	20	CO1	L3

17.	One end point P of a line PQ, 75 mm long, is 10 mm above HP and 20 mm in front of VP. The line is inclined 45^o to HP and its plan is inclined 35^o to x-y line. Draw the projections of the line PQ and find out true inclination of the line with respect to VP.	20	CO1	L3
Module 2				
Sl. No.	Question	**Marks**	**CO**	**BL**
1.	A square prism of base 40 mm side and height 65 mm, has its axis inclined at 450 to the HP and has an edge of base on HP and inclined at 300 to VP. Draw its projections.	20	CO2	L3
2.	A hexagonal prism side of base 20 mm side and axis 60 mm long is resting on one of its edges of the base on HP, which is inclined at 450 to VP. Draw the projections of the prism if the axis makes an angle of 750 with HP.	20	CO2	L3
3.	A pentagonal prism side of base 20 mm side and axis 60 mm long is resting on one of its edges of the base on HP, which is inclined at 450 to VP. Draw the projections of the prism if the axis makes an angle of 750 with HP.	20	CO2	L3
4.	A right regular pentagonal pyramid, with sides of base 30 mm and height 65 mm rests on the edge of its base on the horizontal plane, the base being tilted until the vertex is at 60 mm above the HP. Draw the projections of the pyramid when the edge on which it rests is made parallel to Front reference plane (FRP)(Draw the projections when the base of the pyramid is visible in the Front View).	20	CO2	L3
5.	A pentagonal pyramid, base 25 mm side and axis 50 mm long has one of its triangular faces in the VP and the edge of the base contained by that face makes an angle of 300 with the HP. Draw its projections.	20	CO2	L3
6.	Draw the projections of a cube of 25 mm long edges resting on HP on one of its corner with a solid diagonal perpendicular to VP.	20	CO2	L3
7.	A square pyramid, base 38 mm side and axis 50 mm long is freely suspended from one of the corners of its base. Draw its projections, when a vertical plane makes an angle of 450 with the VP.	20	CO2	L3
8.	A cone of base diameter 40mm & axis 60mm has its generator on HP. A plane containing that generator & the axis is perpendicular to HP & inclined at 45o to VP. Draw the projections when the base is nearer to VP.	20	CO2	L3
9.	A pentagonal pyramid, height 60mm and base edge 30mm is lying on one of the long edges on HP, which is inclined at 40° with XY in Top View (or a plane containing the axis & the slant edge on which the solid rests makes an angle of 40° with VP). Draw the projections.	20	CO2	L3
10.	A pentagonal pyramid of 30mm base side axis 60mm long is resting on an edge of its base on the ground so that highest point of the base is 20mm above ground. Draw its projections if the vertical plane containing the axis is inclined at 30° to VP.	20	CO2	L3

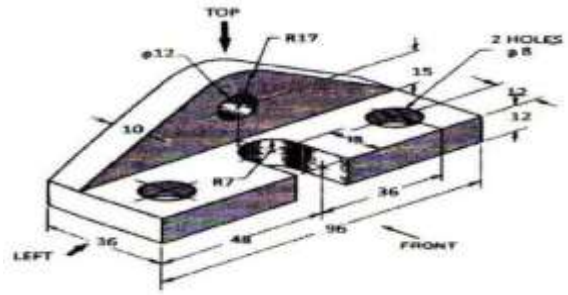
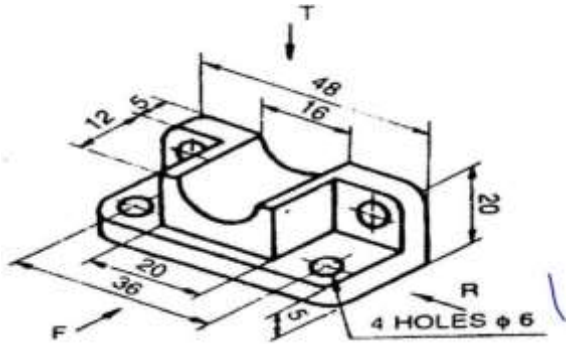
11.	A hexagonal prism base 20 mm side and axis 40 mm long is placed with one of its base edges on the HP such that the axis is inclined at 30^o to HP and 45o to VP. Draw the projections of the prism	20	CO2	L3
12.	A cone of base diameter 50 mm and axis length 60 mm is resting on VP on one of its generators with the front view of the axis inclined at 40^o to HP. Draw its projections.	20	CO2	L3
Module 3				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1.	A cube of 35 mm long edges is resting on the HP on one of its faces with a vertical face inclined at 30^0 to the VP. Its cut by a section plane parallel to VP and 9 mm away from the axis and further away from the VP. Draw the sectional front view and the top view	20	CO3	L3
2.	A cylinder of 60 mm height and having its axis vertical is cut by a section plane, perpendicular to the VP, inclined at 45^0 to the HP and intersecting the axis 32 mm above the base. Draw its front view, sectional top view and true shape of the section.	20	CO3	L3
3.	A hexagonal prism base edge 30 mm and height 60 mm rests on HP with a base edge inclined at 15^0 to the VP. It is cut by a cutting plane perpendicular to VP and inclined at 40^0 to the HP and bisecting the axis. Draw the sectional FV and sectional TV and the true shape of the section	20	CO3	L3
4.	A cone, base 75 mm dia and axis 80 mm long is resting on the HP and cutting the axis at a point 35 mm from the apex. Draw its front view, sectional top view and true shape of the section.	20	CO3	L3
5.	A cone of base diameter 60 mm, standing upright is cut by a section plane such that the true shape is a parabola whose double ordinate is 50 mm and abscissa is 70 mm. Draw the front view, top view and the true shape of the section.	20	CO3	L3
6.	A square pyramid of base 50 mm and height 70 mm is rest on its base on HP. It is cut by a sectional plane perpendicular to VP and inclined to HP. The true shape of the section is a trapezium are 40 mm and 30 mm respectively. Draw the sectional view, top view. Find the angle of inclination of section plane.	20	CO3	L3
7.	A hexagonal prism, edge of base 20 mm and axis 50 mm long, rests with its base on HP, such that one of its rectangular faces is parallel to VP. Its cut by a plane perpendicular to VP inclined at 20450 to HP and passing through the right corner of the top face of the prism. Develop the lateral surface of the truncated prism.	20	CO3	L3
8.	A cube of 40 mm edge stands on one of its faces on HP with a vertical face making 450 to VP. A horizontal hole of 30 mm diameter is drilled centrally through the cube such that the hole passes through the opposite vertical edges of the cube. Obtain the development of the lateral surface of the cube with the hole.	20	CO3	L3
9.	A right regular pentagonal prism edge of base 25 mm and height 64 mm rests on its base with one of its edges perpendicular to VP. An ant moves from the bottom corner to the diagonally opposite corner lying in a vertical face perpendicular to VP. Draw the development	20	CO3	L3

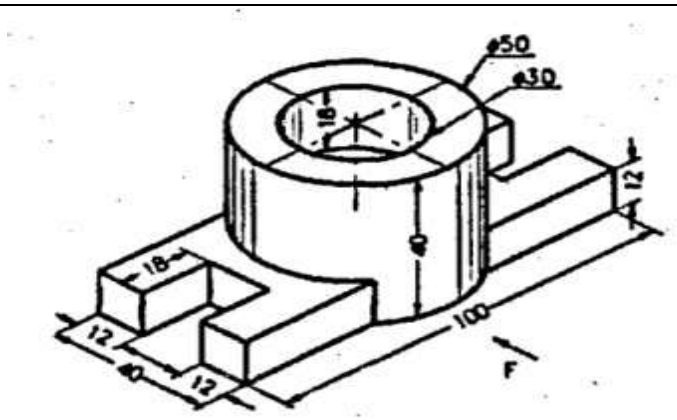
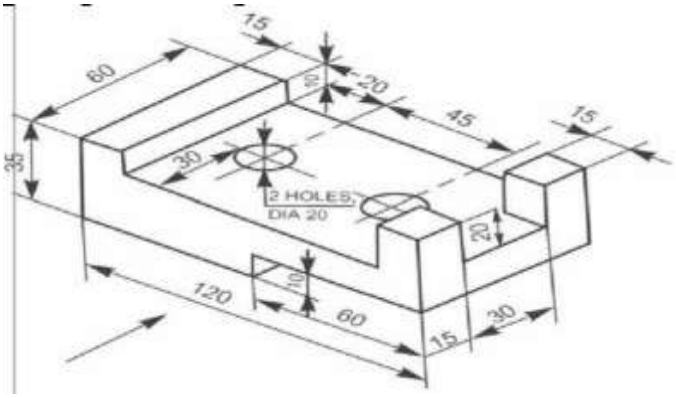
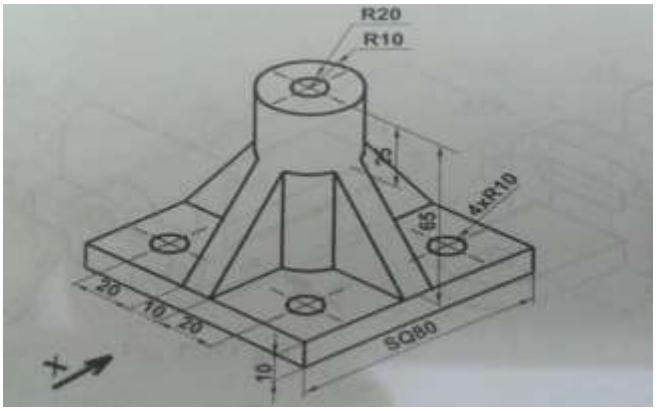
	of the surface and mark the path of the ant in elevation. Also compare the distance moved by the ant in the clockwise and anticlockwise direction of rotation.			
10.	A cone of base 50 mm diameter and 60 mm height rests with its base on HP. Its cut by a section plane perpendicular to VP, parallel to one of the generators and passing through a point on the axis at a distance of 22 mm from the apex. Draw the sectional top view and develop the lateral surface of the remaining portion of the cone.	20	CO3	L3

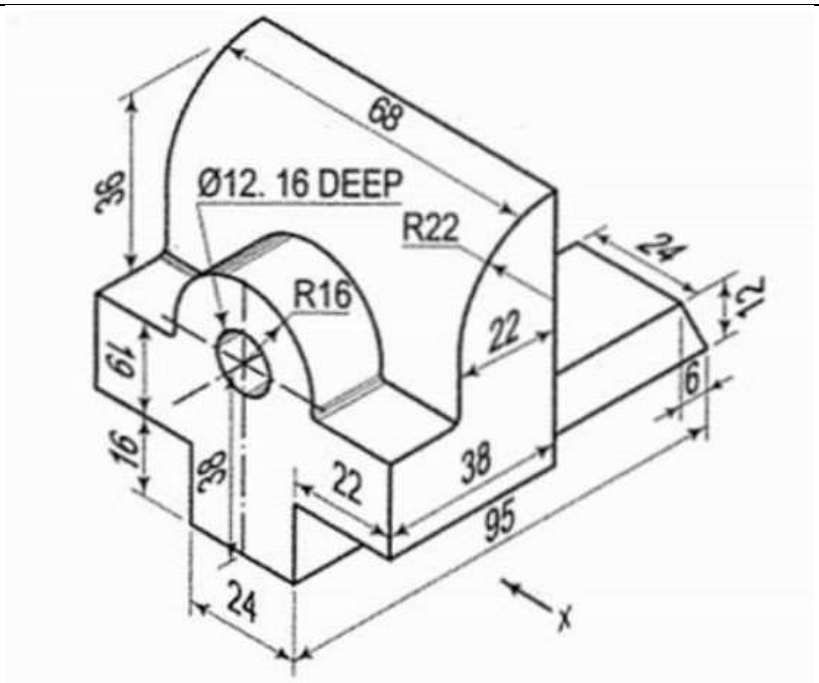
11.	The vertical section of a right circular cone through the axis is an isosceles triangle of 50 mm base and 60 mm height. A fly sits on the extreme left end of the base and walks around the surface of the cone and returns to the starting point. Find geometrically the length of the shortest path the fly can take, show the path in the front and top view.	20	CO3	L3
12.	A monument in the form of a frustum of a square pyramid of base 1.2 m side, top 0.5 m side and height 1 m. An electrical connection is to be made along the surface of this monument between one corner of the base and diagonally opposite corner on the top. Find the shortest length of the wire required and show the position of the wire in the top and front views.	20	CO3	L3
13.	A hexagonal pyramid, side of base 25 mm and altitude 70 mm long, rests with its base on HP with two of its base sides parallel to VP. It is cut by a section plane perpendicular to VP, inclined at 45^{o} to HP and passing through the axis 15mm from the base. Draw the sectional top view and true shape of the section.	20	CO3	L3
14.	A pentagonal pyramid, side of base 50 mm and height 80 mm rests on its base on the ground with one of its base sides parallel to VP. A section plane perpendicular to VP and inclined at 30o to HP cuts the pyramid, bisecting its axis. Draw the development of the truncated pyramid.		CO3	L3
Module 4				
Sl. No.	**Question**		CO	BL
1.	Draw the isometric projection view of a rectangular prism of base 50 mm x 40 mm and height 75 mm, when its rests with its base on HP and one of its rectangular faces is parallel to VP.	20	CO4	L3
2.	Draw the isometric view/ projection of a hexagonal prism side of base 25 mm and height 60 mm lying on HP with one of its rectangular faces parallel to VP.	20	CO4	L3
3.	A pentagonal pyramid, base 30 mm and axis 65 mm long, rests with its base on HP. An edge of base is parallel to VP and nearer to it. A horizontal section plane cuts the pyramid and passes through a point on the axis at a distance of 25 mm from the apex. Draw the	20	CO4	L3

	isometric view/ projection of the frustum of pyramid.			
4.	A hexagonal prism, side of base 25 mm and height 50 mm rests on HP and one of the edges of its base is parallel to VP. A section plane perpendicular to VP and inclined at 50^0 to HP bisects the axis of the prism. Draw the isometric view/ projection of the prism, showing the cut surface.	20	CO4	L3
5.	Draw the isometric view/ projection of the bottom portion of the cone of base dia 50 mm and height 80 mm resting on its base in the HP and axis parallel to VP, when its cut by a cutting plane perpendicular to VP and inclined at 30^0 to HP. The cutting plane cuts the axis at 40 mm above its base.	20	CO4	L3

6.	A square pyramid side of base 35 mm and height 70 mm is resting on the HP with the side of base equally inclined to VP. Its cut by an inclined plane perpendicular to the VP and inclined at 30^0 to the HP, through the mid-point of the vertical axis. Draw the projection of the truncated pyramid.	20	CO4	L3
7	A sphere of radius 15 mm is resting centrally on the top surface of a square plate of side 50 mm and of negligible thickness. Draw the isometric projection and view.	20	CO4	L3
8.	Draw the isometric view and projection of a hollow hexagonal prism edge of base 30 mm and height 60 mm, having a through circular hole of diameter 30 mm. The hole is drilled centrally along the axis of the hexagonal prism.	20	CO4	L3
9.	A hexagonal based prism of base edge 30 mm and axis height 80 mm is resting with one of its rectangular faces on HP. A cylinder of dia 30 mm and height 40 mm rests centrally with its base on the top of the rectangular face of the prism. Draw the 2isometric view/ projection for the combination of solids	20	CO4	L3
10.	A hemisphere of dia 80 mm is resting on the ground with its flat surface facing upwards. A square pyramid having side of base 40 mm and axis 60 mm is resting on its base centrally on the top of the hemisphere. Draw the isometric view/ projection of the combinations of the solid.	20	CO4	L3
11.	A square pyramid of base edge 20 mm and height 40 mm is mounted centrally on a face of a cube of base edge 50 mm. Draw the isometric projection of the objects.	20	CO4	L3
12.	Draw the isometric projections of a hexagonal prism with edge of base 30 mm and axis 60 mm when it rests on a rectangular face on the ground.	20	CO4	L3
Module 5				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1.	A square prism of side 30 mm & height 60 mm is resting on its face on G.P with axis perpendicular to P.P in such a way that the nearest base is parallel to & 10 mm behind the P.P. The S.P is 80 mm to the right of the axis of the solid; 50 mm above G.P; 25 mm in -front	20	CO4	L3

	of P.P. Draw the perspective view.			
2.	A platform of a stage 70*50*30 in size with the nearest vertical edge in the P.P. The longest face containing that edge is inclined 60 degree to the P.P. The S.P is contained in a C.P. passing through 25 mm to the right of the nearest corner. Draw the perspective view of the stage if the station point is 45 mm above G.P and 40 mm in-front of P.P?	20	CO4	L3
3.	Draw the perspective projection of a pentagonal prism of side 25 mm and length 50 mm, lying on one of its rectangular faces on the ground plane and one pentagonal face touching the picture plane . The station point is 55 mm in front of the picture plane and lies in the central plane which is 75 mm to the left of the centre of the prism. Station point is 30 mm above the ground plane.	20	CO4	L3
4.	A square prism of base edge 30 mm and height 60 mm is resting on a face with the axis inclined at 300 with PP and the centre of the nearest base in the PP, SP is 30 mm infront of the PP, 5 mm to the right of the mid-point of the axis and 50 mm above GP. Draw the perspective view of the prism.	20	CO4	L3
5.	Draw the perspective projection of a pentagonal prism of side 25 mm & length 50 mm lying on one of its rectangular face on G.P. & one end face touching P.P. The S.P is 55 mm in-front of P.P & lies in a C.P which is 65 mm to the left of the centre of the prism .The S.P is 30 mm above G.P.	20	CO4	L3
6.	Draw front view, top view and profile view. 	20	CO5	L3
7.	Draw front view, top view and profile view. 	20	CO5	L3
8.	Draw front view, top view and profile view.	20	CO5	L3

				
9.	Draw front view, top view and profile view. 	20	CO5	L3
10.	Draw front view, top view and profile view. 	20	CO5	L3
11.	A square pyramid of base side 30 mm and height 45 mm is resting on the ground plane. The nearest edge of the base is parallel to and 20 mm behind the Picture Plane (PP). The station point is situated at a distance of 70 mm in front of the PP, 40 mm to the right of the axis of the pyramid, and 60 mm above the ground. Draw the perspective view of the pyramid.	20	CO5	L3
12.	Draw the front view, top view, and side view of the object given below. Front view should be drawn as seen in the direction of the arrow X.	20	CO5	L3

Prepared By: Prof. Jaison Joseph

Checked By: Prof. Jaison Joseph (Course Committee Convener)

Approved By: Prof. Ramadas T.(Course Committee Chairperson)

Course Code & Name: EST 120, Basics of Civil and Mechanical Engineering

1. Prescribed Syllabus

Module	Topic	Hours
1	General Introduction to Civil Engineering: Relevance of Civil Engineering in the overall infrastructural development of the country. Responsibility of an engineer in ensuring the safety of built environment. Brief introduction to major disciplines of Civil Engineering like Transportation Engineering, Structural Engineering, Geo-technical Engineering, Water Resources Engineering and Environmental Engineering. Introduction to buildings: Types of buildings, selection of site for buildings, components of a residential building and their functions. Building rules and regulations: Relevance of NBC, KBR & CRZ norms (brief discussion only). Building area: Plinth area, built up area, floor area, carpet area and floor area ratio for a building as per KBR.	**6**
2	Surveying: Importance, objectives and principles. Construction materials, Conventional construction materials: types, properties and uses of building materials: bricks, stones, cement, sand and timber Cement concrete: Constituent materials, properties and types. Steel: Steel sections and steel reinforcements, types and uses. Modern construction materials:- Architectural glass, ceramics, Plastics, composite materials, thermal and acoustic insulating materials, decorative panels, waterproofing materials. Modern uses of gypsum, pre-fabricated building components (brief discussion only).	**7**
3	Building Construction: Foundations: Bearing capacity of soil (definition only), functions of foundations, types – shallow and deep (brief discussion only). Load bearing and framed structures (concept only). Brick masonry: - Header and stretcher bond, English bond & Flemish bond random rubble masonry. Roofs and floors: - Functions, types; flooring materials (brief discussion only). Basic infrastructure services: MEP, HVAC, elevators, escalators and ramps (Civil Engineering aspects only), fire safety for buildings. Green buildings:- Materials, energy systems, water management and environment for green buildings. (brief discussion only).	**7**
5	Refrigeration: Unit of refrigeration, reversed Carnot cycle, COP, vapour compression cycle (only description and no problems); Definitions of dry, wet & dew point temperatures, specific humidity and relative humidity, Cooling and dehumidification, Layout of unit and central air conditioners. Description about working with sketches of: Reciprocating pump, Centrifugal pump,	**7**

	Pelton turbine, Francis turbine and Kaplan turbine. Overall efficiency, Problems on calculation of input and output power of pumps and turbines (No velocity triangles) Description about working with sketches of: Belt and Chain drives, Gear and Gear trains, Single plate clutches.	
6	Manufacturing Process: Basic description of the manufacturing processes – Sand Casting, Forging, Rolling, Extrusion and their applications. Metal Joining Processes: List types of welding, Description with sketches of Arc Welding, Soldering and Brazing and their applications Basic Machining operations: Turning, Drilling, Milling and Grinding. Description about working with block diagram of: Lathe, Drilling machine, Milling machine, CNC Machine. Principle of CAD/CAM, Rapid and Additive manufacturing	**6**

2. Text Books (T)

T1. Chudley, R., Construction Technology, Vol. I to IV, Longman Group, England

T2. Chudley, R. and Greeno, R., Building Construction Handbook, Addison Wesley, Longman Group, England

T3. Gopi, S., Basic Civil Engineering, Pearson Publishers

T4. Kandya, A. A., Elements of Civil Engineering, Charotar Publishing house

T5. Mamlouk, M. S., and Zaniewski, J. P., Materials for Civil and Construction Engineering, Pearson Publishers

T6. Shibu Nalpat, Basic Civil Engineering, Nalpat Publishers

T7. B. C. Punmia, Basic Civil Engineering, Khanna Publications

T8. Balachandran, Basic Mechanical Engineering, Owl Books

T9. Benjamin, J., Basic Mechanical Engineering, Pentex Books

3. Reference Books (R)

R1. McKay, W. B. and McKay, J. K., Building Construction Volumes 1 to 4, Pearson India Education Services

R2. Minu, S., Basic Civil Engineering, Karunya Publications

R3. Rangwala, S. C., Essentials of Civil Engineering, Charotar Publishing House

R4. Rangwala, S. C. and Dalal, K. B., Engineering Materials, Charotar Publishing house

R5. Rangwala, S. C. and Dalal, K. B., Building Construction, Charotar Publishing house

R6. Kerala Municipal Building Rules – 1999

R7. B. C. Punmia, Surveying Vol. 1, Laxmi Publications

R8. T.P Kanetkar, S.V Kulkarni, Surveying and levelling Part-I, Vidyarthi Griha Prakashan

R9. Clifford, M., Simmons, K. and Shipway, P., An Introduction to Mechanical Engineering

R10. Roy and Choudhary, Elements of Mechanical Engineering, Media Promoters &Publishers Pvt. Ltd., Mumbai.

R11. Sawhney, G. S., Fundamentals of Mechanical Engineering, PHI

R12. G Shanmugam, M S Palanichamy, Basic Civil and Mechanical Engineering, McGraw Hill

4. Course Objectives

Objective of this course is to provide an insight and inculcate the essentials of Civil and Mechanical Engineering discipline to the students of all branches of Engineering and to provide the students an illustration of the significance of the Civil and Mechanical Engineering Profession in satisfying the societal needs.

5. Course Pre / Co-requisite

Nil

6. Course Outcomes

After completion of the course, student will be able to

CO1: Recall the role of civil engineer in society and to relate the various disciplines of Civil Engineering.

CO2: Explain different types of buildings, building components, building materials and building construction.

CO3: Describe the importance, objectives and principles of surveying.

CO4: Summarise the basic infrastructure services MEP, HVAC, elevators, escalators and Ramps.

CO5: Discuss the Materials, energy systems, water management and environment for green buildings.

CO6: Analyse thermodynamic cycles and calculate its efficiency

CO7: Illustrate the working and features of IC Engines

CO8: Explain the basic principles of Refrigeration and Air Conditioning

CO9: Describe the working of hydraulic machines

CO10: Explain the working of power transmission elements.

CO11: Describe the basic manufacturing, metal joining and machining processes

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2	PS O3
CO1	**H**					**H**	**M**	**M**							
CO2	**H**	**M**		**L**	**H**			**H**							
CO3	**H**	**M**			**H**				**M**						
CO4	**H**	**M**			**H**				**M**						
CO5	**H**	**M**			**H**	**M**	**H**		**M**						
CO6	**H**	**M**													
CO7	**H**	**L**													
CO8	**H**	**L**													
CO9	**H**	**M**													
CO1 0	**H**	**L**													
CO1 1	**H**														

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification

CO1	PO1	Knowledge on fundamentals aspects of civil engineering science will help students to solve Engineering problems in future.
	PO6	Understanding the role of engineer will help students to assess safety and legal issues in professional engineering practices.
	PO7	Knowledge about the responsibilities of an engineer will help students to develop solutions for sustainable development.
	PO8	Understanding the responsibility of an engineer will enable students to apply ethical principles in the engineering practices.
CO2	PO1	Knowledge about building construction will enable students to solve simple civil engineering problems
	PO2	Understanding the components and construction materials used in a building will enable students to analyse problems related with building construction.
	PO4	Knowledge about building materials will help students to develop valid conclusion for engineering problems in building construction.
	PO5	Knowledge on building materials will enable students to identify appropriate materials/resources adopted for the sustainable development.
	PO8	Knowledge on building rules and regulations will enable students to apply ethical principles in engineering practices.
CO3	PO1	Understanding the principles of Surveying will enable students to solve problems in the field of surveying.
	PO2	Understanding surveying principles will help students to analyse simple surveying problems.
	PO5	Knowledge on the principle of surveying will enable the students to select and apply appropriate method for solve real field problems.
	PO9	Knowledge on the principle of surveying will help the students to function effectively as an individual in multidisciplinary settings.
CO4	PO1	Knowledge about basic infrastructure services will enable students to apply in real field situations.
	PO2	Understanding the basic infrastructure services will enable students to analyse the use of this services in the construction.
	PO5	Knowledge on basic infrastructure services will help the students to select appropriate service.
	PO9	Knowledge on basic infrastructure services will help the students to function effectively as an individual in multidisciplinary settings.
CO5	PO1	Knowledge about green buildings will enable students to apply in real field situations.
	PO2	Understanding the concepts of green building will enable students to identify energy efficient materials and construction methods.
	PO5	Knowledge on the concepts of green building will help the students to select appropriate energy efficient services in the building construction.
	PO6	Insight on the concepts of green buildings will help the students to apply appropriate techniques and methods for an economical construction.
	PO7	Knowledge about green buildings will enable the students to apply the concept for a sustainable construction.
	PO9	Knowledge on the concepts of green buildings will help the students to function effectively as an individual in multidisciplinary settings.

CO6	PO1: Acquiring knowledge to solve engineering problems related to thermodynamic cycle and process enables the students to find solutions to engineering problems PO2: Acquiring knowledge to solve engineering problems related to thermodynamic cycle and process enables the students to conduct literature review, formulate and analyse complex engineering problems
CO7	PO1: Knowledge acquired in principles Energy conversion devices like IC engine enables the students to find solutions to engineering problems. PO2: Acquiring knowledge to solve engineering problems related to IC engine enables the students to conduct literature review, formulate and analyse complex engineering problems
CO8	PO1: Knowledge acquired in principles of refrigeration and air conditioning enables students to apply engineering specialisation for the solution of complex engineering problems. PO2: Acquiring knowledge to solve engineering problems related to principles of refrigeration and air conditioning enables the students to conduct literature review, formulate and analyse complex engineering problems
CO9	PO1: Knowledge acquired in principles Energy conversion devices like hydraulic machines enables the students to find solutions to engineering problems. PO2: Acquiring knowledge to solve engineering problems related to hydraulic machines enables the students to conduct literature review, formulate and analyse complex engineering problems
CO10	PO1: Knowledge acquired in principles power devices enables the students to find solutions to engineering problems. PO2: Acquiring knowledge to solve engineering problems related to principles power devices enables the students to conduct literature review, formulate and analyse complex engineering problems
CO11	PO1: Awareness about basic understanding of to select different manufacturing process enables students to apply these fundamental knowledge for the solution of complex engineering problems.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	Nil(Civil)		
2	Basics theories and definitions in Thermodynamics(Mechanical)	Additional Classes	PO1

11. Internal Assessment mark allocation (as per university curriculum)

(Provide details as mentioned in syllabus)

Attendance - 10 marks

Continuous Assessment Test- 25 marks

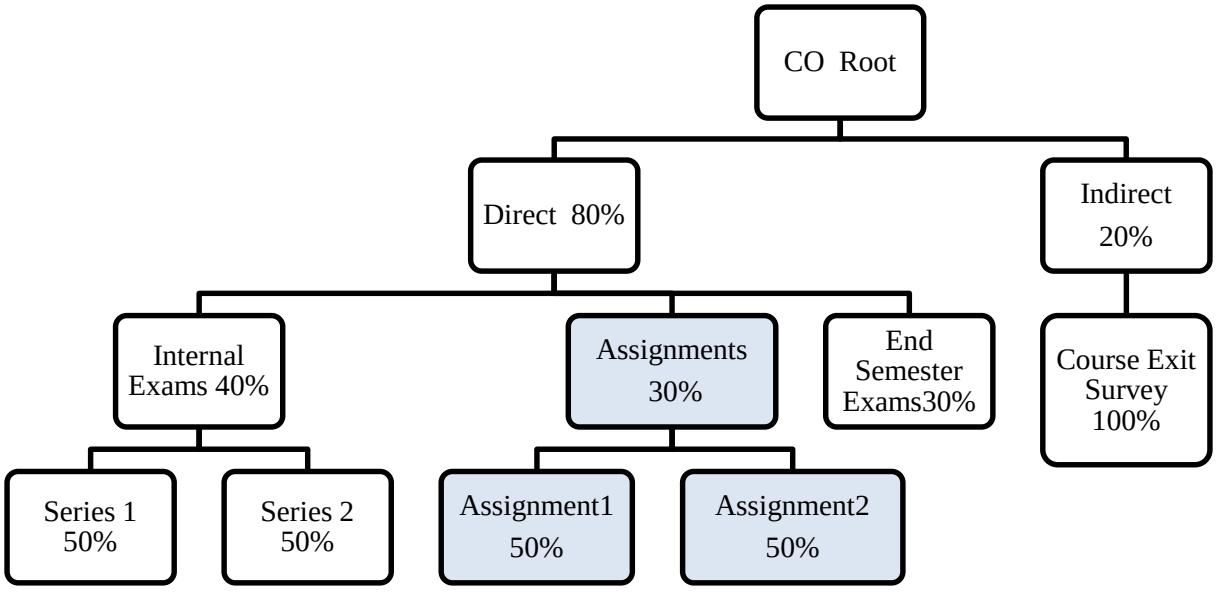
Assignment (s)/ Course Project- 15 marks

Total- 50marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		**Weightage#**	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**	**CO7**	**CO8**	**CO9**	**CO10**	**CO11**
Direct Assessment Tools**	Internal Exam(s) 25%	Series 1	12.5%	x	x	x			x	x				
		Series 2	12.5%		x		x	x			x	X	x	
	Assignment (s)/ Course Project /Quiz etc. 15%	Assignment 1	7.5%	x		x				x		X		
		Assignment 2	7.5%		x		x	x					x	X
	Attendance		10%	x	x	x	x	x						
	End Semester Exam		30%	x	x	x	x	x	x	x		X	x	X
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x	x	x		X	x	X

13. Assessment Configuration



14. Course Plan

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1	**General Introduction to Civil Engineering** Role and relevance of Civil Engineering in infrastructural development	1	T1	Lecture
2	Responsibilities of Civil Engineers in ensuring safety of structures	1	T1	Lecture
3	Major disciplines: Transportation, Structural, Geotechnical, Water Resources, Environmental Engineering	1	T1	Lecture
4	Buildings – types, site selection, components of residential buildings	1	T1	Lecture
5	Building rules and regulations – NBC, KBR, CRZ (brief)	1	T1	Lecture
6	Building area definitions – plinth, built-up, floor, carpet, FAR	1	T1	Lecture
7	Surveying: objectives, importance, principles	2	T1	Lecture
8	Conventional materials: bricks, stones, cement, sand, timber, types	2	T1	Lecture
9	Cement concrete – materials, properties,	2	T1	Lecture
10	Steel sections and reinforcements	2	T1	Lecture
11	Modern materials: glass, ceramics, plastics, composites, insulation, waterproofing, gypsum, prefabricated components	2	T1	Lecture
12	Foundations: bearing capacity (definition), functions, types – shallow & deep	3	T1	Lecture
13	Load-bearing vs framed structures	3	T1	Lecture
14	Masonry: header, stretcher, English, Flemish bonds; rubble masonry	3	T1	Lecture
15	Roofs and floors: functions, types, flooring	3	T1	Lecture
16	Infrastructure services: MEP, HVAC, elevators, ramps, fire safety	3	T1	Lecture
17	Green buildings: materials, energy systems, water management, environment	3	T1	Lecture

18	Carnot, Otto, Diesel cycles – derivation of efficiency	4	T1	Lecture
19	Problems on heat added, heat rejected, work done, efficiency	4	T1	Lecture
20	IC Engines – SI, CI, 2-Stroke, 4-Stroke	4	T1	Lecture
21	Engine parts and functions	4	T1	Lecture
22	Efficiencies (definitions only)	4	T1	Lecture
23	Air, fuel, cooling and lubrication systems	4	T1	Lecture
24	CRDI, MPFI and hybrid engines	4	T1	Lecture
25	Unit of refrigeration, reversed Carnot cycle	5	T1	Lecture
26	Vapour compression cycle – description	5	T1	Lecture
27	Air properties – dry/wet/dew point temp, humidity, cooling & dehumidification	5	T1	Lecture
28	Layout of unit and central A/C systems	5	T1	Lecture
29	Working of pumps (reciprocating, centrifugal), turbines (Pelton, Francis, Kaplan)	5	T1	Lecture
30	Efficiency, input-output power problems	5	T1	Lecture
31	Drives: belt, chain, gears, single plate clutch	5	T1	Lecture
32	Basic manufacturing methods – sand casting, forging, rolling, extrusion	6	T1	Lecture
33	Metal joining – welding, soldering, brazing (with sketches)	6	T1	Lecture
34	Machining operations – turning, drilling, milling, grinding	6	T1	Lecture
35	Working (block diagrams) – lathe, drilling, milling, CNC machine	6	T1	Lecture
36	Principles of CAD/CAM	6	T1	Lecture
37	Rapid and additive manufacturing	6	T1	Lecture

15. Question Bank

Module 1				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	Explain the relevance of civil engineering in the infrastructure development of the country.	**4**	**CO1**	**L2**
2	List the role of civil engineers in infrastructure development of the country	**4**	**CO1**	**L1**
3	List the responsibilities of an engineer in ensuring the safety of built environment	**4**	**CO1**	**L1**
4	List the various disciplines of civil engineering.	**4**	**CO1**	**L1**
5	List the factors to be considered in the site selection for buildings.	**4**	**CO2**	**L1**
6	Discuss about Group A and Group C buildings as per NBC.	**4**	**CO2**	**L2**
7	Discuss the role of a civil engineer in the infra structural development of a country.	**4**	**CO1**	**L2**
8	Discuss about the minimum size requirements of rooms for a residential building as per NBC.	**4**	**CO2**	**L2**
9	Explain any two major disciplines of civil engineering.	**4**	**CO1**	**L2**
10	Recall the functions of (a) lintels, (b) sunshades and (c) walls in a building.	**4**	**CO2**	**L1**
11	Differentiate between floor area and carpet area.	**4**	**CO2**	**L2**
12	Explain about Kerala building rules and its importance	**5**	**CO2**	**L2**
13	Explain the role of NBC, KBR, CRZ norms in building rules and regulations prevailing in our country.	**5**	**CO2**	**L2**
14	Explain the classification of buildings as per NBC.	**5**	**CO2**	**L2**
15	Explain coastal regulation zone and its classifications.	**5**	**CO2**	**L2**
16	Distinguish between plinth area and carpet area.	**5**	**CO2**	**L2**
17	Explain the term FAR/FSI.	**5**	**CO2**	**L2**
18	Discuss the requisites of a good site plan for a building.	**5**	**CO1**	**L2**
19	List out any five major factors to be considered for the selection of a good site for a residential building.	**5**	**CO1**	**L2**

20	Explain the classification of buildings as per occupancy according to National building code.	**5**	**CO1**	**L2**
21	Explain the components of residential building with neat sketch	**5**	**CO2**	**L2**
22	List out the different activities which are prohibited as per CRZ norms.	**6**	**CO1**	**L2**
23	Explain the different infrastructural facilities necessary for the development of country.	**6**	**CO1**	**L2**
24	With neat sketch explain the different components of a building.	**6**	**CO2**	**L2**
MODULE 2				
	Question	**Marks**	**CO**	**BL**
1	List the modern uses of gypsum	**4**	**CO2**	**L1**
2	List the uses of plastics in construction	**4**	**CO2**	**L1**
3	Explain different types of steel used in the construction and their properties.	**4**	**CO2**	**L2**
4	List the different kinds of cement used in the constructions and write the uses of it.	**4**	**CO2**	**L1**
5	List and explain any five modern construction materials used for constructions.	**4**	**CO2**	**L1**
6	List the properties of good building bricks. Explain any five.	**4**	**CO2**	**L1**
7	List the features of prefabricated construction	**4**	**CO2**	**L1**
8	List the qualities of a building stone.	**4**	**CO2**	**L1**
9	Discuss any four advantages of prefabricated building components.	**4**	**CO2**	**L2**
10	Explain the objectives and principles of surveying	**4**	**CO3**	**L2**
11	Explain the different classifications of timber.	**4**	**CO2**	**L1**
12	Explain the advantages and uses of rapid hardening cement .	**4**	**CO2**	**L2**
13	Illustrate the commercial forms of steels used in construction.	**5**	**CO2**	**L2**
14	Explain the advantages of RCC over PCC.	**5**	**CO2**	**L2**
15	Explain the common defects of timber.	**5**	**CO2**	**L2**

16	Explain the various tests conducted to ensuring the quality of bricks.	**5**	**CO2**	**L2**
17	Classify the different types of waterproofing methods	**5**	**CO2**	**L2**
18	Distinguish between thermal insulators and acoustic insulators	**5**	**CO2**	**L2**
19	List the major constituents of cement and explain its properties.	**5**	**CO2**	**L2**
20	Enumerate the properties and uses of first class bricks	**5**	**CO2**	**L2**
21	With sketches explain any five market forms of steel section and their uses.	**5**	**CO2**	**L2**
22	Explain the types and uses of architectural glass as a construction material.	**5**	**CO2**	**L2**
23	List out any five major qualities of a good timber.	**5**	**CO2**	**L1**
24	List out two uses of any five different types of cement.	**5**	**CO2**	**L1**
25	Explain the properties and uses of any two composite materials used in building construction	**6**	**CO2**	**L2**
26	Discuss about the primary classification of surveying.	**6**	**CO3**	**L2**
27	Explain the classification of survey based on instruments used.	**6**	**CO3**	**L2**
Module 3				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	Define bearing capacity of soil.	**4**	**CO2**	**L1**
2	Define stone masonry. List out the classifications of stone masonry.	**4**	**CO2**	**L1**
3	List the advantages of brick masonry over stone masonry.	**4**	**CO2**	**L1**
4	Define a) Pitch b) Ridge c) Wall plate d) Batten	**4**	**CO2**	**L1**
5	List the factors to be considered for the selection of a flooring material.	**4**	**CO2**	**L1**
6	List out the criteria for the selection of a good roofing material.	**4**	**CO2**	**L1**
7	List out any four acoustic insulation and thermal insulation materials.	**4**	**CO5**	**L1**
8	With neat sketch explain strap footing.	**4**	**CO2**	**L1**
9	List the different materials used in the construction of green building.	**4**	**CO5**	**L1**

10	Enlist the various aspects to be considered in fire safety of buildings?	**4**	**CO2**	**L1**
11	Distinguish between English bond and Flemish bond with neat sketch.	**5**	**CO2**	**L2**
12	Explain the following types of foundations with neat sketches (a) Isolated stepped footing (b) cantilever footing (c) continuous footing	**5**	**CO2**	**L2**
13	Explain the different types of floor and floor coverings.	**5**	**CO2**	**L2**
14	Explain the civil engineering aspects of elevators, escalators and ramps in building.	**5**	**CO4**	**L2**
15	Discuss the importance of fire safety in buildings.	**5**	**CO4**	**L2**
16	Explain the civil engineering aspects of HAVC and MEP in commercial buildings.	**5**	**CO4**	**L2**
17	Discuss the relevance and features of Green Buildings.	**5**	**CO5**	**L2**
18	Explain the energy systems and water management in green building.	**5**	**CO5**	**L2**
19	Draw the elevation and plan of one brick thick wall with English bond.	**5**	**CO2**	**L2**
20	With a neat sketch explain any two types of shallow foundation.	**5**	**CO2**	**L1**
21	With neat sketches compare English bond and Flemish bond.	**5**	**CO2**	**L2**
22	Explain the water management and energy management in green buildings.	**5**	**CO5**	**L2**
23	Explain the different types of roofs with sketches.	**5**	**CO2**	**L2**
24	With neat sketch explain king post roof truss.	**6**	**CO2**	**L2**
25	Explain the importance of green building? List out any four materials used in the construction of green building.	**6**	**CO5**	**L2**
26	Draw the plan and elevation of one brick thick wall with Flemish Bond.	**6**	**CO2**	**L2**

Module 4

Sl. No.	Question	Marks	CO	BL
1	**Explain the fuel system for petrol engines.**	**4**	**CO6**	**L1**
2	**Explain the working of Air Standard Carnot Cycle.**	**4**	**CO6**	**L1**
3	**Sketch a Diesel cycle on P-V and T-S diagram and explain.**	**4**	**CO6**	**L1**
4	**Draw the p-V diagram of a diesel cycle and define the terms (i) Compression ratio, (ii) Expansion ratio, and (iii) Cut-off ratio related to the Diesel cycle. (2019)**	**4**	**CO6**	**L1**

5	**Draw the p-V diagram of an Otto cycle and define the term Compression ratio.**	**4**	**CO6**	**L1**
6	**With the help of a block diagram explain the fuel system of CI engines.**	**4**	**CO6**	**L1**
7	**What is an automobile? Discuss the classification of automobiles.**	**4**	**CO7**	**L1**
8	**With the help of a block diagram explain the components of an automobile**	**4**	**CO7**	**L1**
9	**With the help of a neat sketch show the important parts of an internal Combustion engine. (2019)**	**4**	**CO7**	**L1**
10	**Give the concept of hybrid engines. (2019)**	**4**	**CO7**	**L1**
11	**Define (i) Brake thermal efficiency (ii) Indicated thermal efficiency (iii) Mechanical efficiency and (iv) Volumetric efficiency of an IC engine.**	**4**	**CO7**	**L1**
12	**With the help of a neat sketch show the important parts of an internal Combustion engine.**	**4**	**CO7**	**L1**
13	**Sketch and explain Ideal cycle for petrol engines.**	**4**	**CO6**	**L2**
14	**"No engine can be made to work on carnot cycle" Justify your answer.**	**4**	**CO6**	**L2**
15	**Why petrol engines are called as SI engines and diesel engines are called as CI engines?**	**4**	**CO6**	**L2**
16	**Why the compression ratio of petrol engine is low compared to diesel engines?**	**4**	**CO6**	**L3**
17	**Explain the fuel system of a petrol engine.**	**5**	**CO7**	**L1**
18	**Name the Air Standard cycle for Petrol engine. Explain with a neat PV diagram**	**5**	**CO6**	**L2**
19	**In a Diesel cycle the compression ratio is 13 and cut off occurs at 8% of the stroke. Find the air standard efficiency**	**5**	**CO6**	**L2**
20	**1 kg of air at temperature 15^0C and pressure 100 kPa is taken through a Diesel Cycle. The compression ratio is 15 and heat added is 1850 kJ. Calculate the ideal cycle efficiency.**	**5**	**CO6**	**L2**
21	**A Carnot engine, working between 650 K and 310 K, produces 150 kJ of work. Find thermal efficiency and heat added during the process.**	**5**	**CO6**	**L2**
22	**In an Otto cycle, at the beginning of the compression air is at 27^oC and 1 bar. The clearance volume is 20% of the swept volume. Find i) Air standard efficiency. ii) Temperature at the end of compression.**	**5**	**CO6**	**L3**
23	**In an ideal diesel cycle, the temperature at the beginning and end of the expansion is 1850^0C and 850^0C. Determine the ideal efficiency of the cycle. Take $\gamma = 1.4$. If compression**	**5**	**CO6**	**L3**

	ratio is 15 and pressure at the beginning is 1 bar, calculate the maximum pressure in the cycle.			
24	**Explain MPFI, CRDI and hybrid engines.**	**6**	**CO7**	**L1**
25	**Explain the MPFI system with block diagram. Also give its advantages (2019)**	**6**	**CO7**	**L2**
26	**1 kg of air at temperature of 15^0C and pressure of 100 kPa is taken through a Diesel cycle .The compression ratio is 15 and the heat added is 1850 KJ Calculate the ideal cycle efficiency?**	**8**	**CO6**	**L2**
27	**Explain the Carnot cycle with PV diagram and derive the expression for thermal efficiency.**	**10**	**CO6**	**L1**
28	**Describe briefly on working and constructional features ofa)Lubrication system of an engineb) Cooling system of an engine**	**10**	**CO7**	**L1**
29	**Explain the working of a 4 stroke SI engine with neat sketches**	**10**	**CO7**	**L1**
30	**Derive an expression for the air standard efficiency of a diesel cycle.**	**10**	**CO6**	**L2**
31	**Derive an expression for the air standard efficiency of Otto**	**10**	**CO6**	**L2**
32	**An engine operating on an air standard Otto cycle has a compression ratio equal to 7. The conditions at the start of compression are 0.1 MPa and 300K. The pressure at the end of heat addition is 4 MPa. Determine the thermal efficiency and network done where C_v = 0.718 kJ/ Kg and γ for air = 1.4.**	**10**	**CO6**	**L2**
33	**An engine operating on Carnot cycle between temperature limits 20oC and 800oC rejects heat at the rate 200 KJ/s. Determine (i) the ideal thermal efficiency of the cycle. (ii) Power output of the engine.**	**10**	**CO6**	**L2**
34	**In a constant volume Otto cycle, the pressure at the end of compression is 15 times that at the start, the temperature of air at the beginning of compression is 38^0C and the maximum temperature attained in the cycle is 1950^0C. Determine Compression ratio, thermal efficiency of the cycle and work done per kg of air. Take γ for air = 1.4.**	**10**	**CO6**	**L2**
35	**A Carnot cycle works with adiabatic compression ratio of 5 and isothermal expansion ratio of 2. The volume of air at the beginning of isothermal expansion is 0.3 m3. If the maximum temperature and pressure is limited to 550K and 21 bar, determine the minimum temperature in the cycle and efficiency of the cycle.**	**10**	**CO6**	**L2**
36	**A carnot engine operates between a source at 1000 K and a sink at 300K. If the engine is supplied with a heat at a rate of 800kJ/min, determine the thermal efficiency and power output of the engine.**	**10**	**CO6**	**L2**
37	**An engine working on Diesel cycle has diameter 150 mm and stroke 200 mm. The clearance volume is 10 % of the swept volume. Determine the compression ratio and air standard efficiency of the engine if the cut-off takes place at 6 % of the stroke.**	**10**	**CO6**	**L2**
38	**In an air standard Diesel cycle, the compression ratio is 16 and at the beginning of compression the temperature is 150C and the pressure is 0.1MPa. Heat is added until the temperature at the end of constant pressure process is**	**10**	**CO6**	**L2**

	14800C.Calculate (1)The cut off ratio(2)The heat supplied per kg of air(3)The cycle efficiency			
39	**Calculate the ideal air standard thermal efficiency based on the Otto cycle for a petrol engine with a cylinder bore of 50mm and stroke of 75 mm and a clearance volume of 21.3 cm^3.**	**10**	**CO6**	**L2**
40	**Differentiate the working of 4 stroke engine and 2 stroke engine.**	**10**	**CO7**	**L2**
41	**An engine working on Diesel cycle has diameter 150 mm and stroke 200mm. The clearance volume is 10 % of the swept volume. Determine the compression ratio and air standard efficiency of the engine if the cut-off takes place at 6 % of the stroke. (2019)**	**10**	**CO6**	**L3**
Module 5				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	**What are the different types of gears used in power transmission?**	**4**	**CO10**	**L1**
2	**Describe the working of a single plate clutch.**	**4**	**CO10**	**L1**
3	**Explain cooling and dehumidification process. Also show the process in psychrometric chart. (2019)**	**4**	**CO8**	**L1**
4	**Explain the split air conditioner and its working.**	**4**	**CO8**	**L1**
5	**Discuss the classification of hydraulic turbines.**	**4**	**CO9**	**L1**
6	**A centrifugal pump discharges water at a rate of 200 litres/minute against a head of 16 m when running at 300 rpm. Calculate the power required to run the pump if the overall efficiency of the pump is 50 %.**	**4**	**CO9**	**L2**
7	**Why gear drives are called positive drives, Whereas belt and rope drives are not considered positive?**	**4**	**CO10**	**L2**
8	**Explain a single plate clutch.**	**5**	**CO10**	**L1**
9	**Explain the gear terminology with neat sketch.**	**5**	**CO10**	**L1**
10	**Explain the open belt and cross belt drive in power transmission. Also give the applications. (2019)**	**5**	**CO10**	**L1**
11	**What are the desirable properties of refrigerants?**	**5**	**CO8**	**L1**
12	**Write short notes on: i)Psychrometric chart ii) Gear trains iii) Impact of refrigerants on environment**	**5**	**CO8**	**L1**
13	**Explain the reversed Carnot cycle with PV Diagram.**	**5**	**CO8**	**L1**
	with sketches			
15	**Distinguish between gear drive and belt drive system.**	**5**	**CO10**	**L2**
16	**Distinguish between open and closed belt drives.**	**5**	**CO10**	**L2**

17	**Illustrate the working of an epicyclic gear train**	**5**	**CO10**	**L2**
18	**Compare and contrast impulse and reaction turbines. (2019)**	**5**	**CO9**	**L2**
19	**Differentiate between reciprocating and centrifugal pumps.**	**5**	**CO9**	**L2**
20	**A turbine is to operate under a head of 25 m at 200 rpm. The discharge is 9 m3/s. If the overall efficiency of the turbine is 90%. Determine the power developed by the turbine.**	**5**	**CO9**	**L2**
21	**A centrifugal pump using 1kW of electric motor for pumping water against 3m suction head and 7m delivery head. The discharge of the pump is 100 litters /minute. Find the efficiency of pump.(2019)**	**5**	**CO9**	**L3**
22	**A turbine is working at a head of 250 m and the discharge through the penstock is 2 m3/ s. If the efficiency of the turbine is 55 %, find the power developed by the turbine. (2019)**	**5**	**CO9**	**L3**
23	**Define: COP, Ton of refrigeration, specific humidity, relative humidity, WPT and dew point temperature.**	**6**	**CO8**	**L1**
24	**Describe the working of a Kaplan turbine with a suitable sketch.**	**6**	**CO9**	**L1**
25	**With the help of suitable sketch explain the working of a Window Air Conditioner.**	**6**	**CO8**	**L2**
26	**Draw the schematic diagram of a summer air conditioning system and explain the processes involved in it.**	**6**	**CO8**	**L2**
27	**A Pelton turbine with a head of 450m generates 13 MW at 450rpm. Calculate discharge of the turbine if the overall efficiency is 80%.**	**6**	**CO9**	**L2**
28	**With the help of a neat sketch explain the working of a reciprocating pump**	**6**	**CO9**	**L2**
29	**Explain the working of belt drive and gear drive with the help of neat sketches.**	**10**	**CO10**	**L1**

30	**Sketch different types of gear trains and explain. (2019)**	**10**	**CO10**	**L1**
31	**Explain the working of vapour compression refrigeration system.**	**10**	**CO8**	**L1**
32	**With the help of a neat sketch explain the working of an air conditioning system for hot and humid outdoor conditions.**	**10**	**CO8**	**L1**
33	**Explain the working principle and construction features of Reciprocating pump.**	**10**	**CO9**	**L1**
Module 6				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	**How the welding processes are classified? List out the different types of welding methods.**	**4**	**CO11**	**L1**
2	**Explain the general procedure used in making a sand mould for the casting**	**4**	**CO11**	**L1**
3	**Describe the working of a cluster rolling mill giving a sketch.**	**4**	**CO11**	**L1**
4	**Define the terms Rapid prototyping and Additive manufacturing.**	**4**	**CO11**	**L1**
5	**Differentiate between up-milling and down-milling operations.**	**4**	**CO11**	**L2**
6	**Explain the functions of runners and risers used in casting.**	**4**	**CO11**	**L2**
7	**Explain the advantages and disadvantages of rapid manufacturing systems.**	**4**	**CO11**	**L2**
8	**Compare conventional machine tools and CNC machines.**	**4**	**CO11**	**L2**
9	**Compare welding, brazing and soldering.**	**5**	**CO11**	**L2**
10	**Explain the principle of Rapid manufacturing.**	**5**	**CO11**	**L2**
11	**Explain the principle of Additive manufacturing.**	**5**	**CO11**	**L2**

12	**Using a block diagram, explain components of a CNC machine.**	**5**	**CO11**	**L2**
13	**What are the important types of metal joining processes?**	**5**	**CO11**	**L2**
14	**What are the possible defects of sand casting process?**	**5**	**CO11**	**L2**
15	**Describe the basic manufacturing operations performed in a machine tool.**	**5**	**CO11**	**L2**
16	**Describe the arc welding process with a neat sketch. (2019)**	**6**	**CO11**	**L1**
17	**Describe the direct extrusion and indirect extrusion with sketches**	**6**	**CO11**	**L1**
18	**Explain the two high, three high, four high and cluster rolling mills with neat sketches.**	**10**	**CO11**	**L1**
19	**Describe the following terms: a. Rolling b. Extrusion c. Forging**	**10**	**CO11**	**L1**
20	**With a neat sketch, explain the working and parts of a lathe. List 5 operations performed in a lathe.**	**10**	**CO11**	**L1**
21	**With a neat sketch, explain the working and parts of a Drilling Machine.**	**10**	**CO11**	**L1**
22	**Describe the working of a Milling machine. Draw the block diagram of a Milling machine and indicate its main parts.**	**10**	**CO11**	**L1**
23	**Explain the working of a drilling machine with block diagram.**	**10**	**CO11**	**L1**
24	**Discuss any four operations that can be performed on a lathe with simple sketches.**	**10**	**CO11**	**L1**
25	**What is casting? With the help of a neat sketch explain the process of sand mould casting.**	**10**	**CO11**	**L1**
26	**Describe the operations which can be performed using drilling machine.**	**10**	**CO11**	**L2**

Prepared By : Mr. Jibin Jose, Course Faculty

Checked By: Mr. Arun V (Subject Group Coordinators)

Course Code & Name: HUN101 LIFE SKILLS

1. Prescribed Syllabus

Module	Topic	Hours
1	Overview of Life Skills: Meaning and significance of life skills, Life skills identified by WHO: Self-awareness, Empathy, Critical thinking, Creative thinking, Decision making, problem solving, Effective communication, interpersonal relationship, coping with stress, coping with emotion. Life skills for professionals: positive thinking, right attitude, attention to detail, having the big picture, learning skills, research skills, perseverance, setting goals and achieving them, helping others, leadership, motivation, self-motivation, and motivating others, personality development, IQ,EQ, and SQ	9
2	Self-awareness: definition, need for self-awareness; Coping with Stress and Emotions, Human Values, tools and techniques of SA: questionnaires, journaling, reflective questions, meditation, mindfulness, psychometric tests, feedback. Stress Management: Stress, reasons and effects, identifying stress, stress diaries, the four A's of stress management, techniques, Approaches: action-oriented, emotion-oriented, acceptance oriented, resilience, Gratitude Training, Coping with emotions: Identifying and managing emotions, harmful ways of dealing with emotions, PATH method and relaxation techniques.	10
3	21st century skills: Creativity, Critical Thinking, Collaboration, Problem Solving, Decision Making, Need for Creativity in the 21st century, Imagination, Intuition, Experience, Sources of Creativity, Lateral Thinking, Myths of creativity, Critical thinking Vs Creative thinking, Functions of Left Brain &Right brain, Convergent & Divergent Thinking, Critical reading & Multiple Intelligence. Steps in problem solving: Problem Solving Techniques, Six Thinking Hats, Mind Mapping, Forced Connections. Analytical Thinking, Numeric, symbolic, and graphic reasoning. Scientific temperament and Logical thinking.	9
4	Group and Team Dynamics: Introduction to Groups: Composition, formation, Cycle, thinking, Clarifying expectations, Problem Solving, Consensus, Dynamics techniques, Group vs Team, Team Dynamics, Virtual Teams. Managing team performance and managing conflicts, Intrapreneurship.	9
5	Leadership: Leadership framework, entrepreneurial and moral leadership, vision, cultural dimensions. Growing as a leader, turnaround leadership, managing diverse stakeholders, crisis management. Types of Leadership, Traits, Styles, VUCA Leadership, Levels of Leadership, Transactional vs Transformational Leaders, Leadership Grid, Effective Leaders.	8

2. Text Books (T)

Not prescribed

3. Reference Books (R)

1. English for Engineers and Technologists (Combined edition, Vol. 1 and 2), Orient Blackswan

2010.

2. Meenakshi Raman and Sangeetha Sharma,"Technical Communication: Principles and Practice", 2nd Edition, Oxford University Press, 2011

3. Stephen E. Lucas, "The Art of Public Speaking", 10th Edition; McGraw Hill Education, 2012.

3. Course Objectives

Clear, precise, and effective communication has become a sine qua non in today's information-driven world given its interdependencies and seamless connectivity. Any aspiring professional cannot but master the key elements of such communication. The objective of this course is to equip students with the necessary skills to listen, read, write, and speak so as to comprehend and successfully convey any idea, technical or otherwise, as well as give them the necessary polish to become persuasive communicators.

2. Course Pre / Co-requisite

None

3. Course Outcomes

Students will be able to:

CO 1: Define and Identify different life skills required in personal and professional life.
CO 2: Develop an awareness of the self and apply well-defined techniques to cope with emotions and stress.
CO 3: Explain the basic mechanics of effective communication and demonstrate these through presentations.
CO 4: Take part in group discussions
CO 5: Use appropriate thinking and problem solving techniques to solve new problems.
CO6: Understand the basics of teamwork and leadership.

4. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1						2		1	2	2	1	3			
CO2									3			2			
CO3						1			1	3					
CO4										3		1			
CO5		3	2	1											
CO6						1			3						

5. Justification for CO-PO-PSO Correlation

CO	PO/PSO	**Justification**
CO1	PO6	Identification of different life skills like Morals, values, empathy, professionalism etc; will enable to identify social issues and handle the responsibilities relevant for the engineering profession
	PO8	Learning the fundamental ethical principles like trustworthiness and honesty will help to commit themselves to professional ethics and responsibilities of engineering practice
	PO9	By understanding the importance of caring, sharing, cooperation and team work will help to perform better as an individual and also as a member in a team or groups.
	PO10	Knowledge of technical communication helps to communicate effectively with the engineering community through effective reports and presentations
	PSO11	By understanding the concepts like team performance management, it will be easy to analyse and manage the team as a leader or the member and improve the performance of the team.
	PO12	Learning, understanding and application of life skills helps to engage in lifelong learning which gives a broadest perspective of life.
CO2	PO9	Learning different techniques of stress management helps to work effectively in a group or team by handling various levels of stressful situations.
	PO12	Understanding the relevance of self-awareness helps the students recognize the need for life-long learning in the broadest context of technological knowledge.
CO3	PO6-	By leaning basic mechanics of communication helps to analyse various societal issues and discuss them through presentations.
	PO9-	effective communication will give immense opportunities to perform better in multidisciplinary teams as a member or a leader
	PO10	Effective communication skills helps to have elaborate discussions and presentations with the professional bodies regarding engineering concepts and various other related societal issues.
C04	PO10	By taking part in different group discussions, students will be able to communicate effectively with the engineering community and society at large and discuss about the problems and find out the solutions needed.
	PO12	By developing the capacity to effective participation in group

		discussions, enables to recognize the need for life-long learning in the broadest context of technological knowledge.
CO5	PO2	Concepts of mind mapping and six thinking Hats in problem solving will help the students to analyse and formulate different engineering problems from different dimensions
	PO3	By critical and creative thinking it is easy to design and develop solutions for complex engineering problems highlighting public health, safety and other societal issues
	PO4	Problem solving techniques helps to identify and choose various modern tools to apply in various engineering problems.
CO6	PO6	Being the part or being a leader of a team, helps to analyse and apply reasoning in various issues related to society.
	PO9	Understanding the importance of team dynamics will provide a better platform to perform effectively as a team member and leader as well.

6. Curricular gaps (if any)

Nil

7. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1			

** Proposed Actions: Webinar/Industry Visit/Expert talks /NPTEL/project/training etc.

* To better attain POs and PSOs and to bridge the gap between industry academia

8. Internal Assessment mark allocation (as per university curriculum)

(Provide details as mentioned in syllabus)

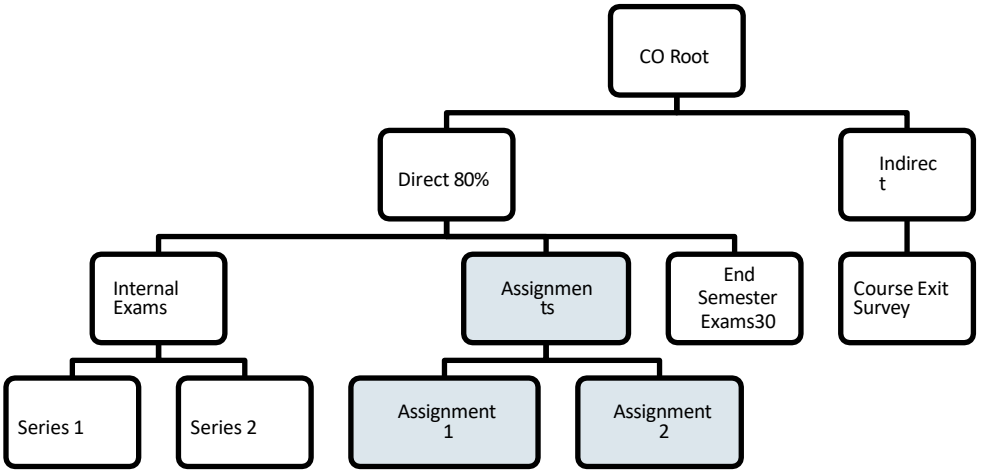
Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

9. Assessment – CO Mapping (Put ‘ x’ if mapping is present)

	Tools		Weightage#	CO1	CO2	CO3	CO4	CO5	CO6
Direct Assessment Tools**	Internal Exam(s) **40%**	Series 1	20%	x	x				
		Series 2	20%					x	x
	Assignment (s)/ Course Project /Quiz etc. **30%**	Assignment 1	15%		x	x	x		
		Assignment 2	15%			x	x		
	End Semester Exam		30%	x	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x	x

**Fill appropriate course specific Direct Assessment tools
Fill appropriate weights such that total weight for direct assessment tools is 100%

10. Assessment Configuration



11. Course Plan

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1	Meaning and significance of life skills	1	T1, T2, R1	Lecture
2	Life skills identified by WHO	1	T1, T2, R1	Lecture
3	Life skills for professionals	1	T1, T2, R1	Lecture
4	leadership, motivation, personality development	1	T1, T2, R1	Lecture
5	IQ,EQ, and SQ	1	T1, T2, R1	Lecture
6	Self-awareness: definition, need for self-awareness	2	T1, T2, R1	Lecture
7	Coping With Stress and Emotions, HumanValues, tools and techniques of SA	2	T1, T2, R1	Lecture
8	Effective communication	4	T1, T2, R1	Group Discussion
9	Stress Management: Stress, reasons and effects, identifying stress, stress diaries	2	T1, T2, R1	Lecture
10	Coping with emotions: Identifying and managing emotions, harmful ways of dealing with emotions, PATH method and relaxation techniques.	2	T1, T2, R1	Lecture
11	Introduction to presentations and group discussions	4	T1, T2, R1	Group Discussion
12	Morals, Values and Ethics	2	T1, T2, R1	Lecture
13	Integrity, Civic Virtue, Respect for Others, Living Peacefully	2	T1, T2, R1	Lecture
14	Caring, Sharing, Honesty, Courage, Valuing Time, Time management, Co operation, Commitment	2	T1, T2, R1	Lecture
15	Empathy, Self-Confidence, Character, Spirituality,	2	T1, T2, R1	Lecture

	Avoiding Procrastination, Sense of Engineering Ethics., Revision			
16	21st century skills: Creativity, Critical Thinking, Collaboration, Problem Solving, Decision Making,	3	T1, T2, R1	Lecture
17	Need for Creativity in the 21st century, Imagination, Intuition, Experience	3	T1, T2, R1	Lecture
18	Presentation skills	3	T1, T2, R1	Lecture
19	Sources of Creativity, Lateral Thinking, Myths of Creativity	3	T1, T2, R1	Lecture
20	Critical thinking Vs Creative thinking, Functions of Left Brain & Right brain, Convergent & Divergent Thinking	3	T1, T2, R1	Lecture
21	Critical reading & Multiple Intelligence.	4	T1, T2, R1	Lecture
22	Steps in problem solving: Problem Solving Techniques	4	T1, T2, R1	Lecture
23	Six Thinking Hats, Mind Mapping, Forced Connections	4	T1, T2, R1	Lecture
24	Analytical Thinking, Numeric, symbolic, and graphic Reasoning	4	T1, T2, R1	Lecture
25	Scientific temperament and Logical thinking	4	T1, T2, R1	Lecture
26	revision-module 3	4	T1, T2, R1	Group Discussion
27	Group and Team Dynamics	4	T1, T2, R1	Lecture
28	Composition, formation, Cycle, thinking	4	T1, T2, R1	Lecture
29	Clarifying expectations, Problem Solving, Consensus	4	T1, T2, R1	Lecture
30	Dynamics techniques, Group vs Team	5	T1, T2, R1	Lecture

31	Team Dynamics	5	T1, T2, R1	Lecture
32	Virtual Teams	5	T1, T2, R1	Lecture
33	Managing team performance and managing conflicts	5	T1, T2, R1	Lecture
34	Intrapreneurship.	5	T1, T2, R1	Lecture
35	revision-module 4	5	T1, T2, R1	Group Discussion
36	Leadership	5	T1, T2, R1	Lecture
37	Leadership framework, entrepreneurial and moral leadership	5	T1, T2, R1	Lecture
38	vision, cultural dimensions	4	T1, T2, R1	Group Discussion
39	Growing as a leader	5	T1, T2, R1	Lecture
40	turnaround leadership	5	T1, T2, R1	Lecture
41	managing diverse stakeholders, crisis management	5	T1, T2, R1	Lecture
42	Growing as a leader, turnaround leadership	3	T1, T2, R1	Lecture
43	Types of Leadership, Traits, Styles	3	T1, T2, R1	Lecture
44	Non-verbal Communication and Body Language	3	T1, T2, R1	Lecture
45	VUCA Leadership, Levels of Leadership	4	T1, T2, R1	Lecture
46	Transactional vs Transformational Leaders, Leadership Grid, Effective Leaders	4	T1, T2, R1	Lecture

12. Question Bank

MODULE 1				
SI.NO	**Question**	**Mark**	**CO**	**Bloom's Level**
1.	Define Life skills and list the Life skills defined by WHO	**5**	**CO1**	**L1**
2.	List out the 10 core life skills identified by World Health Organization	**5**	**CO1**	**L1**
3.	List out the major life skills identified by WHO and explain any four of them	**5**	**CO1**	**L1**
4.	Recall the core life skills as social, thinking and emotional skills	**5**	**CO1**	**L1**
5.	Identify the negative consequences of lacking major life skills	**5**	**CO1**	**L1**
6.	Define in your own words the 5 C's of effective communication	**5**	**CO1**	**L1**
7.	List out the major life skills required by a professional	**5**	**CO1**	**L1**
8.	List out the 10 skills important for a research scholar	**5**	**CO1**	**L1**
9.	State the importance of learning skills and research skills	**5**	**CO1**	**L1**
10	Define goal setting and explain the concept of S.M.A.R.T goal	**5**	**CO1**	**L1**
11	List out any five measures for pursuing goals	**5**	**CO1**	**L1**
12.	Define creative thinking and compare between Critical thinking and creative thinking.	**5**	**CO1**	**L1**
13.	Define the three types of human intelligence with examples	**5**	**CO1**	**L1**
14.	Briefly explain the importance of life skills in one's life	**5**	**CO1**	**L2**
15.	Explain the importance of communication skill and empathy in the social life of an individual.	**5**	**CO1**	**L2**
17.	Explain any 5 life skills that are necessary for a professional life	**5**	**CO1**	**L2**
18.	Briefly explain the idea of 'having bigger vision' and 'attention to detail'.	**5**	**CO1**	**L2**
19.	Explain the importance of Positive Attitude and ways to develop the same.	**5**	**CO1**	**L2**

20.	Explain the terms EQ , SQ and IQ	**5**	**CO1**	**L2**
21.	Explain the role life skills play in helping people achieve better results in both their personal and professional lives? Describe the Main Components of Life Skills?	**5**	**CO1**	**L2**
22.	Explain how life skills aid for the personality development of an individual	**5**	**CO1**	**L2**
23.	Identify the different types of communication.	**5**	**CO3**	**L1**
24	Identify the communication network structure that can be observed in the given situations. (a) A group discussion on development. (b) An address from the Principal regarding punctuality. (c) A reporter interviewing a movie star. (d) Discussing the answers of a test with a group of friends.	**5**	**CO3**	**L1**
25	Recall the differences between kinesics, proxemics, and chronemics with examples	**5**	**CO3**	**L1**
26	Define Effective Communication. Identify different types of communication networks.	**5**	**CO3**	**L1**
27	Explain the importance of non-verbal communication in making a presentation	**5**	**CO3**	**L2**
28	a) Explain the term 'Miscommunication'. b) Explain different barriers to communication.	**5**	**CO3**	**L2**
29	Briefly explain non-verbal communication and its importance.	**5**	**CO3**	**L2**
30	Explain the importance of communication in a multicultural environment.	**5**	**CO3**	**L2**

MODULE 2				
1	Define the term self-awareness and state its importance	5	CO2	L1
2	Identify various self-awareness tools.	5	CO2	L1
3	Identify how knowing about yourself helps in the overall development of a person	5	CO2	L1
4	a) Define stress and stressors b) list out the factors that causes stress	5	CO2	L1
5	Define stress diary and illustrate the basic format of a stress diary	5	CO2	L1
6	List few stress management techniques and explain them	5	CO2	L1
7 7	Define stress management and name few techniques of stress management	5	CO2	L1
8	Define stress management and three healthy ways to manage stress	5	CO2	L1
9	Define the term commitment and explain the three components of commitment proposed by Allen and Meyer	5	CO2	L1
10	Define the following skills with examples: a) coping with stress b) coping with emotions	5	CO2	L1
11	Identify the different types of harmful ways and healthy ways of dealing with emotions with examples	5	CO2	L1
12	List out and explain the harmful ways of dealing with negative emotions	5	CO2	L1
13	List the arguments raised against moral absolutism and moral relativism.	5	CO2	L1
14	Identify the common forms of unethical behaviour	5	CO2	L1
15	List out the measures to promote good work ethics	5	CO2	L1
16	Define the term ‘integrity’ and illustrate the different types of integrity	5	CO2	L1
17	Identify the categories of civic virtues	5	CO2	L1
18	Identify the different types of courage	5	CO2	L1
19	List the ways to improve self-confidence	5	CO2	L1

20	Explain the term ‘self-awareness’ and list out the ways of improving self-awareness	5	CO2	L2
21	Describe how journaling helps in developing self-awareness	5	CO2	L2
22	Explain 5 healthy ways to deal with stress.	5	CO2	L2
23	Explain the concepts of questionnaire, reflective questions and feedback with suitable examples	5	CO2	L2
24	Describe how mind relaxation techniques help in developing self awareness	5	CO2	L2
25	Explain the differences between internal stressors and external stressors with examples	5	CO2	L2
26	Describe the ways to identify stress	5	CO2	L2
27	Explain the four categories of symptoms of stress with at least two examples	5	CO2	L2
MODULE 3				
1	State the importance of creativity in thinking.	5	CO5	L1
2	Identify the skills that are relevant in 21st century.	5	CO5	L1
3	Define creativity and illustrate the three levels of creativity.	5	CO5	L1
4	Recall the differences between imagination and intuition.	5	CO5	L1
5	Recall the differences between Intrinsic and extrinsic motivation with examples	5	CO5	L1
6	Define Lateral thinking	5	CO5	L1

7	Recall the differences between Vertical thinking and lateral thinking	5	CO5	L1
8	Identify and define different myths of creativity.	5	CO5	L1
9	List out the myths of creativity and explain any four of them	5	CO5	L1
10	Define critical thinking and explain its three components	5	CO5	L1
11	Identify the essential skills required for effective critical thinking	5	CO5	L1
12	Identify the differences in the cognitive functions of left and right brain	5	CO5	L1
13	Recall the differences between creative thinking and critical thinking	5	CO5	L1
14	Define the importance of problem solving	5	CO5	L1
15	Define the term brainstorming and explain four rules of brainstorming	5	CO5	L1
16	Recall the advantages and disadvantages of six thinking hats	5	CO5	L1
17	List out the useful strategies for mathematical problem solving	5	CO5	L1
18	Explain any FIVE types of creativity	5	CO5	L2
19	Describe in detail the functions of the left and right brain.	5	CO5	L2
20	Explain a) imagination, intuition and experience b) relation of above mentioned factors with creativity	5	CO5	L2
21	Describe the sources of creativity	5	CO5	L2
22	Explain the main aspects important for creative thinking	5	CO5	L2

23	Briefly explain a)convergent thinking b)divergent thinking	5	CO5	L2
24	Explain the concept of critical reading and its importance	5	CO5	L2
25	Describe the concept of multiple intelligence defined by Gardner	5	CO5	L2
26	'Critical reading is an active process'. Discuss.	5	CO5	L2
	MODULE 4			
1	List the ways in which a person can participate in a group discussion effectively?	5	CO4	L1
2	Identify the important characteristics of group discussion.	5	CO4	L1
3	'Listening skills are essential for effectively participating in a group discussion.' Explain.	5	CO4	L2
4	Discuss the importance of group dynamics in a Group Discussion.	5	CO4	L2
5	Define the term 'group' and list the characteristics of a group.	5	CO6	L1
6	List out the 5 stages of a group formation.	5	CO6	L1
7	Recall the different types of groups	5	CO6	L1
8	List the different steps in group problem solving	5	CO6	L1
9	Recall The differences between a group and a team	5	CO6	L1
10	Define virtual team	5	CO6	L1
11	Recall The differences between homogeneous and heterogeneous teams	5	CO6	L1

12	Outline the steps in a TPM cycle	5	CO6	L1
13	Outline the characteristics of an effective group work	5	CO6	L1
14	Explain what team dynamics is and how it affects the team's performance.	5	CO6	L2
15	Explain the importance of group formation	5	CO6	L2
16	Explain the phenomenon of 'groupthink'	5	CO6	L2
17	Describe elaborately the process involved in problem solving as group	5	CO6	L2
18	Explain the group dynamics techniques	5	CO6	L2
19	Describe the types and benefits of teamwork	5	CO6	L2
20	Describe the ways to overcome the barrier of expectation and conflicts within a group	5	CO6	L2
21	Explain about managing team performances	5	CO6	L2
22	A group focuses on individual contribution, while a team focuses on synergy. Discuss	5	CO6	L2
23	Explain intrapreneurship and its characteristics	5	CO6	L2
	MODULE 5			
1	Identify the differences between a leader and a boss	5	CO6	L1
2	List out the key elements of the leadership framework	5	CO6	L1
3	Identify and explain the major personality traits of leaders	5	CO6	L1
4	Recall the differences between transactional and transformational leadership	5	CO6	L1
5	Identify the 4 basic steps to grow as a leader	5	CO6	L1
6	Define the 5 levels of leadership	5	CO6	L1

7	Define leadership Grid with examples	5	CO6	L1
8	List the personality traits of effective leader	5	CO6	L1
9	Identify the role of leaders in managing diverse stakeholders successfully.	5	CO6	L1
10	Explain leadership skill and its characteristics	5	CO6	L2
11	'Management is doing things right; leadership is doing the rightthings'. Discuss	5	CO6	L2
12	Briefly explain different leadership styles	5	CO6	L2
13	Explain Entrepreneurial leadership	5	CO6	L2
14	Describe turnaround leadership.	5	CO6	L2
15	Describe the strategies and qualities of turnaround leadership.	5	CO6	L2
16	Explain and elaborate the term VUCA LEADERSHIP	5	CO6	L2
17	Discuss leadership styles that are effective for successful management of multicultural groups and teams.	5	CO6	L2

Prepared By: Merrina Margaret, Course Faculty

Checked By: Rose Paul, Course Committee Chairman

Course Code & Name: CYL120 ENGINEERING CHEMISTRY LAB

1. Prescribed Syllabus

Sl. No	Topic	Hours
1	Estimation of total hardness of water-EDTA method	2
2	Potentiometric titration	2
3	Determination of cell constant and conductance of solutions	2
4	Calibration of pH meter and determination of pH of a solution	2
5	Estimation of chloride in water	2
6	Identification of drugs using TLC	2
7	Determination of wavelength of absorption maximum and colorimetric estimation of Fe^{3+} in solution	2
8	Determination of molar absorptivity of a compound ($KMnO_4$ or any water-soluble food colorant)	2
9	Synthesis of polymers (a) Urea-formaldehyde resin (b) Phenol-formaldehyde resin	2
10	Estimation of iron in iron ore	2
11	Estimation of copper in brass	2
12	Estimation of dissolved oxygen by Winkler's method	2
13	Synthesis of polymers (a) Urea-formaldehyde resin (b) Phenol-formaldehyde resin	2
14	(a) Analysis of IR spectra (minimum 3 spectra) (b) Analysis of 1H NMR spectra (minimum 3 spectra)	2
15	Flame photometric estimation of Na+ to find out the salinity in sand	2
16	Determination of saponification of a vegetable oil	2

2. Text Books (T)

Nil

3. Reference Books (R)

Nil

4. Course Objectives

To impart scientific approach and to familiarize with the experiments in chemistry relevant for research projects in higher semesters

5. Course Pre / Co-requisite

Experiments in chemistry introduced at the plus two levels in schools

6. Course Outcomes

After completion of the course, student will be able to

CO 1: Understand and practice different techniques of quantitative chemical analysis to generate experimental skills and apply these skills to various analyses

CO 2: Develop skills relevant to synthesize organic polymers and acquire the practical skill to use TLC for the identification of drugs

CO3: Develop the ability to understand and explain the use of modern spectroscopic techniques for analysing and interpreting the IR spectra and NMR spectra of some organic compounds

CO 4:Acquire the ability to understand, explain and use instrumental techniques for chemical analysis

CO 5:Learn to design and carry out scientific experiments as well as accurately record and analyse the results of such experiments.

CO 6:Function as a member of a team, communicate effectively and engage in further learning. Also understand how chemistry addresses social, economic and environment problems and why it is an integral part of curriculum.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3				2							3
CO2	3				3							3
CO3	3				3							3
CO4	3				3							3
CO5	3				1							3
CO6	3				1							3

8. Justification for CO-PO-PSO Correlation

CO1	PO 1 Knowledge of qualitative & quantitative estimation methods will help the student to find solutions to many engineering problems. PO 5 The student will be able to solve problems by measuring chemical parameters by applying knowledge of engineering sciences. PO 12 The student will gain the ability to design experiments (like estimation of quality of water) which can meet public health, safety and environmental considerations.
CO2	PO 1 The student will acquire the skill for the preparation of engineering plastics. PO 5 The student will acquire the skill for instrumental techniques that can be used to solve complex engineering problems. PO 12 Problem analysis can be done by the demonstration of theoretical concepts.

CO3	PO 1 The student will acquire basic knowledge to operate instruments like colorimeter, conductivity meter, pH meter etc which can be used for chemical analysis. PO 5 The student will be able to solve problems by measuring chemical parameters by applying knowledge of engineering sciences PO 12 The student will be able to use problem analysis using instruments to arrive at suitable conclusions.
CO4	PO 1 The student will acquire Research based knowledge which can be attained and developed for demonstrating theoretical concepts. PO 5 Analysis and interpretation of data to solve problems can be attained by the students from practical knowledge. PO 12 The students will be able to acquire Theoretical concepts that can be used to develop scientific attitude.
CO5	PO 1 Data obtained from Qualitative & quantitative estimation methods will help the student to arrive at substantiated conclusions to engineering problems. PO 5 Modern instrumental techniques like colorimeter, conductivity meter etc. can be used for chemical analysis. PO 12 Analysis and interpretation of data to solve problems can be attained from practical knowledge.
CO6	PO 1 The student can analyse problems using instruments to arrive at suitable conclusions. PO 5 The student can attain from practical knowledge analysis and interpretation of data to solve problems. PO 12 Quality of water like hardness, amount of chlorine can be estimated with the consideration of public health, safety and environmental considerations.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	Nil		

11. Internal Assessment mark allocation (as per university curriculum)

(Provide details as mentioned in syllabus)

Continuous Internal Evaluation Pattern

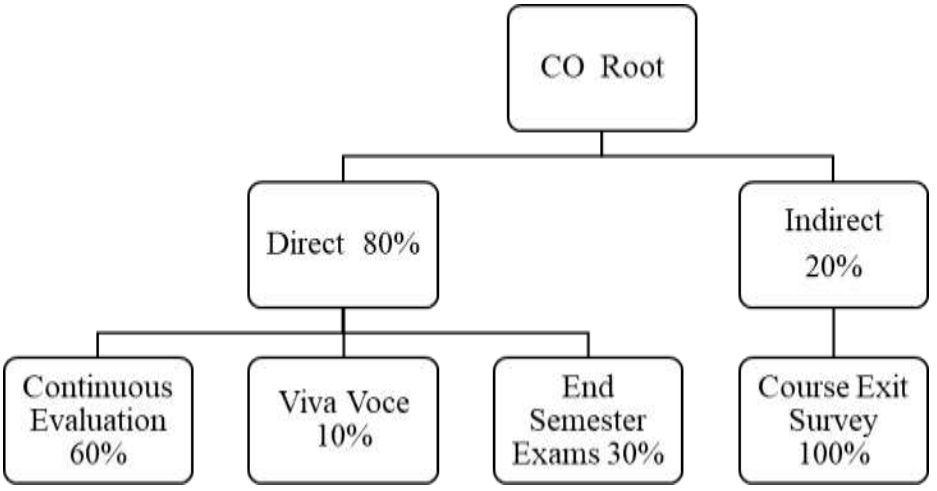
Attendance	: 20 marks
Class work/Assessment/Viva-voce	: 50 marks
End semester examination (Internally by college)	: 30 marks
Total	**:100 marks**

End Semester Examination Pattern: Written Objective Examination of one hour.

12. Assessment – CO Mapping (Put‘ x’ if mapping is present)

	Tools**	Weightage#	CO1	CO2	CO3	CO4	CO5	CO6
Direct Assessment Tools	Continuous Evaluation Experiment wise CO mapping	60%	x	X	x	x	x	X
	Viva-voce	10%	x	X	x	x	x	X
	End Semester Exam (internally by college)	30%	x	X	x	x	x	X
Indirect Assessment Tool	Course Exit Survey	100%	x	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

List of Experiments

Weeks(W)	Experiments	Relevance to COs
1	Calibration of pH meter and determination of pH of a solution	CO 1, CO 5, CO 6
2	Determination of cell constant and conductance of solutions	CO 1, CO 4
3	Potentiometric titration	CO 1, CO 4
4	Estimation of total hardness of water-EDTA method	CO 1, CO 5, CO 6
5	Synthesis of polymers - Urea-formaldehyde resin	CO 1, CO 2

6	Synthesis of polymers - Phenol-formaldehyde resin	CO 1, CO 2
7	Analysis of IR spectra	CO 1, CO 3, CO 4
8	Analysis of 1H NMR spectra	CO 1, CO 3, CO 4
9	Determination of acid value of a vegetable oil	CO 1, CO 4, CO 6
10	Determination of saponification of a vegetable oil	CO 1, CO 4, CO 6
11	Estimation of dissolved oxygen by Winkler's method	CO 1, CO 5, CO 6
12	Determination of wavelength of absorption maximum and colorimetric estimation of Fe^{3+} in solution	CO 1, CO 4

Prepared By: Dr. SHYBI A A Course Faculty

Checked By: Dr. Jude Martin Mendez

Course Code & Name: ESL120 Civil and Mechanical Workshop

1. Prescribed Syllabus

Module	Topic	Hours
1	Use screw gauge and vernier caliper to measure the diameter of the steel rod and thickness of a flat bar.	2
2	Setting out a one room building with a given plan and a measuring tape	2
3	Find the level difference between any two points using dumpy level	2
4	Construct a one and half thick brick wall of 50cm height and 60cm length using English bond	2
5	Transfer the level from one point to another using a water level	2
6	Estimate the number of different building blocks to construct a wall	2
7	Introduce the students to plumbing tools, different types of pipes, types of connections, traps, valves, fixtures and sanitary fittings	2
8	Install a rainwater harvesting installation in the campus	2
9	Calculate the area of built up space and a small parcel of land	2
10	General practices	2
11	Carpentry	2
12	Smithy	2
13	Foundry	2
14	Carpentry	2
15	Fitting	2
16	Smithy	2
17	Sheet metal	2
18	Welding	2

2. Text Books (T)

T1. Hajra Choudhury, Workshop Technology, Media promoters.

3. Reference Books (R)

R1. Khanna P.N, “Indian Practical Civil Engineering Handbook”, Engineers Publishers.
R2. Bhavikatti. S, "Surveying and Levelling (Volume 1)", I.K. International Publishing House R3. Arora S.P and Bindra S.P, " Building Construction", Dhanpat Rai Publications
R4. S. C. Rangwala, “Engineering Materials,” Charotar Publishing House.
R5. Raghuvamshi, Workshop Technology, Media promoters.

4. Course Objectives

- To enable the students to identify and manage the tools, materials and methods required to execute an engineering project.
- To introduce students to a team working environment where they develop the necessary skills for planning, preparing and executing an engineering project.
- Students will be introduced to a team working environment where they develop the necessaryskills for planning, preparing and executing an engineering project.
- To enable the student to familiarize various tools, measuring devices, practices and different methods of manufacturing processes employed in industry for fabricating components

5. Course Pre / Co-requisite

Nil

6. Course Outcomes

After completion of the course, student will be able to

CO1: Name different devices and tools used for civil engineering measurements
CO2: Explain the use of various tools and devices for various field measurements
CO3: Demonstrate the steps involved in basic civil engineering activities like plot measurement, setting out operation, evaluating the natural profile of land, plumbing and undertaking simple construction work.
CO4: Choose materials and methods required for basic civil engineering activities like field measurements, masonry work and plumbing.
CO5: Compare different techniques and devices used in civil engineering measurements
CO6: Identify Basic Mechanical workshop operations in accordance with the material and objects
CO7: Apply appropriate Tools and Instruments with respect to the mechanical workshop trades
CO8: Apply appropriate safety measures with respect to the mechanical workshop trade.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO 3
CO1	L				L	L			M	M					
CO2	L				L	L			M	M					
CO3	L				L	L		M	M	M	L				
CO4	L				L	L		M	M	M	L	L			
CO5	L				L	L			M	M		L			
CO6	M														
CO7	M														
CO8	M														

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	PO1	Understanding the different tools used for taking measurements will enable students to apply the knowledge in identifying the instruments and their application in the construction field.
	PO5	Familiarity with modern tools used in Civil Engineering applications will help students to select suitable tools while using them for field measurements.
	PO6	Knowledge on Civil Engineering measurement tools will help students to understand their responsibilities to follow professional engineering practice considering societal health and safety.
	PO9	Knowledge on various tools and devices related to Civil Engineering measurements will enable students to gain the ability to function effectively in multi-disciplinary teams as individuals or in team.
	PO10	Knowledge obtained by taking field measurements by using different tools will help students in better communication with the Engineering community.
CO2	PO1	Knowledge about the use of various tools and devices for field measurements will enable the students to apply it for various applications in the construction field.
	PO5	Understanding various field measuring tools and devices will help the students to choose appropriate tools for a real field situation.
	PO6	Insight on the use of various field measuring tools and devices will enable the students to apply them suitably to assess safety and the consequent responsibilities relevant to the professional engineering practice.
	PO9	Knowledge on the use of various tools and devices for field measurements will help the students to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
	PO10	Understanding the concepts of various tools and devices for field measurements will enable the students to communicate effectively with the engineering community
CO3	PO1	Knowledge on steps involved in basic civil engineering activities will enable students to formulate solutions to field problems.
	PO5	Understanding the basic steps involved in civil engineering activities like plot measurement, setting out operation, evaluating the natural profile of land, plumbing works etc. will enable the students to identify appropriate techniques or resources to be used in these situations.
	PO6	Understanding the steps involved in basic civil engineering/construction works will enable the students to apply them suitably to identify the safety aspects relevant to professional engineering practice.
	PO8	Knowledge on the steps involved in basic civil

		engineering/construction activities as per the norms of engineering field practices will enable the students to exhibit the sense of commitment towards professional ethics.
	PO9	Knowledge on simple construction activities will help the students to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
	PO10	Familiarization of simple construction works will help the students to communicate effectively with the engineering community, and give and receive clear instructions.
	PO11	Familiarization of simple construction works will help the students to manage simple field projects as an individual or a member of a team.
CO4	PO1	Basic aspects of different materials and methods used in civil engineering will enable students to identify their application in the construction field and find solution to Civil Engineering problems.
	PO5	Knowledge of different materials and methods used in civil engineering measurements will help students to apply appropriate techniques in obtaining field measurements, masonry work and plumbing.
	PO6	Understanding of materials and methods used in the civil engineering field will help students to apply them suitably to assess safety and the consequent responsibilities relevant to the professional engineering practice.
	PO8	Knowledge of different materials and methods used in civil engineering/construction activities as per the norms of engineering field practices will enable the students to exhibit a sense of commitment towards professional ethics.
	PO9	Knowledge on different materials and methods used in civil engineering measurements will help the students to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
	PO10	Understanding of different materials and methods used in civil engineering measurements will enable the students to communicate effectively with the engineering community, and give and receive clear instructions during execution of works.
	PO11	Familiarization of simple construction materials and methods will help the students to manage simple field projects as a member or leader in a team.
	PO12	Knowledge of different materials and methods used in civil engineering measurements will enable students to apply them in real time applications.
CO5	PO1	Basic knowledge of different techniques and devices used in civil engineering measurements will enable students to identify their

		application in the construction field and find solution to Civil Engineering problems.
	PO5	Knowledge of different techniques and devices used in civil engineering measurements will help students to students to apply appropriate techniques in obtaining field measurements.
	PO6	Understanding of different techniques and devices used in civil engineering measurements will help students to apply them suitably to assess safety and the consequent responsibilities relevant to the professional engineering practice.
	PO9	Knowledge on different techniques and devices used in civil engineering measurements will help the students to function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
	PO10	Understanding of different techniques used in civil engineering measurements will enable the students to communicate effectively with the engineering community, and give and receive clear instructions during execution of works.
	PO12	Knowledge on different techniques and devices used in civil engineering measurements will help students to students to engage themselves in independent and lifelong learning.
	PO1	Basic knowledge of different techniques and devices used in civil engineering measurements will enable students to identify their application in the construction field and find solution to Civil Engineering problems.
	PO5	Knowledge of different techniques and devices used in civil engineering measurements will help students to students to apply appropriate techniques in obtaining field measurements.
CO6	PO1	Students will be able to apply the knowledge of mathematics and fundamentals of basic mechanical workshop operations to solve engineering problems.
CO7	PO1	Students will be able to apply appropriate tools and instruments with respect to the mechanical workshop trades to solve engineering problems.
CO8	PO1	Students will be able to apply appropriate safety measures with respect to the mechanical workshop trades to solve engineering problems.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	Demonstration of minor instruments.	Explanation in lab	PO1, PO5, PO6, PO8, PO9, PO10.

11. Internal Assessment mark allocation (as per university curriculum)

(Provide details as mentioned in syllabus)

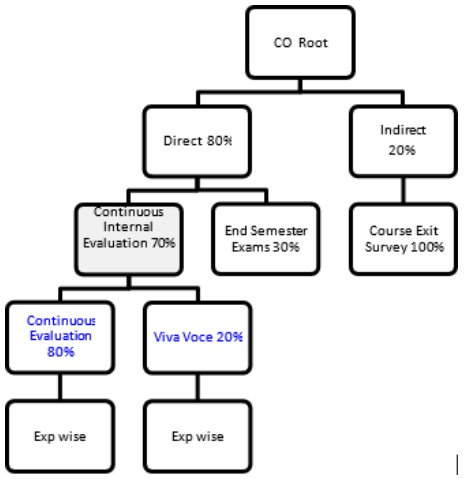
1. Continuous Internal evaluation - 20 marks
2. Viva - 5 marks

End Semester Examination - 15 marks
Attendance - 10 marks
Total - 50 marks

12. Assessment – CO Mapping (Put‘ x’ if mapping is present)

	Tools**	Weightage#	CO1	CO2	CO3	CO4	CO5	CO6	CO7	CO8
Direct Assessment Tools	Continuous Evaluation Experiment wise CO mapping	60%	x	x	x	x	x	x	x	x
	Viva – Voce Experiment wise CO mapping	10%	x	x	x	x	x	x	x	x
	End Semester Exam	**30%**	x	x	x	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey	100%	x	x	x	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Weeks(W)	Experiments	Relevance to COs
1	Use screw gauge and vernier caliper to measure the diameter of the steel rod and thickness of a flat bar.	CO1,CO2,CO3,CO4.CO5
2	Setting out a one room building with a given plan and a measuring tape	CO1,CO2,CO3,CO4.CO5
3	Find the level difference between any two points using dumpy level	CO1,CO2,CO3,CO4.CO5
4	Construct a one and half thick brick wall of 50cm height and 60cm length using English bond	CO1,CO2,CO3,CO4.CO5
5	Transfer the level from one point to another using a water level	CO1,CO2,CO3,CO4.CO5
6	Estimate the number of different types of building blocks to construct a wall	CO1,CO2,CO3,CO4.CO5
7	Introduce the students to plumbing tools, different types of pipes, types of connections, traps, valves, fixtures and sanitary fittings	CO1,CO2,CO3,CO4.CO5
8	Install a rainwater harvesting installation in the campus	CO1,CO2,CO3,CO4.CO5
9	Calculate the area of built up space and a small parcel of land	CO1,CO2,CO3,CO4.CO5
10	General practices	CO6,CO7,CO8
11	Carpentry	CO6,CO7,CO8
12	Smithy	CO6,CO7,CO8
13	Foundry	CO6,CO7,CO8
14	Carpentry	CO6,CO7,CO8
15	Fitting	CO6,CO7,CO8
16	Smithy	CO6,CO7,CO8
17	Sheet metal	CO6,CO7,CO8
18	Welding	CO6,CO7,CO8

Prepared By : Prof. Mohammed Nihal, Course Faculty

Checked By : Ms. Asha K R, Course Committee Chairman

Semester: 2

Curriculum

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT 102	VECTOR CALCULUS, DIFFERENTIAL EQUATIONS AND TRANSFORMS	3-1-0	4	4
B	PHT 110	ENGINEERING PHYSICS B	3-1-0	4	4
C	EST 100	ENGINEERING MECHANICS	2-1-0	3	3
D	EST 130	BASICS OF ELECTRICAL & ELECTRONICS ENGINEERING	4-0-0	4	4
E	HUN 102	PROFESSIONAL COMMUNICATION	2-0-2	2	-
F	EST 102	PROGRAMMING IN C	2-1-2	5	4
S	PHL 120	ENGINEERING PHYSICS LAI	0-0-2	2	1
T	ESL130	ELECTRICAL & ELECTRONICS WORKSHOP	0-0-2	2	1
TOTAL				28/29	21

Course Code & Name: MAT102 Vector Calculus, Differential equations and Transforms

1. Prescribed Syllabus

Module	Topic	Hours
1	Module 1 (Calculus of vector functions) (Text 1: Relevant topics from sections 12.1, 12.2, 12.6, 13.6, 15.1, 15.2, 15.3) Vector valued function of single variable, derivative of vector function and geometrical interpretation, motion along a curve-velocity, speed and acceleration. Concept of scalar and vector fields, Gradient and its properties, directional derivative, divergence and curl, Line integrals of vector fields, work as line integral, Conservative vector fields, independence of path and potential function (results without proof).	**9**
2	Module 2 (Vector integral theorems) (Text 1: Relevant topics from sections 15.4, 15.5, 15.6, 15.7, 15.8) Green's theorem (for simply connected domains, without proof) and applications to evaluating line integrals and finding areas. Surface integrals over surfaces of the form z = g (x, y), y = g (x, z) or x = g (y, z), Flux integrals over surfaces of the form z = g(x, y), y = g(x, z) or x = g(y, z), divergence theorem (without proof) and its applications to finding flux integrals, Stokes' theorem (without proof) and its applications to finding line integrals of vector fields and work done.	**9**
3	Module- 3 (Ordinary differential equations) (Text 2: Relevant topics from sections 2.1, 2.2, 2.5, 2.6, 2.7, 2.10, 3.1, 3.2, 3.3) Homogenous linear differential equation of second order, superposition principle, general solution, homogenous linear ODEs with constant coefficients-general solution. Solution of Euler-Cauchy equations (second order only). Existence and uniqueness (without proof). Non homogenous linear ODEs-general solution, solution by the method of undetermined coefficients (for the right-hand side of the form x^n ,e^{kx} ,$sinax$,$cosax$, $e^{kx}sinax$, $e^{kx}cosax$and their linear combinations), methods of variation of parameters. Solution of higher order equations-homogeneous and non-homogeneous with constant coefficient using method of undetermined coefficient.	**9**
4	Module- 4 (Laplace transforms) (Text 2: Relevant topics from sections 6.1,6.2,6.3,6.4,6.5) Laplace Transform and its inverse, Existence theorem (without proof), linearity, Laplace transform of basic functions, first shifting theorem, Laplace transform of derivatives and integrals, solution of differential equations using Laplace transform, Unit step function, Second shifting theorems. Dirac delta function and its Laplace transform, Solution of ordinary differential equation involving unit 9step function and Dirac delta functions. Convolution theorem (without proof) and its application to finding inverse Laplace transform of products of functions.	**10**

5	Module-5 (Fourier Transforms) (Text 2: Relevant topics from sections 11.7,11.8, 11.9) Fourier integral representation, Fourier sine and cosine integrals. Fourier sine and cosine transforms, inverse sine and cosine transform. Fourier transform and inverse Fourier transform, basic properties. The Fourier transforms of derivatives. Convolution theorem (without proof)	**8**

2. Text Books (T)

T1. H. Anton, I. Biven S.Davis, "Calculus", Wiley, 10th edition, 2015.
T2. Erwin Kreyszig, "Advanced Engineering Mathematics", Wiley, 10th edition, 2015.

3. Reference Books (R)

R1. J. Stewart, Essential Calculus, Cengage, 2nd edition, 2017

R2. G.B. Thomas and R.L. Finney, Calculus and Analytic geometry, 9th Edition, Pearson, Reprint, 2002.

R3. Peter O Neil, Advanced Engineering Mathematics, 7th Edition, Thomson, 2007.

R4. Louis C Barret, C Ray Wylie, "Advanced Engineering Mathematics", Tata McGraw Hill, 6th edition, 2003.

R5. Veerarajan T." Engineering Mathematics for first year", Tata McGraw - Hill, 2008

R6. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th edition, 2010.

R7. Srimanta Pal, Subodh C. Bhunia, "Engineering Mathematics", Oxford University Press, 2015

R8. Ronald N. Bracewell, "The Fourier Transform and its Applications", McGraw – Hill International Editions, 2000.

4. Course Objectives

This course introduces the concepts and applications of differentiation and integration of vector valued functions, differential equations, Laplace and Fourier Transforms. The objective of this course is to familiarize the prospective engineers with some advanced concepts and methods in Mathematics which include the Calculus of vector valued functions, ordinary differential equations and basic transforms such as Laplace and Fourier Transforms which are invaluable for any engineer's mathematical tool box. The topics treated in this course have applications in all branches of engineering.

5. Course Pre / Co-requisite

Calculus of single and multi variable functions**.**

6. Course Outcomes

After completion of the course, student will be able to

CO1: Compute the derivatives and line integrals of vector functions and learn their applications

CO2: Evaluate surface and volume integrals and learn their inter-relations and applications.

CO3: Solve homogeneous and non-homogeneous linear differential equation with constant coefficients

CO4: Compute Laplace transform and apply them to solve ODEs arising in engineering

CO5: Determine the Fourier transforms of functions and apply them to solve problems arising in engineering

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	H	H	H	H	M	L			L	M		M
CO2	H	H	H	H	M	L			L	M		M
CO3	H	H	H	H	M	L			L	M		M
CO4	H	H	H	H	M	L			L	M		M
CO5	H	H	H	H	M	L			L	M		M

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	PO1	Concept of calculus of vector valued functions will help to solve problems in Engineering
	PO2	The concept of derivatives and line integrals of vector functions can be used to identify, formulate and analyse complex engineering problems
	PO3	The concept of derivatives and line integrals of vector functions and their applications can be used to design solutions for complex engineering problems
	PO4	The concept of derivatives and line integrals of vector functions and their applications can be used to conduct investigation of complex problems

		including design of experiments, analysis and interpretation of data to provide valid conclusions
	PO5	The concept of derivatives and line integrals of vector functions and their applications can be used to create, select and apply appropriate techniques, modern engineering and IT tools including prediction and modelling to complex engineering activities
	PO6	The concept of derivatives and line integrals of vector functions and their applications can be used to assess the issues related to society
	PO9	The knowledge of derivatives and line integrals of vector functions and their applications will help the individual to function effectively in diverse teams
	PO10	The concept of derivatives and line integrals of vector functions and their applications will help to communicate effectively on complex engineering activities
	PO12	The concept of derivatives and line integrals of vector functions and their applications will help to recognise the need for independent and lifelong learning in the broadest context of technological knowledge
CO2	**PO1**	Basic knowledge in finding area and volume using multiple integrals can be used to solve Engineering problems
	PO2	Theory of multiple integrals can be used to analyse complex Engineering problems
	PO3	The concept of finding area and volume using multiple integrals can be used to design solutions of complex engineering problems
	PO4	The concept of finding area and volume using multiple integrals can be used to conduct investigations of complex problems involving the synthesis of data to provide valid conclusions
	PO5	The concept of finding area and volume using multiple integrals can be used to create and select appropriate techniques and model complex engineering activities with an understanding of the limitations
	PO6	The concept of finding area and volume using multiple integrals will help to apply reasoning to assess issues and responsibilities relevant to the professional engineering practice

	PO9	The knowledge of multiple integrals enhances the leadership quality of students before entering into team works
	PO10	The concept of finding area and volume using multiple integrals will help to communicate effectively on complex engineering activities with the engineering community
	PO12	Theory of multiple integrals can be used and applied in the future course of action
CO3	**PO1**	Fundamental knowledge of methods of solving differential equations will help to simplify several problems in Engineering
	PO2	Methods of solving differential equations will help to formulate problems with high complexity in Engineering.
	PO3	Solution of homogeneous and non-homogeneous differential equations are used to design solutions for complex engineering problems
	PO4	Solution of homogeneous and non-homogeneous differential equations are used to conduct investigation of complex problems
	PO5	Various methods of solving differential equations will help to select appropriate techniques in complex engineering activities.
	PO6	The concept of differential equations will help to assess the issues related to society
	PO9	Various methods of solving differential equations will help to function effectively as an individual and a member in diverse teams
	PO10	Methods of solving differential equations will help to communicate effectively on complex engineering activities.
	PO12	Theory of differential equations will help to engage in independent and lifelong learning.
CO4	**PO1**	Knowledge of Laplace transforms is used to solve ODEs arising in engineering.
	PO2	The concept of Laplace transforms and its application to solve ODEs are used to find solutions of complex problems in the field of engineering.
	PO3	The concept of Laplace transforms and its application to solve ODEs are used to develop solutions for complex engineering problems.
	PO4	The concept of Laplace transforms and its application to solve ODEs are used to conduct investigation of complex problems involving analysis and interpretation of data to obtain valid conclusions.

	PO5	The concept of Laplace transforms and its application to solve ODEs are used to create, select and apply appropriate techniques, modern engineering and IT tools including prediction and modelling to complex engineering activities
	PO6	The concept of Laplace transforms and its application to solve ODEs are used to assess the issues related to the professional engineering society.
	PO9	The concept of Laplace transforms and its application to solve ODEs are used to function effectively as an individual and a member in diverse teams.
	PO10	The concept of Laplace transforms and its application to solve ODEs are used to communicate effectively, give, and receive instructions on complex engineering activities with the engineering community.
	PO12	The concept of Laplace transforms and its application to solve ODEs are used to recognise the need for independent and lifelong learning in the broadest context of technological knowledge.
CO5	**PO1**	Basic knowledge of Fourier transforms of functions will help to solve problems arising in engineering
	PO2	Fundamental knowledge Fourier transforms of functions will help to formulate and analyze problems with high complexity in Engineering.
	PO3	Theory of Fourier transforms of functions are used to design solutions for complex engineering problems
	PO4	The concept of Fourier transforms of functions are used to conduct investigation of complex problems
	PO5	Evaluation of Fourier transforms of functions will help to select appropriate techniques in complex engineering activities.
	PO6	The concept of Fourier transforms will help to assess the issues related to society
	PO9	Knowledge of Fourier transforms of functions will help to function effectively as an individual and a member in diverse teams
	PO10	Evaluation of Fourier transforms of functions will help to communicate effectively on complex engineering activities.
	PO12	Theory of Fourier transforms of functions will help to engage in independent and lifelong learning.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs

** Proposed Actions: Webinar/Industry Visit/Expert talks /NPTEL/project/training Etc
* To better attain POs and PSOs and to bridge the gap between industry academia

11. Internal Assessment mark allocation (as per university curriculum)

(Provide details as mentioned in syllabus)

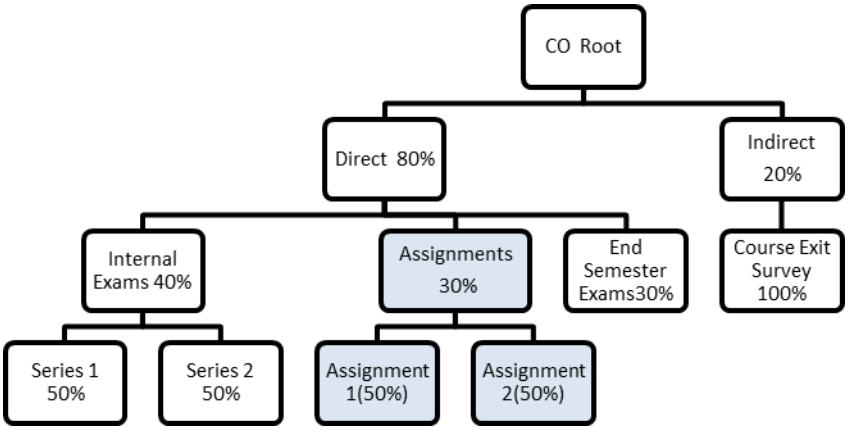
Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put' x' if mapping is present)

	Tools		Weightage#	CO1	CO2	CO3	CO4	CO5
Direct Assessment Tools**	Internal Exam(s) 40%	Series 1	20%	x	x			
		Series 2	20%			X	x	
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x	x			
		Assignment 2	15%			X	x	x
	End Semester Exam		30%	x	x	X	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	X	x	x

**Fill appropriate course specific Direct Assessment tools
Fill appropriate weights such that total weight for direct assessment tools is 100%

13. Assessment Configuration



14. Course Plan

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1	Vector valued function of a scalar variable - derivative of vector valued function of scalar variable t-geometrical meaning	1	T1	Lecture
2	Vector valued function of a scalar variable - derivative of vector valued function of scalar variable t-geometrical meaning	1	T1	Lecture
3	Motion along a curve-speed , velocity, acceleration	1	T1	Lecture
4	Gradient and its properties, directional derivative , divergent and curl	1	T1	Lecture
5	Gradient and its properties, directional derivative , divergent and curl	1	T1	Lecture
6	Gradient and its properties, directional derivative , divergent and curl	1	T1	Lecture
7	Line integrals with respect to arc length, line integrals of vector fields. Work done as line integral	1	T1	Lecture
8	Line integrals with respect to arc length, line integrals of vector fields. Work done as line integral	1	T1	Lecture
9	Conservative vector field, independence of path, potential function	2	T1	Lecture
10	Conservative vector field, independence of path, potential function	2	T1	Lecture
11	Green's theorem and it's applications	2	T1	Lecture
12	Green's theorem and it's applications	2	T1	Lecture
13	Green's theorem and it's applications	2	T1	Lecture
14	Surface integrals , flux integral and their evaluation		T1	Lecture
15	Divergence theorem and applications	2	T1	Lecture
16	Divergence theorem and applications	2	T1	Lecture
17	Stokes theorem and applications	2	T1	Lecture
18	Stokes theorem and applications	2	T1	Lecture
19	Homogenous linear equation of second order, Superposition principle, general solution	3	T2	Lecture
20	Homogenous linear ODEs of second order with constant coefficients	3	T2	Lecture

21	Homogenous linear ODEs of second order with constant coefficients	3	T2	Lecture
22	Second order Euler-Cauchy equation	3	T2	Lecture
23	Second order Euler-Cauchy equation	3	T2	Lecture
24	Non homogenous linear differential equations of second order with constant coefficient-solution by undetermined coefficients, variation of parameters.	3	T2	Lecture
25	Higher order equations with constant coefficients	3	T2	Lecture
26	Higher order equations with constant coefficients	3	T2	Lecture
27	Higher order equations with constant coefficients	3	T2	Lecture
28	Laplace Transform , inverse Transform, Linearity, First shifting theorem, transform of basic functions	3	T2	Lecture
29	Laplace Transform , inverse Transform, Linearity, First shifting theorem, transform of basic functions	3	T2	Lecture
30	Transform of derivatives and integrals	4	T2	Lecture
31	Transform of derivatives and integrals	4	T2	Lecture
32	Solution of Differential equations, Initial value problems by Laplace transform method.	4	T2	Lecture
33	Unit step function --- Second shifting theorem	4	T2	Lecture
34	Unit step function --- Second shifting theorem	4	T2	Lecture
35	Dirac Delta function and solution of ODE involving Dirac delta function	4	T2	Lecture
36	Dirac Delta function and solution of ODE involving Dirac delta function	4	T2	Lecture
37	Convolution and related problems.	4	T2	Lecture
38	Convolution and related problems	4	T2	Lecture
39	Fourier integral representation	4	T2	Lecture
40	Fourier integral representation	4	T2	Lecture
41	Fourier Cosine and Sine integrals and transforms	5	T2	Lecture
42	Complex Fourier integral representation, Fourier transform and its inverse transforms, basic properties	5	T2	Lecture
43	Fourier transform of derivatives, Convolution theorem	5	T2	Lecture

44	Fourier integral representation	5	T2	Lecture
45	Fourier integral representation	5	T2	Lecture

15. Question Bank

Module 1				
Sl. No	**Question**	**Marks**	**CO**	**BL**
1.	Prove that $F^{\rightarrow} = (x^2 - yz)i + (y^2 - xz)j + (z^2 - xy)k$ is irrotational	**3**	**CO1**	**L1**
2.	Show that $F(x, y) = 2xy^3i + 3x^2y^2j$ is conservative	**3**	**CO1**	**L1**
3	Confirm that $\varphi(x, y, z) = x^2 - 3y^2 + 4z^3$ is a potential function for $F(x, y, z) = 2xi - 6yj + 12z^2\,k$	**3**	**CO1**	**L2**
4.	Find the divergence of the vector field f(x,y,z) $= x^2yi + 2y^3zj + 3zk$	**3**	**CO1**	**L2**
5.	Find the velocity, acceleration and speed of a particle moving along the curve $r^{\rightarrow} = (1 + 3t)\hat{\imath} + (3 - 4t)\hat{\jmath} + (1 + 3t)\hat{k}$.	**3**	**CO1**	**L2**
6.	Find the workdone by the force field on a particle that moves along the curve $y^2 = x$ from (0,0) to (0,1)	**3**	**CO1**	**L2**
7.	Find the unit tangent vector at a point $t_0 = \frac{\pi}{6}$ to the curve $r^{\rightarrow\rightarrow\rightarrow}(t^{\rightarrow\rightarrow\rightarrow})^{\rightarrow} = \cos 3t\,\hat{\imath} + \sin 3t\,\hat{\jmath} + 3t\,\hat{k}$	**3**	**CO1**	**L2**
8.	Show that $\int_A^B (2xy + z^3)dx + x^2\,dy + 3xz^2dz$ is independent of the path joining the points A & B	**3**	**CO1**	**L2**
9.	Find the directional derivative of $f(x, y) = xe^y$ at (1,1) in the direction of $\hat{\imath} - \hat{\jmath}$.	**3**	**CO1**	**L2**
10.	Find the directional derivative of the function $\emptyset = 3x^2y - y^3z^2$ at $(-1, -2, -1)$ in the direction of negative z axis.	**3**	**CO1**	**L2**
11.	Find the directional derivatives of $f(x, y) = x^2 - 3xy + y^2$ at the p the direction of $\vec{a} = \frac{1}{3}\vec{i} + \frac{2}{3}\vec{j}$.	**3**	**CO1**	**L2**

12.	Evaluate $\int_C 3xy\,dy$ where C is the line segment joining (0,0) a	**3**	**CO1**	**L2**
13.	If $F(x,y,z) = x^2i - 3j + yz^2k$, find div $\vec{F}$	**3**	**CO1**	**L2**
14.	Find the velocity and acceleration of a particle whose position vector $\vec{r}(t) = e^t\,\vec{i} + e^{-t}\,\vec{j}$ at $t = 0$.	**3**	**CO1**	**L2**
15.	If C is the unit circle $x^2 + y^2 = 1$ oriented counter clockwise, fir	**3**	**CO1**	**L2**
16.	Find the values of constants a, b, c so that $\vec{F} = (axy + bz^3)i + (3x^2 - cz$ may be irrotational. For these values of a, b, c find the scalar potential of	**7**	**CO1**	**L2**
17.	Find the divergence and curl of $\vec{F}(x,y,z) = x^2i + y^3zj + 3zk$	**7**	**CO1**	**L2**
18.	Prove that $\nabla^2(r^n) = n(n+1)r^{n-2}$,where $\vec{r} = x\,i + y\,j + z\,k$	**7**	**CO1**	**L3**
19.	**Find the work done by the force field $F(x,y,z) = (x^2 + xy)\,i + (y - x^2y)j$ on a pa along the curve $C: x = t, y = \frac{1}{t}$, $1 \le t \le 3$**	**7**	**CO1**	**L3**
20.	**Determine whether $F(x,y) = 4y\,i + 4xj$ is a conservative vector field. so, find the potential function and the potential energy.**	**7**	**CO1**	**L3**
21.	Let $\vec{r} = xi + yj + zk$ and let $r = \|\vec{r}\|$ and f be a differentiable function of one variable show that $\nabla f(r) = \frac{f'(r)}{r}\vec{r}$.	**7**	**CO1**	**L3**
22.	Evaluate the line integral $\int_C [-y\,dx + x\,dy]$ along $y^2 = 3x$ fr	**7**	**CO1**	**L3**
23.	Evaluate the line integral $\int_C (xy + z^3)\,ds$ from (1,0,0) to $(-1,0,\pi)$ along the helix C that is represented by the parametric equations $x = \cos t, y = \sin t, z = t$	**7**	**CO1**	**L3**

24.	Evaluate the line integral $\int_C (y-x)\,dx + x^2y\,dy$ along the curve C, $y^2 = x^3$ from (1, -1) to (1,1)	7	**CO1**	**L3**
25.	Find the work done by the force field $\vec{F} = (x+y)i + xyj - z^2k$ along the line segment from (0,0,0) to(1,3,1) and then to $(2,-1,5)$.	7	**CO1**	**L3**
26.	Show that $\vec{F} = (2xy + z^3)i + x^2j + 3xz^2k$ is a conservative vector field. Also find its scalar potential.	7	**CO1**	**L3**
27.	Show that $\int_{(1,2)}^{(4,0)} 4y\,dx + 4x\,dy$ is independent of path and find its value.	7	**CO1**	**L3**
28.	Find the work done by$F(x,y) = (x^2 + y^2)\boldsymbol{i} - x\boldsymbol{j}$ alo $C: x^2 + y^2 = 1$ counter clockwise from (1,0) to (0,1	7	**CO1**	**L3**
29.	Find the divergence of the vector field $F = \frac{c}{(x^2+y^2+z^2)^{3/2}}\,(x\,i + y\,j + z\,k)$	7	**CO1**	**L3**
30.	Evaluate $\int y\,dx + z\,dy + x\,dz$ along the path $x = \cos \pi t, y$ from (1,0,0) to $(-1,0,1)$	7	**CO1**	**L3**
31.	Use a line integral to evaluate the work done by the force field $\vec{F}$ along the triangle with vertices (0,0), (2,1) and (0,1) in the positiv	7	**CO1**	**L3**
32.	Use the given information to find the position and velocity vector with acceleration $\vec{a}(t) = -\cos t\,\hat{\imath} - \sin t\,\hat{\jmath}$, $\vec{v}(0) = \hat{\imath}$, $\vec{r}(0) =$	7	**CO1**	**L3**
33.	Evaluate $\int_C (xyz)dx - \cos(yz)\,dy$ where C is the straight line $(1,1,1)$ to $(-2,1,3)$.	7	**CO1**	**L3**
34.	Show that the vector field $\vec{F}(x,y) = \cos y\,\hat{\imath} - xsin\,y\,\hat{\jmath}$ is conser φ such that $\vec{F} = \nabla\varphi$. Hence evaluate $\int_{(0,1)}^{(\pi,0)} \cos y\,dx - xsiny\,dy$	7	**CO1**	**L3**
35.	Find the directional derivative of $\varphi(x,y,z) = x^3z - yx^2 + z^2$ a direction of $\vec{a} = 2\vec{i} - \vec{j} + 2\vec{k}$. Also find the maximum directio	7	**CO1**	**L3**

36.	Find the parametric equation of the tangent line $\vec{r}(t)=t^2\,\vec{i}-\frac{1}{t+3}\,\vec{j}+(4-t^2)\vec{k}$ at (4,-1,0).	**7**	**CO1**	**L3**
37.	Using line integral evaluate $\int_C x^2 y\,dx+x\,dy$ where C is the tria connecting (0,0) ,(1,0) and (1,2) in the positive direction.	**7**	**CO1**	**L3**
38.	Find the parametric equation of the tangent line to the curve $\vec{r}(t)=2\cos\pi t\,\vec{i}+2\sin\pi t\,\vec{j}+6t\,\vec{k}$ at the point $t=\frac{1}{3}$	**7**	**CO1**	**L3**
39.	Find the position anrd velocity vectors of given $\vec{a}(t)=(t+1)^{-2}\,\vec{j}-e^{-2t}\vec{k},\ \vec{v}(0)=3\vec{i}-\vec{j},\ \vec{r}(0)=\vec{k}$	**7**	**CO1**	**L3**
40.	If $\vec{r}=x\vec{i}+y\,\vec{j}+z\,\vec{k}$ and let $\vec{F}(r)=f(r)\,\vec{r}$ prove that $div\vec{F}=3f$	**7**	**CO1**	**L3**

Module 2

Sl. No	Question	Marks	CO	BL
1.	State Green's theorem.	**3**	**CO2**	**L1**
2.	State Divergence theorem.	**3**	**CO2**	**L1**
3.	State Stoke's theorem.	**3**	**CO2**	**L1**
4.	Evaluate $\int_c F.dr$ where $F(x,y)=sinxi+cosxj$ where C is the curve $r(t)=\pi i+tj$, $0\le t\le 2$	**3**	**CO2**	**L2**
5	Evaluate $\int_C (e^x\,dx+2y\,dy-dz)$ where C is the curve $x^2+y^$	**3**	**CO2**	**L2**
6	Evaluate $\iint_S \bar{F}.\bar{n}ds$ where S is the surface of the cylinder x^2+ $z=3$ where $\bar{F}=(2x-y)\bar{i}+(2y-z)\bar{j}+z^2\bar{k}$	**3**	**CO2**	**L2**
7	Using Green's theorem evaluate $\int_C x\,dy-y\,dx$ where C is the c	**3**	**CO2**	**L2**

8	Use line integral to find the area enclosed by the ellipse $\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$	**3**	**CO2**	**L2**
9	If S is the surface of the sphere $x^2 + y^2 + z^2 = 1$ evaluate $\iint_S (xi + 2yj + 3zk).\hat{n}\ dS$	**3**	**CO2**	**L2**
10	Determine the source and sink of the vector field $F^{\rightarrow} = 2(x^3 - 2x)i + 2(y^3 - 2y)j + 2(z^3 - 2z)k$	**3**	**CO2**	**L2**
11	Use the Divergence theorem to find the outward flux of the vector field $F(x, y, z) = 2x\ i + 3y\ j + z^2\ k$ across the unit cube.	**3**	**CO2**	**L2**
12	If σ is any closed surface enclosing a volume V and $F = 2xi + 2yj + 3zk$, Using Divergence theorem show that $\iint_\sigma F.n\ dS = 7V$	**3**	**CO2**	**L2**
13	Determine the sources and sinks of the vector field $\vec{f}(x, y) = x^2\vec{i}$	**3**	**CO2**	**L2**
14	Using Divergence theorem evaluate $\iint_S \vec{f}.\vec{n}\, dS$ where $\vec{f} = 2x\vec{i} + 4y$ is the surface of the sphere $x^2 + y^2 + z^2 = 1$	**3**	**CO2**	**L2**
15	Apply Stoke's theorem to evaluate $\int_C (x + y)dx + (2x - y)dy + (y + z)dz$ where C is the boundary of the triangle with vertices (0,0,0), (2,0,0), (0,3,0).	**3**	**CO2**	**L2**
16	Use Green's Theorem to evaluate $\int_c y^2dx + x^2dy$ where C is the square with vertices (0,0), (1,0), (1,1) and (0,1) oriented counter clockwise.	**7**	**CO2**	**L2**
17	Using Green's theorem to evaluate $\int_C (3x^2 - 8y^2)dx + (4y - 6xy)dy$ where C is the boundary of the region defined by x=0,y=0, x+y=1.	**7**	**CO2**	**L2**
18	Use Green's Theorem to evaluate $\int_c x^2ydx + xdy$ along the triangular path joining (0,0), (1,0), (1,2).	**7**	**CO2**	**L2**
19	Verify Green's theorem for $\int_C (xy + y^2)dx + x^2dy$ where C is bounded by y=x and $y=x^2$	**7**	**CO2**	**L2**

20	Use Green's theorem to evaluate $\int_C (xy + y^2)dx + x^2dy$ where C is the boundary of the region defined by $y=x^2$ and $x=y^2$.	**7**	**CO2**	**L2**
21	Use Green's theorem to evaluate $\int_C \log(1+y)dx - \frac{xy}{1+y}dy$ where C with vertices (0,0),(2,0) and (0,4).	**7**	**CO2**	**L2**
22	Apply Green's theorem to evaluate the work done by the force field $\vec{F} = (e^x - y^3)i + (\cos y + x^3)j$ on a particle that travels once around the unit circle $x^2 + y^2 = 1$ in the counter clockwise direction.	**7**	**CO2**	**L3**
23	Using Divergence theorem evaluate $\iint_S F.\hat{n}\ dS$ where $\vec{F} = x^3i + y^3j + z^3k$ and S is the surface of the cylindrical solid bounded by $x^2 + y^2 = 4$, $z = 0, z = 4$.	**7**	**CO2**	**L3**
24	Verify Divergence theorem for $\vec{F} = x^2i + zj + yzk$ taken over the cube bounded by $x = 0, x = 1, y = 0, y = 1, z = 0, z = 1$	**7**	**CO2**	**L3**
25	Use Stoke's theorem to evaluate $\int_C F.\text{dr}$ where $\vec{F} = xyi + yzj + xzk$, C is the triangle in the plane $x + y + z = 1$ with vertices (1,0,0) ,(0,1,0,) and (0,0,1) with counter clockwise orientation looking from the first octant towards the origin.	**7**	**CO2**	**L3**
26	Use Stoke's theorem to evaluate $\oint_C F.dr$ where $\vec{F} = y^2\hat{i} + x^2\hat{j} - (x + z)\hat{k}$ and C is the boundary of the triangle with vertices (0,0,0), (1,0,0,) and (1,1,0).	**7**	**CO2**	**L3**
27	Use Stoke's theorem to evaluate $\int_C F.\text{dr}$ where $\vec{F} = xzi + 4x^2y^2j + yxk$, C is the rectangle $0 \le x \le 1,\ 0 \le y \le 3$ in the plane z=y.	**7**	**CO2**	**L3**
28	Use Stoke's theorem to find the work performed by the force field $\vec{F} = x^2i + 4xy^3j + y^2xk$ on a particle that traverses the rectangle $0 \le x \le 1,$	**7**	**CO2**	**L3**

	$0 \leq y \leq 3$ in the plane z=y.			
29	Use Stoke's theorem to calculate the circulation around the bounding circle $x^2 + y^2 = 9$ and the force field $F^{\rightarrow} = yi - xj$,where S is the disk of radius 3 centred at origin in the XY plane.	**7**	**CO2**	**L3**
30	Use Stoke's Theorem to evaluate the work done by the force fi $\vec{F}(x,y,z) = 3z\,\hat{\imath} + 4x\,\hat{\jmath} + 2y\hat{k}$ over the boundary of the parab $z = 4 - x^2 - y^2, z \geq 0$ with upward orientation.	**7**	**CO2**	**L3**
31	Let σ be the portion of the surface $z = 1 - x^2 - y^2$ that lies above and σ is the oriented upwards. Find the flux of the vector field	**7**	**CO2**	**L3**
32	Find the mass of the lamina that is the portion of the plane $x +$ the first octant where the density function of the surface is $\sigma =$	**7**	**CO2**	**L3**
33	Use Divergence theorem to find the outward flux of the $\vec{F} = (2x + y^2)\vec{i} + x\,y\,\vec{j} + (xy - 2z)\vec{k}$ across the surface of bounded by $x + y + z = 2$ and the coordinate planes.	**7**	**CO2**	**L3**
34	Find the flux of the vector field $\vec{F}(x,y,z) = x\vec{k}$ across the surface, the paraboloid $z = x^2 + y^2$ below the plane $z = 2y$ oriented by d normal.	**7**	**CO2**	**L3**
35	Use Stokes theorem evaluate $\oint_C \vec{f}.dr$ where $\vec{f}(x,y,z) = (z-y)\vec{i} + (z+x)\vec{j} - (x+y)\vec{k}$ and C is the bound paraboloid $z = 9 - x^2 - y^2$ above the XY-plane with upward	**7**	**CO2**	**L3**
36	Use Green's theorem to find the work done by the $\vec{f}(x,y) = xy\vec{i} + \left(\frac{x^2}{2} + xy\right)\vec{j}$ on a particle that starts at (4,0) trans semicircle $x^2 + y^2 = 16$ and returns to its starting point along the x	**7**	**CO2**	**L3**
37	Find mass of the lamina that is a portion of cone $z = \sqrt{x^2 + y^2}$ that planes $z = 1$ and $z = 3$, if the density is $\phi(x,y,z) = x^2 z$	**7**	**CO2**	**L3**

38	Let σ be the portion of the surface $z = 1 - x^2 - y^2$ that lies above and σ is the oriented upwards. Find the flux of the vector field	**7**	**CO2**	**L3**
39	Use stokes theorem to evaluate $\oint_C \vec{F}.dr$ where $\vec{F}(x,y,z) = z^2\,\vec{i} + 3x$ C is the circle $x^2 + y^2 = 1$ in the XY plane with counter clockwise orien down the positive Z axis	**7**	**CO2**	**L3**

Module 3

Sl. No	Question	Marks	CO	BL
1.	Find the Wronskian of $e^{-x}cos5x$,$e^{-x}sin5x$	**3**	**CO3**	**L2**
2.	Show that e^{2x} , e^{3x} are linearly independent solutions of the differential equation $\frac{d^2y}{dx^2}$ -5$\frac{dy}{dx}$+ $6y = 0$ .What is its general solution	**3**	**CO3**	**L2**
3.	Find a second order homogenous linear ODE for which e^{-x} , $and\ e^{-2x}$ are the solutions	**3**	**CO3**	**L2**
4.	Solve the ODE $\frac{d^3y}{dx^3} - 4\frac{d^2y}{dx^2} + 5\frac{dy}{dx} - 2y = 0$	**3**	**CO3**	**L2**
5	Find the general solution of $y'' - y = 0$	**3**	**CO3**	**L2**
6	Does the function $y = c_1 cos\, x + c_2 sin\, x$ form a solution of $y'' + y = 0$. Is it the general solution? Justify your answer.	**3**	**CO3**	**L2**
7	Find the general solution of $y''' - y'' + 4y' = 0$	**3**	**CO3**	**L2**
8	Solve $(x^2D^2 + xD - 9)y = 0$	**3**	**CO3**	**L2**
9	Solve the initial value problem $y'' + y = 0: y(0) = 3, y'(0) =$	**3**	**CO3**	**L2**
10	Find the Wronskian corresponding to the solution of $y'' - 3y$	**3**	**CO3**	**L2**
11	Solve the initial value problem $y'' + y' - 2y = 0,\ \ y(0) = 4,\ \ y$	**3**	**CO3**	**L2**
12	Solve $y'''' + 10y'' + 9y = 0$.	**3**	**CO3**	**L2**
13	Solve the initial value problem $y'' + 5y' + 6y = 0,\ y(0) =$	**3**	**CO3**	**L2**
14	Solve $y''' - y' = 0$	**3**	**CO3**	**L2**

15	Solve the ODE $y''' - 3y'' - 4y' + 6y = 0$	**7**	**CO3**	**L2**
16	Solve the IVP $y'' - 2y' + 5y = 0, y(0) = -3, y'(0) = 1$	**7**	**CO3**	**L2**
17	Verify linear independence of $e^{-x}cosx$ and $e^{-x}sinx$ using Wronskian and hence solve the initial value problem $y'' + 2y' + y = 0, y(0) = 0, y'(0) = 15$	**7**	**CO3**	**L2**
18	Show that the functions x *and* lnx are linearly independent .Hence form an ODE for the given basis$\{x, lnx\}$	**7**	**CO3**	**L2**
19	Solve $(D^2 + 3D + 2)y = 5$	**7**	**CO3**	**L2**
20	Solve $y'' - 6y' + 9y = e^{3x}$	**7**	**CO3**	**L2**
21	Solve using the method of undetermined coefficients $y'' - 7y' + 12y = e^{2x}, \quad y(0) = 1, \ y'(0) = 2$.	**7**	**CO3**	**L2**
22	Solve $y'' + y = sinx$	**7**	**CO3**	**L3**
23	Solve $y'' + 4y = 4\,sec^2 2x$ by the method of variation of parameters.	**7**	**CO3**	**L3**
24	Solve $y'' + 4y = \tan 2x$ by the method of variation of parameters.	**7**	**CO3**	**L3**
25	Solve the IVP $y''' + 3y'' + 3y' + y = 30\,e^{-x}, y(0) = 3, y'(0) = -3, y''(0) = -47$	**7**	**CO3**	**L3**
26	$Solve\ y'' + 4y' + 4y = x^2 + e^{-x}\,cosx$	**7**	**CO3**	**L3**
27	Solve $(D^2 - 4D + 4)y = sin^2 x$	**7**	**CO3**	**L3**
28	Find the particular integral of $(D^2 + 4D + 1)y = e^x\,sin3x$	**7**	**CO3**	**L3**
29	Solve $(D^4 + 2D^2 + 1)y = x^4$	**7**	**CO3**	**L3**
30	Using the method of variation of parameters solve $y'' + y = secx$	**7**	**CO3**	**L3**
31	Solve using the method of undetermined coefficients: $y'' - 4y$	**7**	**CO3**	**L3**
32	Solve using the method of variation of parameters: $y'' + 4y =$	**7**	**CO3**	**L3**
33	Solve using the method of undetermined coefficients: $y''' + 2y'' -$	**7**	**CO3**	**L3**
34	Solve the initial value problem $x^2y'' - 3xy' + 3y = 0, y(1) =$	**7**	**CO3**	**L3**
35	Solve using the method of undetermined coefficients $y'' - 4y'$	**7**	**CO3**	**L3**
36	Solve using the Method of variation of parameters $y'' + y =$	**7**	**CO3**	**L3**
37	Solve the boundary value problem $x^2y'' - 3xy' + 4y = 0, \quad y($	**7**	**CO3**	**L3**

38	Using the method of undetermined coefficients solve, $y''-$	**7**	**CO3**	**L3**
39	Using the Method of variation of parameters solve, $y''-4y'+5$	**7**	**CO3**	**L3**
40	Solve the initial value problem, by method of undetermined coefficients $y''+4y=8x^2,\ y(0)=-3,\ y'(0)=0$	**7**	**CO3**	**L3**
41	Solve the initial value problem $x^2y''+3xy'+y=0,\ y(1)=-$	**7**	**CO3**	**L3**

Module 4

Sl. No	Question	Marks	CO	BL
1	Find the Laplace transform of (i) $\sinh t\cos t$ (ii) $(t-1)^3$	**3+3**	**CO4**	**L2**
2	Find the inverse Laplace transform of $(i)\ \frac{2}{S^2+\frac{5}{3}}$ $(ii)\ \frac{1}{s(s^2-a^2)}$	**3+3**	**CO4**	**L2**
3	Find the inverse Laplace transform of $(i)\ \frac{2\pi}{(s+\pi)^3}$ (ii) $\frac{2}{s^4}-\frac{48}{s^6}$	**3+3**	**CO4**	**L2**
4	Define Unit step function. Find its Laplace Transform	**3**	**CO4**	**L1**
5	State First shifting theorem	**3**	**CO4**	**L1**
6	**Find the Laplace transforms of the following** **i)** $\cos t - t\sin t$ **ii)** $4te^{-2t}$	**3+3**	**CO4**	**L2**
7	Find the Laplace Transform of : $(i)\ \sin 3t\cos 2t$ $(ii)\ e^{-2t}\cos^2 t$	**3+3**	**CO4**	**L2**
8	**Find the Laplace transforms of** $(i)\ te^{kt}$ $(ii)\ \cos(wt+\theta)$	**3+3**	**CO4**	**L2**
9	Find the inverse Laplace transform of $\frac{1}{(s+\sqrt{2})(s-\sqrt{3})}$	**7**	**CO4**	**L3**
10	Find (i) $L^{-1}\left(\frac{3S-137}{S^2+2S+101}\right)$ (ii) $L^{-1}\left(\frac{5s+1}{s^2-25}\right)$	**7**	**CO4**	**L2**

11	Solve the initial value problem, using Laplace transforms. $y'' + y' + 9y = 0,\ y(0) = 0.16,\ y'(0) = 0$	**7**	**CO4**	**L3**
12	Solve $\frac{d^2y}{dt^2} - 4\frac{dy}{dt} + 5y = 4e^{3t}$ given that $y = 2, \frac{dy}{dt} = 7$ when $t = 0$	**7**	**CO4**	**L3**
13	Using convolution theorem find $L^{-1}\frac{s}{(s^2+a^2)^2}$	**7**	**CO4**	**L2**
14	Find $(i)\ L^{-1}[\frac{e^{-2s}}{s^2}]$ $(ii)\ L^{-1}[\frac{Se^{-3s}}{s^2-\pi^2}]$	**7**	**CO4**	**L2**
15	**Find the inverse Laplace transform of the following** **i)** $\frac{2s+1}{s^2+2s+5}$ **ii)** $\frac{(2s-10)}{s^3}e^{-5s}$	**7**	**CO4**	**L3**
16	**Solve** $y''+2y'+5y=25t$, $y(0)=-2$, $y'(0)=-2$ **using Laplace transform**	**7**	**CO4**	**L3**
17	Find the Inverse Laplace Transform of: $(i)\ \frac{s-4}{s^2-4}$ $(ii)\ \frac{4}{s^2-2s-3}$	**7**	**CO4**	**L2**
18	Solve, by using Laplace Transform: $y'' + y = 3\cos 2t;\ y(0) = 0, y'(0)$	**7**	**CO4**	**L3**
19	Find the inverse Laplace transform of $\frac{5}{(s^2+1)(s^2+25)}$ using Con Theorem.	**7**	**CO4**	**L2**
20	Find the Laplace inverse transform of $[\frac{240}{(S^2+1)(S^2+25)}]$ using convolution theorem.	**7**	**CO4**	**L2**
21	Find the inverse Laplace transform of $[\frac{18}{S(S^2-9)}]$ using convolution theorem.	**7**	**CO4**	**L2**
22	Solve the initial value problem $y''-y'-6y=0, y(0)=6, y'(0)=13$ b Laplace transforms.	**7**	**CO4**	**L3**
23	Determine the response of the damped mass spring system under a square wave modelled by $y'' + 3y' + 2y = u(t-1) - u(t-2), y(0) = 0, y'(0) = 0$	**7**	**CO4**	**L3**

24	Determine the response of the damped mass spring system under a unit impulse at time t=1 modelled by $y'' + 3y' + 2y = \delta(t-1), y(0) = 0, y'(0) = 0$	**7**	**CO4**	**L3**
Module 5				
Sl. No	**Question**	**Marks**	**CO**	**BL**
1.	State the convolution theorem for Fourier transform	**3**	**CO5**	**L1**
2.	Recall the formula for the Fourier Transform of $f(x)$ and its inverse.	**3**	**CO5**	**L1**
3.	Find the Fourier cosine transform of e^{-x} $(x > 1)$	**3**	**CO5**	**L2**
4.	Find the Fourier sine transform of e^{-x} $(x > 1)$	**3**	**CO5**	**L2**
5.	Find the Fourier cosine transform of $f(x) = \begin{cases} k, & 0 < x < a \\ 0 & , x > a \end{cases}$	**3**	**CO5**	**L2**
6.	Find the Fourier cosine integral representation of the function $f(x) = \begin{cases} 1, & 0 < x < 1 \\ 0 & , \quad x > 1 \end{cases}$	**3**	**CO5**	**L2**
7.	Given the Fourier transform $\frac{1}{\sqrt{2}} e^{-\frac{\omega^2}{4}}$ of $f(x) = e^{-x^2}$. Find the Fourier transform of xe^{-x^2}.	**3**	**CO5**	**L2**
8.	Express $f(x) = \begin{cases} \frac{1}{2}, & 0 < x < \pi \\ 0, & x > \pi \end{cases}$ as a Fourier sine integral.	**3**	**CO5**	**L2**
9.	Find the Fourier cosine transform of the function $f(x) = \begin{cases} x & if \\ 0 & if \end{cases}$	**3**	**CO5**	**L2**
10.	Find the Fourier Sine Integral of $f(x) = \begin{cases} \sin x & if \quad 0 \\ 0 & if \quad x \end{cases}$	**3**	**CO5**	**L2**
11.	Find the Fourier cosine transform of $f(x) = x^2$, if $0 < x < 1$; 0, if $x > 1$	**7**	**CO5**	**L2**
12.	Represent $f(x) = \begin{cases} x^2 & 0 < x < 1 \\ 0 & x > 1 \end{cases}$ as a Fourier cosine integral.	**7**	**CO5**	**L2**

13.	Find the Fourier transform of $f(x)=\begin{cases}1 & if\ \|x\|<1\\ 0 & otherwise\end{cases}$	**7**	**CO5**	**L2**
14.	Find the Fourier Integral representation of $f(x)=\begin{cases}1 & if\ \|x\|<1\\ 0 & if\ \|x\|>1\end{cases}$	**7**	**CO5**	**L2**
15.	Find the Fourier Cosine Transform of $f(x)=\sin x;\ \ 0<x<\pi.$	**7**	**CO5**	**L2**
16.	Find the Fourier sine transform of $f(x)=\begin{cases}\sin x & if\ \ 0<x<\pi\\ 0 & if\ \ x>\pi\end{cases}$.	**7**	**CO5**	**L2**
17.	Find the Fourier transform of $f(x)=\begin{cases}e^{kx} & if\ \ x<0\\ 0 & if\ \ x>0\end{cases}$, $k>0.$	**7**	**CO5**	**L2**
18.	Find the Fourier sine transform of the function $f(x)=\begin{cases}1, & (\\ -1, & \\ 0, & \end{cases}$	**7**	**CO5**	**L2**
19.	Find the Fourier integral of $f(x)=\begin{cases}\pi-x & if\ \ 0<x<\pi\\ 0 & otherwise\end{cases}$	**7**	**CO5**	**L2**
20.	Find the Fourier Transform of $f(x)=\begin{cases}e^{x} & if\ \ -a<\\ 0 & otherw\end{cases}$	**7**	**CO5**	**L2**
21.	Find the Fourier Cosine integral of $f(x)=\begin{cases}\cos x & if\ \ 0\\ 0 & otherw\end{cases}$	**7**	**CO5**	**L2**
22.	Find the Fourier Cosine Transform of $f(x)=\begin{cases}x^2 & if\ \ 0<\\ 0 & if\end{cases}$	**7**	**CO5**	**L2**
23.	Find the Fourier Transform of $f(x)=\begin{cases}a-\|x\| & if\ \ \|x\|\\ 0 & other\end{cases}$	**7**	**CO5**	**L2**
24.	Using Fourier sine integral ,show that $\int_0^{\infty}\frac{\omega\sin\omega x}{1+\omega^2}\,d\omega=\frac{\pi}{2}e^{-x}$	**7**	**CO5**	**L2**

25.	Using fourier sine integral for $f(x) = e^{-ax}$ show that $\int_0^\infty \frac{\lambda \sin\lambda x}{\lambda^2+a^2} d\lambda = \pi e^{-ax}$	**7**	**CO5**	**L2**
26.	Express $f(x) = 1, \quad 0 < x < \pi$ $0, \quad x > \pi,$ a Fourier sine integral and evaluate $\int_0^\infty \frac{1-\cos\pi\omega}{\omega} \sin x\omega \, d\omega$	**7**	**CO5**	**L3**
27.	Using Fourier integral representation show that $\int_0^\infty \frac{\sin\omega - \omega\cos\omega}{\omega^2} \sin x\omega d\omega = \frac{\pi}{2}x, \ if\ 0 < x < 1$ $\frac{\pi}{4}$, if $x = 1$ 0, if $x > 1$	**7**	**CO5**	**L3**
28.	Find the fourier transform of $f(x) = \begin{cases} 1 - \lvert x \rvert & if \quad \lvert x \rvert \le 1 \\ 0 & if \quad \lvert x \rvert > 1 \end{cases}$ and also fi inverse transform	**7**	**CO5**	**L3**
29.	Find the fourier sine transform of e^{-x}, $x \ge 0$ .Hence evaluate $\int_0^\infty \frac{x\sin x}{1+x^2} dx$	**7**	**CO5**	**L3**
30.	. Use Fourier integral to show that $\int_0^\infty \frac{\cos x\omega + \omega \sin x\omega}{1+\omega^2} d\omega = \begin{cases} 0 & if\ x < \\ \pi/2 & if\ x = \\ \pi e^{-x} & if\ x > \end{cases}$	**7**	**CO5**	**L3**
31.	Find the Fourier Sine Transform of $f(x) = e^{-\lvert x \rvert}$. Hence evaluate $\int_0^\infty \frac{\omega \sin}{1+}$	**7**	**CO5**	**L3**

Prepared By: Shereta D'cotha, Course Faculty

Checked By: Dr. Jude Martin Mendez

Course Code & Name: PHT100 ENGINEERING PHYSICS B

1. Prescribed Syllabus

Module	Topic	Hours
1	Oscillations and Waves Harmonic oscillations, Damped harmonic motion-Derivation of differential equation and its solution, Over damped, Critically damped and Under damped Cases, Quality factor-Expression, Forced oscillations-Differential Equation-Derivation of expressions for amplitude and phase of forced oscillations, Amplitude Resonance-Expression for Resonant frequency, Quality factor and Sharpness of Resonance, Electrical analogy of mechanical oscillators Wave motion- Derivation of one dimensional wave equation and its solution, Three dimensional wave equation and its solution (no derivation), Distinction between transverse and longitudinal waves, Transverse vibration in a stretched string, Statement of laws of vibration	9
2	Wave Optics Interference of light-Principle of superposition of waves, Theory of thin films - Cosine law (Reflected system), Derivation of the conditions of constructive and destructive Interference, Interference due to wedge shaped films - Determination of thickness and test for optical planeness, Newton's rings - Measurement of wavelength and refractive index, Antireflection coatings Diffraction of light, Fresnel and Fraunhofer classes of diffraction, Diffraction grating-Grating equation, Rayleigh criterion for limit of resolution, Resolving and Dispersive power of a grating with expression (no derivation)	8
3	Quantum Mechanics & Nanotechnology Introduction for the need of Quantum mechanics, Wave nature of Particles, Uncertainty principle, Applications-Absence of electrons inside a nucleus and Natural line broadening Mechanism, Formulation of time dependent and independent Schrodinger wave equations-Physical Meaning of wave function, Particle in a one dimensional box- Derivation for normalised wave function and energy eigen values, Quantum Mechanical Tunnelling (Qualitative) Introduction to nanoscience and technology, Increase in surface to volume ratio for nanomaterials, Quantum confinement in one dimension, two dimension and three dimension-Nano sheets, Nano wires and Quantum dots, Properties of nanomaterials-mechanical, electrical and optical, Applications of nanotechnology (qualitative ideas)	9
4	Acoustics & Ultrasonics Acoustics, Classification of sound-Musical sound-Noise, Characteristics of Musical Sounds-Pitch or frequency-Loudness or Intensity-Measurement of Intensity	8

	level-Decibel-Quality or timbre, Absorption coefficient, Reverberation-Reverberation time-Significance- Sabine's formula (no derivation), Factors affecting architectural acoustics and their remedies Ultrasonics-Production-Magnetostriction effect and Piezoelectric effect, Magnetostriction oscillator and Piezoelectric oscillator – Working, Detection of ultrasonic waves - Thermal and Piezoelectric methods, Ultrasonic diffractometer- Expression for the velocity of ultrasonic waves in a liquid , Applications of ultrasonic waves -SONAR,NDT and Medical	
5	Laser and Fibre optics Properties of laser, Absorption and emission of radiation, Spontaneous and stimulated emission, Einstein's coefficients (no derivation), Population inversion, Metastable states, basic components of laser, Active medium, Pumping mechanism, Optical resonant cavity, working principle, Construction and working of Ruby laser and Helium neon laser ,Construction and working of semiconductor laser(Qualitative) ,Applications of laser, Holography, Difference between hologram and photograph, Recording of hologram and reconstruction of image, Applications Optic fibre-Principle of propagation of light, Types of fibres-Step index and Graded index fibres, Numerical aperture –Derivation, Fibre optic communication system (block diagram), Industrial, Medical and Technological applications, Fibre optic sensors-Intensity Modulated and Phase modulated sensors	**8**

2. Text Books (T)

T1. M.N.Avadhanulu, P.G.Kshirsagar,TVS Arun Murthy "A Text book of Engineering Physics", S.Chand &Co., Revised Edition, 2019.
T2. H.K.Malik , A.K. Singh, "Engineering Physics" McGraw Hill Education, Second Edition, 2017

3. Reference Books (R)

R1. Arthur Beiser, "Concepts of Modern Physics ", Tata McGraw Hill Publications, 6th Edition 2003
R2. D.K. Bhattacharya, Poonam Tandon, "Engineering Physics", Oxford University Press, 2015
R3. Md.N.Khan & S.Panigrahi "Principles of Engineering Physics 1&2", Cambridge University Press, 2016
R4. Aruldhas G., "Engineering Physics", PHI Pvt. Ltd., 2015
R5. Ajoy Ghatak, "Optics", Mc Graw Hill Education, Sixth Edition, 2017
R6. T. Pradeep, "Nano:The Essentials'', McGraw Hill India Ltd, 2007
R7. B. B. Laud, "Lasers and Non linear optics", New age International Publishers, 2nd Edition ,2005
R8. Premlet B., "Advanced Engineering Physics", Phasor Books,10th edition ,2017

R9. I. Dominic and. A. Nahari, “A Text Book of Engineering physics”, Owl Books Publishers, Revised edition, 2016

4. Course Objectives

The aim of the Engineering Physics program is to offer students a solid background in the fundamentals of Physics and to impart that knowledge in engineering disciplines. The program is designed to develop scientific attitudes and enable the students to correlate the concepts of Physics with the core programmes

5. Course Pre / Co-requisite

Higher secondary level Physics, Mathematical course on vector calculus, differential equations and linear algebra

6. Course Outcomes

After completion of the course, student will be able to

CO1: Compute the quantitative aspects of waves and oscillations in engineering systems.
CO2: Apply the interaction of light with matter through interference, diffraction and identify these phenomena in different natural optical processes and optical instruments.
CO3: Analyze the behaviour of matter in the atomic and subatomic level through the principles of quantum mechanics to perceive the microscopic processes in electronic devices.
CO4: Apply the knowledge of ultrasonics in non-destructive testing and use the principles of acoustics to explain the nature and characterization of acoustic design and to provide a safe and healthy environment
CO5: Apply the comprehended knowledge about laser and fibre optic communication systems in various engineering applications

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	H	M						L	M			L			
CO2	H	M						L	M			L			
CO3	H	M						L	M			L			
CO4	H	L						L	M			L			
CO5	H	L						L	M			L			

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
	PO1	Computing the quantitative aspects of waves and oscillations in engineering systems helps to solve complex engineering problems like resonance and related phenomenon
	PO2	The quantitative study of waves and oscillations helps to analyze complex engineering problems

CO1	PO8	Compute the quantitative aspects of waves and oscillations in engineering systems helps to apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice
	PO9	Compute the quantitative aspects of waves and oscillations in engineering systems helps to function effectively as an individual and a member in a diverse teams and multidisciplinary settings
	PO12	Compute the quantitative aspects of waves and oscillations in engineering systems helps to recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological knowledge
CO2	PO1	Apply the knowledge of interaction of light with matter through interference, diffraction helps to solve complex engineering problems related to optical instruments
	PO2	Study of interference and diffraction helps to formulate, identify and analyze complex engineering problems
	PO8	Apply the interaction of light with matter through interference, diffraction and identify these phenomena in different natural optical processes and optical instruments helps to apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
	PO9	Apply the interaction of light with matter through interference, diffraction and identify these phenomena in different natural optical processes and optical instruments helps to function effectively as an individual and a member in a diverse teams and multidisciplinary settings.
	PO12	Apply the interaction of light with matter through interference, diffraction and identify these phenomena in different natural optical processes and optical instruments helps to recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological knowledge
CO3	PO1	Analyze the behaviour of matter in the atomic and subatomic level through the principles of quantum mechanics help to solve complex engineering problems related to electronic devices.
	PO2	Knowledge of nanoscience and technology helps to design complex engineering problems and design system components
	PO8	Analyze the behaviour of matter in the atomic and subatomic level through the principles of quantum mechanics to perceive the microscopic processes in electronic devices helps to apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	To better attainment of PO's	Expert talks	Better understanding of the relevance of the topic.

11. Internal Assessment mark allocation (as per university curriculum)

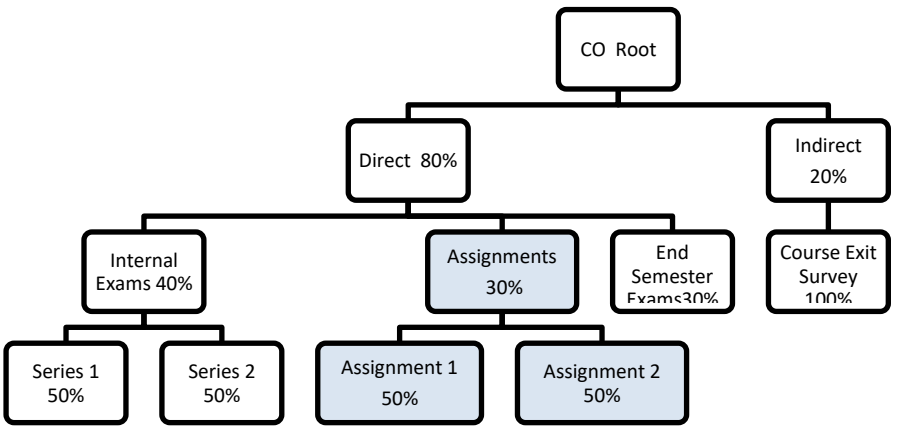
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put' x' if mapping is present)

	Tools		Weightage#	CO1	CO2	CO3	CO4	CO5
Direct Assessment Tools**	Internal Exam(s) 40%	Series 1	20%	x	x			
		Series 2	20%			x	x	x
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x	x			
		Assignment 2	15%			x	x	x
	End Semester Exam		30%	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1	Harmonic oscillations, Damped harmonic motion-Derivation of differential equation and its solution.	1	T1, T2	Lecture
2	Over damped, critically damped and Under damped Cases, Quality Factor-Expression	1	T1, T2	Lecture
3	Forced oscillations-Differential Equation-Derivation of expressions for amplitude and phase of forced oscillations,	1	T1, T2	Lecture
4	Amplitude Resonance- Expression for Resonant frequency, Quality factor and Sharpness of Resonance,	1	T1, T2	Lecture
5	Electrical analogy of mechanical oscillators	1	T1, T2	Lecture
6	Wave motion- Derivation of one-dimensional wave equation and its solution,	1	T1, T2	Lecture
7	Three-dimensional wave equation and its solution (no derivation)	1	T1, T2	Lecture
8	Distinction between transverse and longitudinal waves.	1	T1, T2	Lecture
9	Transverse vibration in a stretched string, Statement of laws of vibration	1	T1, T2	Lecture
10	Interference of light-Principle of superposition of waves, Theory of thin films - Cosine law (Reflected system),	2	T1, T2	Lecture
11	Derivation of the conditions of constructive and destructive Interference	2	T1, T2	Lecture
12	Interference due to wedge shaped films	2	T1, T2	Lecture
13	Determination of thickness and test for optical planeness	2	T1, T2	
14	Newton's rings	2	T1, T2	Lecture
15	Measurement of wavelength and refractive index, Antireflection coatings	2	T1, T2	Lecture
16	Diffraction of light	2	T1, T2	Lecture
17	Fresnel and Fraunhofer classes of diffraction, Diffraction Grating-Grating equation	2	T1, T2	Lecture

18	Rayleigh criterion for limit of resolution, Resolving and Dispersive power of a grating with expression (no derivation)	2	T1, T2	Lecture
19	Introduction for the need of Quantum mechanics, Wave nature of Particles, Uncertainty principle,	3	T1, T2	Lecture
20	Applications-Absence of electrons	3	T1, T2	Lecture
	inside a nucleus and Natural line broadening mechanism.			
21	Formulation of time dependent and independent Schrodinger wave equations.	3	T1, T2	Lecture
22	Physical Meaning of wave function, Particle in a one-dimensional box.	3	T1, T2	Lecture
23	Derivation for normalized wave function and energy.	3	T1, T2	Lecture
24	Eigen values, Quantum Mechanical Tunneling (Qualitative).	3	T1, T2	Lecture
25	Introduction to nanoscience and technology, Increase in surface to volume ratio for nanomaterials,	3	T1, T2	Lecture
26	Quantum confinement in one dimension, two dimension and three dimension-Nano sheets, Nano wires and Quantum dots.	3	T1, T2	Lecture
28	Properties of nanomaterials-mechanical, electrical and optical. Applications of nanotechnology (qualitative ideas)	4	T1, T2	Lecture
29	Magnetic field and Magnetic flux density, Gauss's law for Magnetic flux density	4	T1, T2	Lecture
30	Ampere's Circuital law, Faraday's law in terms of EMF produced by changing magnetic flux	4	T1, T2	Lecture
31	Explanation for Magnetic permeability and susceptibility Classification of magnetic materials-para, dia and ferromagnetic materials	4	T1, T2	Lecture
32	Fundamentals of vector calculus, concept of divergence, gradient and curl along with physical significance, Line, Surface and Volume integrals,	4	T1, T2	Lecture
33	Gauss divergence theorem & Stokes' theorem	4	T1, T2	Lecture
34	Equation of continuity, Derivation of Maxwell's equations in vacuum,	4	T1, T2	Lecture

35	Comparison of displacement current with conduction current. Electromagnetic waves.	4	T1, T2	Lecture
36	Velocity of Electromagnetic waves in free space, Flow of energy and Poynting's vector (no derivation).	4	T1, T2	Lecture
37	Super conducting Phenomena, Meissner effect and perfect diamagnetism.	5	T1, T2	Lecture
38	Types of superconductors- Type I and Type II	5	T1, T2	Lecture
39	BCS Theory (Qualitative), High temperature superconductors,	5	T1, T2	Lecture
40	Applications of super conductivity	5	T1, T2	Lecture
41	Introduction to photonics- Photonic Devices-Light Emitting Diode,	5	T1, T2	Lecture
42	Photo detectors -Junction and PIN photodiodes, Solar cells- I-V Characteristics	5	T1, T2	Lecture
43	Optic fibre-Principle of propagation of light, Types of fibres-Step index and Graded index fibres, Numerical aperture –Derivation.	5	T1, T2	Lecture
44	Fibre optic communication system (block diagram), Industrial, Medical and Technological applications of optical fibre	5	T1, T2	Lecture
45	Fibre optic sensors-Intensity Modulated and Phase modulated sensors	5	T1, T2	Lecture

15. Question Bank

Module 1				
Sl. No	**Question**	**Marks**	**CO**	**BL**
1	Define resonance, give some examples	3	1	L1
2	Explain the relation between path difference and phase difference of wave function	3	1	L1
3	Define free oscillations	3	1	L1
4	Define q-factor	3	1	L1
5	Describe different types of waves	3	1	L2
6	Define the wavelength and frequency of a wave	3	1	L1
7	Distinguish between longitudinal and transverse waves	3	1	L2
8	Explain the concept of phase difference	3	1	L2
9	Discuss characteristics of wave motion	3	1	L2
10	Define wave front.	3	1	L1
11	Distinguish between free oscillation and damped oscillation.	3	1	L2
12	What will happen to fundamental frequency when the length of the string is reduced to one-third of the original length and kept under same tension?	3	1	L3
13	Write the differential equation of a forced harmonic oscillator and find its solution. Derive an expression for amplitude and phase difference.	14	1	L2
14	A simple harmonic wave is represented by $y=8\sin 2\pi(t/0.05 - 0.05x)$.Find wavelength, wavevector, amplitude and velocity of wave. Also find displacement of particle 40cmfrom the origin and 2safter the start of motion. (x,yin cm and t in second).	14	1	L3
15	Derive the differential equation of damped harmonic oscillation and deduce its solution. Calculate the time in which the amplitude of a damped harmonic oscillation with damping constant .04 s^{-1} reduces to 1/e of its undamped value	14	1	L2
16	Derive one dimensional wave equation. Calculate the phase difference between two particle separated by 4 m during the propagation of the wave described by $y(x,t)=2.5 \cos 2\pi(10t-0.005x+0.25)$, where x and y are in cm and t in sec. Also find the particle velocity at x=1 cm and t=1 sec.	14	1	L3
17	Derive one dimensional wave equation and hence obtain the laws of vibration of stretched string. A waveis represented by $\psi=3x10^{-3}$ cos $8.4x\ 10^{13}t+2.8x10^{5}z$. Compute 1) amplitude 2) frequency 3) wavelength 4) wave velocity {z in meters and t in seconds}	14	1	L3
18	Derive an expression for the velocity of transverse waves in a stretched string and state the laws of transverse vibrations.	10	1	L2
19	The amplitude of an undamped harmonic oscillator reduces to 1/10 th of its initial value after 100oscillations. Its time period is 1.15 s. Find the damping constant and relaxation time.	4	1	L3
20	Obtain the expression for sharpness of resonance for forced harmonic oscillator	10	1	L2

21	Derive and solve differential equation of forced harmonic oscillation and discus resonance	10	1	L2
22	Amplitude of a damped harmonic oscillator false to half the initial value in 150 second. Calculate the Q-factor if the period is 2 sec.	4	1	L3
23	The frequency of a turning fork is 300 Hz and its Q-factor $5X10^4$. Find the time after which the energy become (1/10) of its initial value	4	1	L3
24	The amplitude of an under damped harmonic oscillator reduces to (1/10) of its initial value after 100 oscillation. Calculate the damping constant and relaxation time.	4	1	L3
25	Equation of transverse wave travelling along a string is $Y=4\sin\pi(0.01x-2.0t)$ where x and y are in cm, and t is in seconds Find 1. Amplitude 2. Wavelength 3. Initial phase 4. Frequency of the wave	4	1	L3
26	Show that the plane wave equation satisfies the one-dimensional wave equation	10	1	L2
27	Show that $E=E_0\ e^{-i(\omega t-kz)}$ satisfies the one-dimensional wave equation	10	1	L2
28	Obtain an expression of the or sharpness of resonance a for series LCR circuit	10	1	L2
29	What is amplitude resonance? How is the effect of damping related to the sharpness of resonance?	3	1	L2

Module 2				
1	Define non-reflecting film, give an application	3	2	L2
2	Mention the conditions for sustained interference pattern Define grating element, grating equation in terms of grating element	3	2	L1
3	Compare Fresnel and Fraunhofer diffraction	3	2	L2
4	Define resolving power of grating	3	2	L1
5	Compare prism spectrum and diffraction spectrum	3	2	L2
6	Define dispersive power of grating	3	2	L1
7	Define coherent sources	3	2	L1
8	Compare interference and diffraction	3	2	L2
9	Mention condition for sustained interference pattern	3	2	L2
10	Give four examples of interference	3	2	L1
11	Why thin transparent films appear to be beautifully colored under sunlight?	3	2	L3
12	Write any three difference between Fresnel and Fraunhofer diffraction?	3	2	L2
13	Explain air wedge arrangement with neat diagram, deduce the expression for bandwidth of air wedge arrangement and hence the diameter of thin wire using this setup.	10	2	L2

14	Newton's rings are observed by source emitting light of wavelength $\lambda1$=3000Åand $\lambda2$=2500Å.It is found that nth dark ring due to $\lambda1$coincides with (n+1)th dark ring due to $\lambda2$.If the radius of curvature of lens is 90cm, calculate the diameter of nth dark ring of $\lambda1$.	4	2	L3
15	Explain the construction of a grating and derive grating equation.	10	2	L2
16	A plane transmission grating of length 6cmhas 5000lines/cm. Find the resolving power of grating and the smallest wavelength difference that can be resolved for light of wavelength 5000Åin the second order.	4	2	L3
17	Describe with necessary theory experiment to determine the diameter of thin wire using air wedge. A thin soap film seen in sodium light by normal reflection appears totally dark. Deduce the possible values of film thickness (μ=1.3333,λ=589.3 nm)	14	2	L2
18	Discuss the theory of plain transmission grating and also derive the expression sin $\theta=n\lambda$ Determine the highest order spectrum which may be seen with light of wavelength $5x10^{-5}$ cm by means of grating 3000 lines/c	14	2	L2
19	How will you determine liquid forming newton's ring	10	2	L2
20	Describe a method for determination of wavelength of a monochromatic radiation using newton's ring	10	2	L2
21	A parallel beam of light consisting of two wavelength 5890Å and 5896Å is incident normally on a grating having 6000 lines/cm . calculate the angular separation between the two diffracted lines in the second order	4	2	L3
22	A grating has 6000 lines/cm. Find the angular separation of the two yellow lines of mercury of wavelength 577nm and 579nm in the second order.	4	2	L3

23	What is the highest order of spectrum which may be seen with light of wavelength $5x10^{-5}$ cm by means of grating with 3000 lines/cm	4	2	L3
24	In a newton's ring experiment diameter of the 4^{th} and 12^{th} dark rings are 0.400cm and 0.700cm respectively. Obtain the diameter of 20^{th}dark ring	4	2	L3
25	Newton's rings are formed with reflected light of wavelength $5896x10^{-10}$m with a liquid between the plane and curved surface. The diameter of the 5^{th} ring is 0.3cm and the radius of curvature of the curved surface is 1metre. Calculate the refractive index of the liquid.	4	2	L3
26	Newton's rings are observed in reflected light of wavelength $5.9x10^{-5}$cm. The diameter of the 10^{th} dark ring is .05cm. find the radius of curvature of the lens and thickness of the air film	4	2	L3
Module 3				
1	State and explain Heisenberg's uncertainty principle	3	3	L1
2	Define linear operator	3	3	L1
3	Explain the effect of increased surface to volume ratio	3	3	L2
4	Explain magnetic properties of Nano materials	3	3	L2

5	Explain electric properties of Nano materials	3	3	L1
6	Write a note on optical properties of Nano materials	3	3	L1
7	Define tunneling. Name two electronic devices based on this phenomenon	3	3	L1
8	Explain the probability interpretation of the wave function	3	3	L1
9	Define wave function. Write its normalization condition	3	3	L1
10	Explain NANO ring and its application	3	3	L2
11	Give the physical significance of the wave function.	3	3	L2
12	What are the reasons for the change of properties of materials at nano sizes?	3	3	L2
13	Apply Schrodinger equation to derive the energy values and normalized wave functions for a particle confined to an infinite potential box of width L.	10	3	L2
14	Explain the phenomenon of quantum mechanical tunneling with any two examples	4	3	L2
15	Write a note on quantum confinement and based on this explain nano sheets, nano wire and quantum dots.	10	3	L2
16	Write any four applications of nanotechnology in medical field.	4	3	L2
17	Deduce Schrödinger's time dependent equation from the operators for position and momentum. Which of the following functions are Eigen functions of the operator d^2/dx^2? Find the Eigen values in the case: a) cos x b) sin nx c) $\sin^2 x$	14	3	L3
18	Write short note on a) Nano sheets b) Nano wires c) quantum dots. Find the de-Broglie wavelength of an electron having energy 15 ev	14	3	L2
19	Explain nanostructures with its application	10	3	L2
20	Explain the properties of nanomaterial's	10	3	L2

21	Solve Schrödinger's equation for a particle in one dimensional box and obtain the following: (i)Energy values and (ii)Normalized wave function	10	3	L2
22	An electron is confined to one dimensional box of width "L" is known to the in its first exited state. Determine the probability density of electron in the central half	10	3	L2
23	If the kinetic energy of an electron known to be about 1ev, must be measured to within 0.0001ev, what accuracy can its position be measured simultaneously	10	3	L2
Module 4				
1	State faradays low of electromagnetic induction	3	4	L2
2	Define magnetic susceptibility	3	4	L1
3	Obtain the relation b/t relative permeability and susceptibility	3	4	L2
4	Give the properties of para, dia and Ferro magnetic materials	3	4	L1
5	Compare the displacement current and conduction current	3	4	L2
6	Compare the magnetic properties of steel and air.	3	4	L1
7	State a) gauss law b) Ampere's circuital law	3	4	L1
8	Calculate m for material with μr=1.4 and h=350a/m	3	4	L2
9	Distinguish b/t para, die and Ferro magnetic materials write down Maxwell's equations in magnetism and explain the meaning of each one	3	4	L2
10	Derive free space electromagnetic wave equations from Maxwell's law and show that velocity of electromagnetic wave is $1/\sqrt{\mu 0\ \varepsilon 0}$	3	4	L1
11	Distinguish between musical sound and noise?	3	4	L2
12	Mention the properties of ultrasonic waves and list its significant industrial and medical applications?	3	4	L2
13	What is Piezo electric effect? Explain with a circuit diagram the generation of ultrasonics using a piezo electric oscillator.	10	4	L2
14	A quartz crystal of thickness 1mm is vibrating at resonance. Calculate the fundamental frequency, given Youngs modulus=$7.9x10^{10}$ $N/m^2$and density=2650Kg/m^3.	4	2	L3
15	Explain the terms i) Decibel ii) Sabine's formula iii) reverberation iv) reverberation time v) echo.	10	4	L2
16	A cinema hall has a volume of 20000m^3.It is required to have a reverberation time of 4s. What should be the total absorption of the hall?	4	4	L3
17	Give some applications of ferromagnetic materials	3	4	L1
18	Define magnetizing field in terms of flux density and magnetization	4	4	L3
19	State faradays low of electromagnetic induction	4	4	L3
20	Define magnetic susceptibility	4	4	L3
21	Obtain the relation b/t relative permeability and susceptibility	4	4	L3
22	Give the properties of para, Dia and Ferro magnetic materials	4	4	L3
23	Compare the displacement current and conduction current	4	4	L3
Module 5				
1	What is Meissner effect	3	5	L1

2	Name two different types of optic sensors	3	5	L1
3	Define step index fiber	3	5	L2
4	Define graded index fiber	3	5	L2
5	Differentiate b/t a photo diode and photo transistor	3	5	L1
6	What is the principle of optic fiber cable	3	5	L2
7	Explain superconductivity.	3	5	L2
8	Write note on fiber optic sensors	3	5	L1
9	what is mean by the numerical aperture of optic fiber	3	5	L1
10	Write down important applications of superconductivity	3	5	L1
11	What do you mean by pumping in lasers? List any three pumping methods used.	3	5	L2
12	Draw a properly labelled block diagram of a fibre optic communication system.	3	5	L1
13	With properly labelled diagrams, explain the construction and working of He-Ne Laser.	10	5	L2
14	Calculate the acceptance angle and critical angle for a step index fibre whose refractive index are 1.5(core) and 1.45(cladding). The launching medium is air.	4	5	L3
15	What do you mean by acceptance angle and acceptance cone of an optical fibre? Obtain the expression for the acceptance angle of an optic fibre.	10	5	L2
16	Distinguish between spontaneous and stimulated emissions.	4	5	L2
17	Write a short note on high temperature superconductors	3	5	L2
18	Derive the expression for the numerical aperture(n) of a step index fiber.	10	5	L2
19	Calculate the acceptance angle for the following data n1=1.53, n2=1.5, n3=1	4	5	L3
20	Show that super conductress is perfectly dia magnets	10	5	L2
21	Distinguish b/t type 1 and type 2 superconductors with suitable example	4	5	L3
22	Draw the block diagram of optic fibre communication system. Explain its various functional blocks	10	5	L2
24	Differentiate between a photo diode and a photo transistor	3	5	L2
25	Draw and explain VI characteristics of a photo transistor	3	5	L2

Prepared By: Ms.Sreeja C

Checked By: Ms. Dhanya George P, Course Committee Chairman

Course Code & Name: EST100 Engineering Mechanics

1. Prescribed Syllabus

Module	Topic	Hours
1	Introduction to Engineering Mechanics-statics-basic principles of statics-Parallelogram law, equilibrium law, principles of superposition and transmissibility, law of action and reaction(review) free body diagrams. Concurrent coplanar forces-composition and resolution of forces-resultant and equilibrium equations – methods of projections – methods of moments – Varignon's Theorem of moments.	**7**
2	Friction – sliding friction - Coulomb's laws of friction – analysis of single bodies –wedges, ladder-analysis of connected bodies. Parallel coplanar forces – couple - resultant of parallel forces – centre of parallel forces – equilibrium of parallel forces – Simple beam subject to concentrated vertical loads. General coplanar force system - resultant and equilibrium equations.	**7**
3	Centroid of composite areas- – moment of inertia-parallel axis and perpendicular axis theorems. Polar moment of inertia, radius of gyration, mass moment of inertia-ring, cylinder and disc. Theorem of Pappus Guldinus (demonstration only) Forces in space - vectorial representation of forces, moments and couples –resultant and equilibrium equations – concurrent forces in space (simple problems only)	**7**
4	Dynamics – rectilinear translation - equations of kinematics (review) kinetics – equation of motion – D'Alembert's principle. – motion on horizontal and inclined surfaces, motion of connected bodies. Impulse momentum equation and work energy equation (concepts only). Curvilinear translation - equations of kinematics –projectile motion (review), kinetics – equation of motion. Moment of momentum and work energy equation (concepts only).	**7**
5	Rotation – kinematics of rotation- equation of motion for a rigid body rotating about a fixed axis – rotation under a constant moment. Plane motion of rigid body – instantaneous centre of rotation (concept only). Simple harmonic motion – free vibration –degree of freedom- undamped free vibration of spring mass system-effect of damping(concept only)	**7**

2. Text Books (T)

T1. Timoshenko and Young, Engineering Mechanics, McGraw Hill Publishers

T2. Shames, I. H., Engineering Mechanics - Statics and Dynamics, Prentice Hall of India.

T3. R. C. Hibbeler and Ashok Gupta, Engineering Mechanics, Vol. I statics, Vol II Dynamics, Pearson Education.

T4. Benjamin J., Engineering Mechanics, Pentex Book Publishers and Distributors

3. Reference Books (R)

R1. Merriam J. L and Kraige L. G., Engineering Mechanics - Vols. 1 and 2, John Wiley.
R2. Tayal A K, Engineering Mechanics – Statics and Dynamics, Umesh Publications
R3. Bhavikkatti, S.S., Engineering Mechanics, New Age International Publishers
R4. F.P.Beer abd E.R.Johnston (2011), Vector Mechanics for Engineers, Vol.I-Statics, Vol.II-Dynamics, 9th Ed, Tata McGraw Hill
R5. Rajasekaran S and Sankarasubramanian G, Engineering Mechanics - Statics and Dynamics, Vikas Publishing House Pvt Ltd.

4. Course Objectives

To expose the students to the fundamental concepts of mechanics and enhance their problem-solving skills. It introduces students to the influence of applied force system and the geometrical properties of the rigid bodies while stationary or in motion. After this course students will be able to recognize similar problems in real-world situations and respond accordingly.

5. Course Pre / Co-requisite

NIL

6. Course Outcomes

On successful completion of this course students shall be able to
CO1: Recall principles and theorems related to rigid body mechanics
CO2: Identify and describe the components of system of forces acting on the rigid body
CO3: Apply the conditions of equilibrium to various practical problems involving different force system.
CO4: Choose appropriate theorems, principles or formulae to solve problems of mechanics
CO5: Solve problems involving rigid bodies, applying the properties of distributed areas and masses.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	M													
CO2	H	H													

CO 3	H	H													
CO 4	H	H													
CO 5	H	H													

8. Justification for CO-PO-PSO Correlation

CO1	PO1	The principles and theorems related to rigid body mechanics are applied to solve the engineering problems. Medium correlation is due to the fact that this involves the basic knowledge of mathematics and science to solve the complex engineering problems.
	PO2	The principles and theorems related to rigid body mechanics are used to identify, formulate and analyse the complex engineering problems. Medium correlation is due to the fact that this involves the basic knowledge using first principles of mathematics, science and engineering.
CO2	PO1	The components of system of forces acting on the rigid body are used to solve the engineering problems. High correlation is due to the fact that this involves the deep knowledge of mathematics and science to solve the complex engineering problems.
	PO2	The components of system of forces acting on the rigid body are used to identify, formulate and analyse the complex engineering problems. High correlation is due to the fact that this involves the deep knowledge using first principles of mathematics, science and engineering.
CO3	PO1	The conditions of equilibrium are used to solve the engineering problems. High correlation is due to the fact that this involves the deep knowledge of mathematics and science to solve the complex engineering problems.
	PO2	The conditions of equilibrium are used to identify, formulate and analyse the complex engineering problems. High correlation is due to the fact that this involves the deep knowledge using first principles of mathematics, science and engineering.
CO4	PO1	The theorems, principles or formulae should be appropriately used to solve the engineering problems. High correlation is due to the fact that this involves the deep knowledge of mathematics and science to solve the complex engineering problems.
	PO2	The theorems, principles or formulae should be appropriately used to identify, formulate and analyse the complex engineering problems. High correlation is due to the fact that this involves the deep knowledge using first principles of mathematics, science and engineering.
CO5	PO1	The knowledge in the properties of distributed areas and masses are necessary to solve the engineering problems. High correlation is due to the fact that this involves the deep knowledge of mathematics and science to solve the complex engineering problems.
	PO2	The properties of distributed areas and masses are used to identify, formulate and analyse the complex engineering problems. High correlation is due to the fact that this involves the deep knowledge using first principles of mathematics, science and engineering.

9. Curricular gaps (if any)

- Derivation of centroid and moment of inertia of different laminae.

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	Centroid and moment of inertia of different laminae	NPTEL https://youtu.be/ZwuwzE1qAi4	PO1, PO4

11. Internal Assessment mark allocation (as per university curriculum)

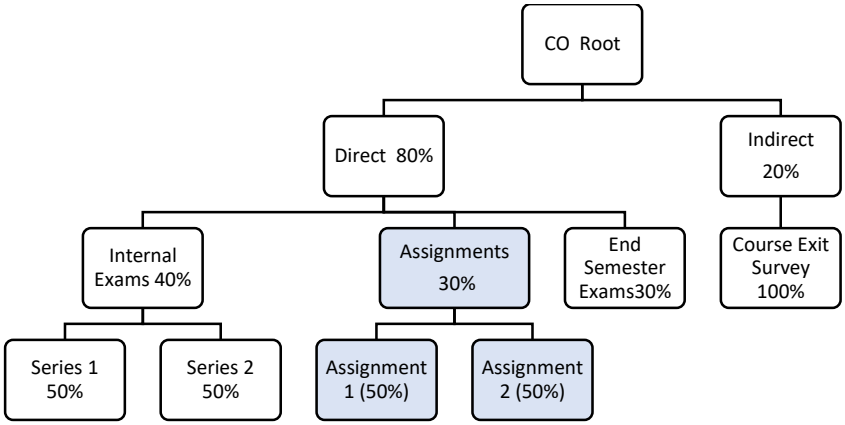
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		Weightage #	CO 1	CO 2	CO 3	CO 4	CO 5
Direct Assessment Tools**	Internal Exam(s) - 40%	Series 1	20%	x	x	x	x	
		Series 2	20%	x	x	x	x	x
	Assignment (s)/ Course Project /Quiz etc. - 30%	Assignment 1	15%	x	x	x	x	
		Assignment 2	15%			x	x	x
	End Semester Exam		30%	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

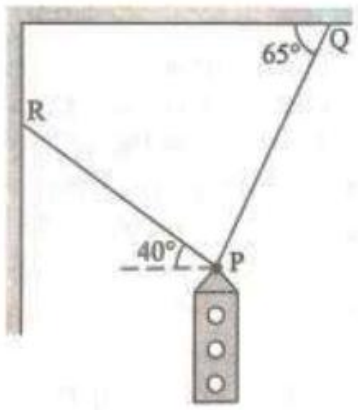
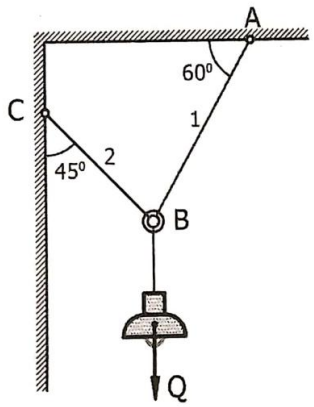
Sl. no	Topic Name	Module	Reference	Teaching Pedagogy
1	Introduction to engineering mechanics – introduction on statics and dynamics - Basic principles of statics – parellogram law, equilibrium law – Superposition and transmissibility, law of action and reaction (review the topics)	1	T4, R2, R3	Lecture
2	Free body diagrams. Degree of freedom-types of supports and nature of reactions - exercises for free body diagram preparation – composition and resolution of forces, resultant and equilibrium equations (review the topics) - numerical exercises for illustration.	1	T4, R2, R3	Lecture
3	Concurrent coplanar forces - analysis of concurrent forces –methods of projections – illustrative numerical exercise – teacher assisted problem solving.	1	T4, R2, R3	Lecture
4	Analysis of concurrent forces -methods of moment-Varignon's Theorem of Moments - illustrative numerical exercise– teacher assisted problem solving.	1	T4, R2, R3	Lecture
5	Analysis of concurrent force systems – extended problem solving - Session I.	1	T4, R2, R3	Lecture
6	Analysis of concurrent force systems – extended problem solving - Session II – learning review quiz.	1	T4, R2, R3	Tutorial
7	Analysis of concurrent force systems – extended problem solving - Session III.	1	T4, R2, R3	Lecture
8	Friction – sliding friction - Coulomb's laws of friction – analysis of single bodies –illustrative examples on wedges and ladder-teacher assisted problem solving tutorials using problems from wedges and ladder.	2	T4, R2, R3	Lecture
9	Problems on friction - analysis of connected bodies. Illustrative numerical exercise– teacher assisted problem solving.	2	T4, R2, R3	Lecture
10	Problems on friction-extended problem solving	2	T4, R2, R3	Tutorial
11	Parallel coplanar forces – couple - resultant of parallel forces – centre of parallel forces – equilibrium of parallel forces – Simple beam subject to concentrated vertical loads.	2	T4, R2, R3	Lecture

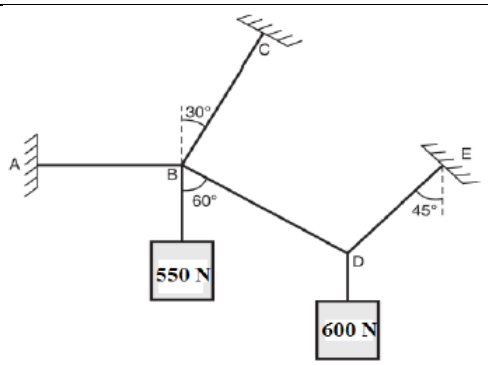
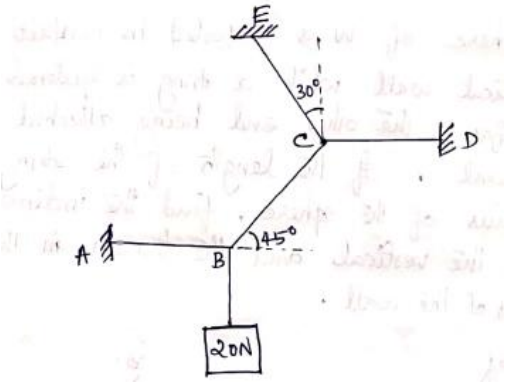
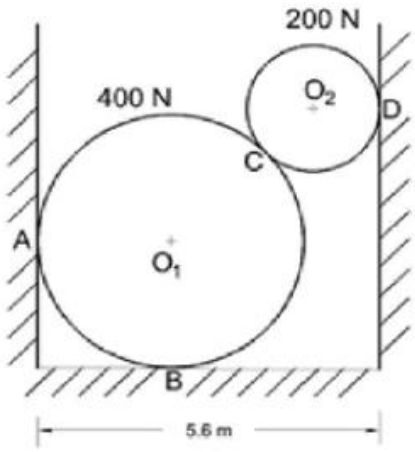
12	General coplanar force system - resultant and equilibrium equations - illustrative examples- teacher assisted problem solving.	2	T4, R2, R3	Tutorial
13	General coplanar force system-resultant and equilibrium equations - illustrative examples	2	T4, R2, R3	Lecture
14	General coplanar force system - Extended problem solving - Quiz to evaluate learning level.	2	T4, R2, R3	Lecture
15	Centroid of simple and regular geometrical shapes – centroid of figures in combination - composite areas- examples for illustration – problems for practice to be done by self.	3	T4, R2, R3	Lecture
16	Moment of inertia- parallel axis theorem –examples for illustration - problems for practice to be done by self.	3	T4, R2, R3	Lecture
17	Moment of inertia - perpendicular axis theorem - example for illustration to be given as hand out and discussion on the solved example.	3	T4, R2, R3	Lecture
18	Solutions to practice problems – problems related to centroid and moment of inertia - problems for practice to be done by self	3	T4, R2, R3	Tutorial
19	Polar moment of inertia, Radius of gyration. Mass moment of inertia of ring, cylinder and uniform disc. Theorem of Pappus Guldinus - Demonstration	3	T4, R2, R3	Lecture
20	Introduction to forces in space – vectorial representation of forces, moments and couples – simple problems to illustrate vector representations of forces, moments and couples to be done in class.	3	T4, R2, R3	Tutorial
21	Solution to practice problems - resultant and equilibrium equations for concurrent forces in space – concurrent forces in space - 2 simple problems to illustrate the application of resultant and equilibrium equations for concurrent forces in space	3	T4, R2, R3	Lecture
22	Introduction to dynamics – review of rectilinear translation - equations of kinematics – problems to review the concepts –additional problems involving extended application as exercises .	4	T4, R2, R3	Lecture
23	Solutions to exercises with necessary explanation given as hand out –introduction to kinetics – equation of motion – D'Alembert's principle– illustration of the concepts using one numerical exercise from motion on horizontal and inclined surfaces.	4	T4, R2, R3	Lecture
24	Motion of connected bodies - example for illustration to be given as hand out and discussion on the solved example – problems for practice to be done by self.	4	T4, R2, R3	Lecture
25	Motion of connected bodies-extended problem solving.	4	T4, R2, R3	Lecture
26	Curvilinear translation - Review of kinematics – projectile motion – simple problems to review the concepts – introduction to kinetics – equation of motion – illustration of the concepts using numerical exercises.	4	T4, R2, R3	Lecture
27	Extended problem solving – rectilinear and curvilinear translation.	4	T4, R2, R3	Tutorial
28	Concepts on Impulse momentum equation and work energy equation (rectilinear translation – discussions to	4	T4, R2, R3	Lecture

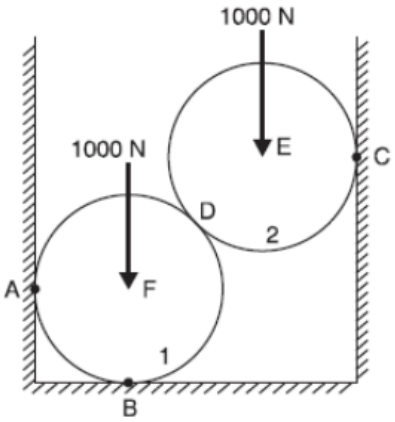
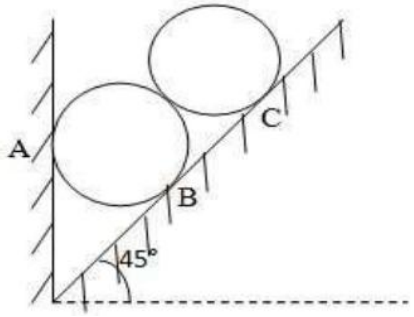
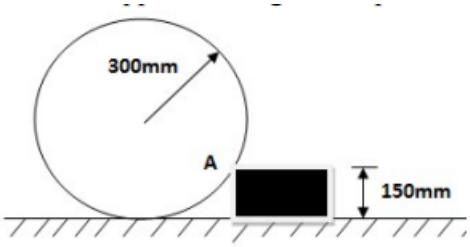
	bring out difference between elastic and inelastic collusions). Concepts on Moment of momentum and work energy equation (curvilinear translation).			
29	Rotation – kinematics of rotation- equation of motion for a rigid body rotating about a fixed axis – simple problems for illustration.	5	T4, R2, R3	Lecture
30	Rotation under a constant moment – teacher assisted problem solving.	5	T4, R2, R3	Lecture
31	Rotation under a constant moment - extended problem solving.	5	T4, R2, R3	Lecture
32	Plane motion of rigid body- instantaneous centre of rotation (concept only).	5	T4, R2, R3	Lecture
33	Introduction to harmonic oscillation –free vibrations – simple harmonic motion – differential equation and solution. Degree of freedom – examples of single degree of freedom (SDOF) systems – Idealisation of mechanical systems as spring-mass systems (concept only).	5	T4, R2, R3	Tutorial
34	SDOF spring mass system –equation of motion – undamped free vibration response - concept of natural frequency. Free vibration response due to initial conditions. Simple problems on determination of natural frequency and free vibration response to test the understanding level.	5	T4, R2, R3	Lecture
35	Free vibration analysis of SDOF spring-mass systems – Problem solving Effect of damping on free vibration response (concept only).	5	T4, R2, R3	Lecture
36				

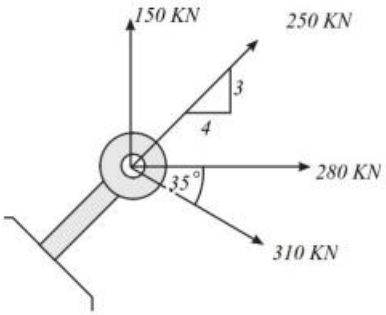
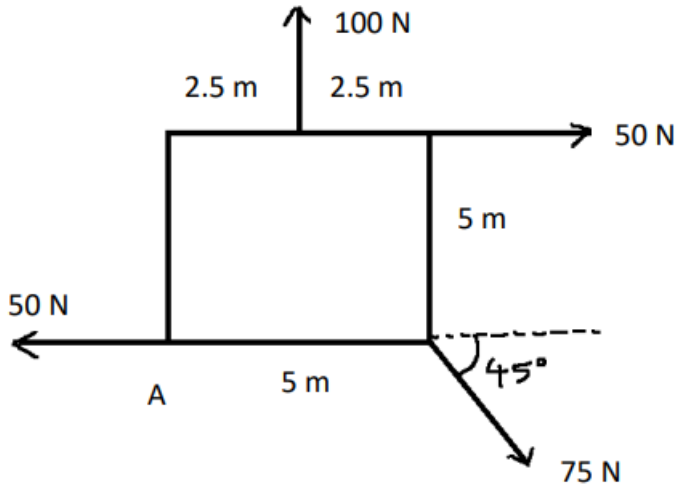
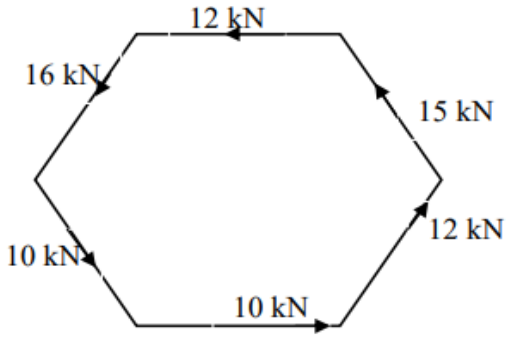
15. Question Bank

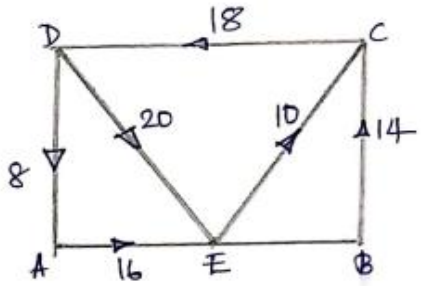
Module 1 and 2				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	State and illustrate the principle of Transmissibility of forces.	**3**	**CO2**	**L1**
2	State & illustrate the principle of Superposition & principle of Transmissibility of forces.	**3**	**CO2**	**L1**
3	Explain Free Body Diagram with figures.	**3**	**CO1**	**L1**
4	Describe the conditions of equilibrium in concurrent Force system.	**3**	**CO1**	**L1**
5	Differentiate rolling friction and sliding friction	**3**	**CO1**	**L1**
6	Briefly explain the terms coefficient of friction & angle of friction.	**3**	**CO1**	**L1**
7	A traffic signal of mass 500 N is hung with the help of two strings, as shown in figure below. Find the forces induced in the strings using Lami's theorem.	**3**	**CO2**	**L2**

				
8	An electric light fixture of weight Q (40N) is supported as shown in figure. Determine the tensile forces in the wires BC & BA if their angle of inclination are as shown (use Lami's theorem). 	**3**	**CO2**	**L2**
9	The resultant of 2 forces when they act at right angles is 12N. When the forces act at an angle of 60^0, their resultant is 14N. Determine the magnitude of the forces.	**10**	**CO3**	**L3**
10	The greatest and least resultants of two forces F1 and F2 are 17 N and 3N respectively. Determine the angle between them when their resultant is $\sqrt{\mathbf{149}}$ N.	**10**	**CO3**	**L3**
11	The system of connected flexible cables shown in figure is supporting two loads of 550 N and 600 N at points B and D, respectively. Determine the tensions in the various segments of the cable.	**10**	**CO3**	**L3**

				
12	Determine the tension in all strings in the given figure. 	**10**	**CO3**	**L3**
13	Two cylinders of weights 400 N and 200 N with radius 2m and 1m rest in a horizontal channel having vertical walls and base width 5.6m as shown in figure A. Find the reactions at A,B and D. 	**14**	**CO3**	**L3**
14	Two spheres, each of weight 1000N and radius 25 cm rest in a horizontal channel of width 90cm as shown in the figure. Find the reactions on the point of contacts A, B and C	**14**	**CO4**	**L3**

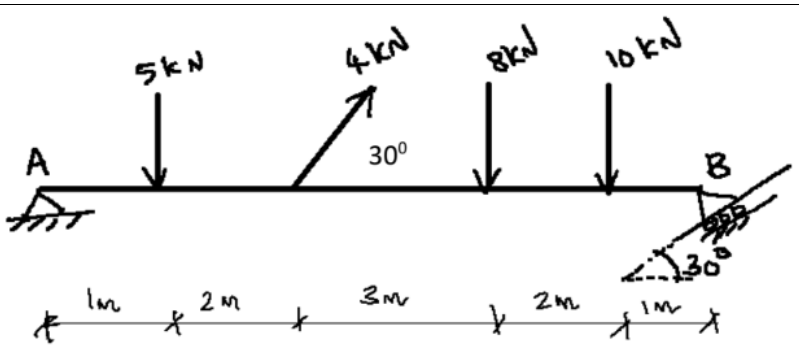
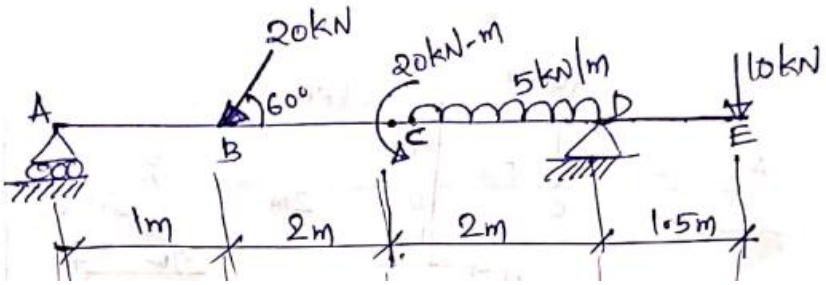
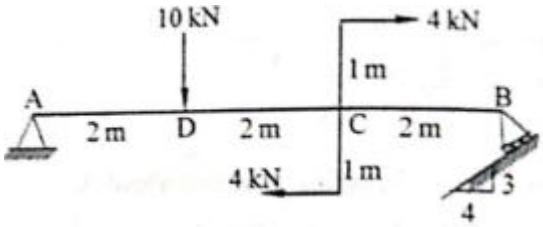
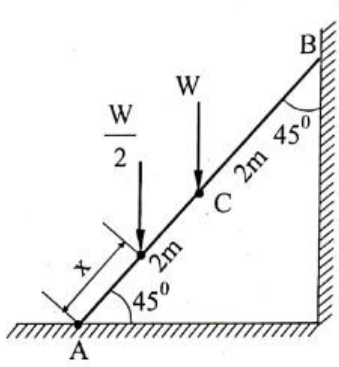
				
15	Two rollers each of weight 75 N are supported by an inclined plane and a vertical wall. Find the reaction at the points of contact A, B, C. Assumeall the surfaces to be smooth. 	**14**	**CO3**	**L3**
16	A roller of radius 300 mm and weight 1000N is to be pulled over a rectangular block of height 150mm as shown in fig. Determine (i) the horizontal force required to be applied through the centre and (ii) the required horizontal force when it is applied through the top end of vertical diameter. 	**14**	**CO3**	**L3**
17	Four forces are acting on a bolt as shown in Figure. Determine the magnitude and direction of the resultant force	**10**	**CO3**	**L3**

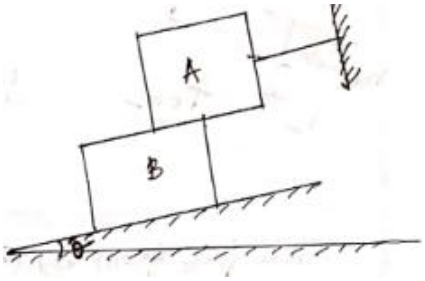
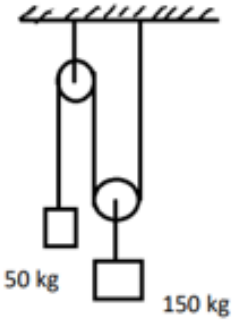
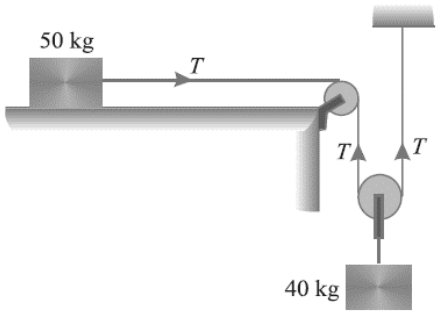
				
18	For the system of forces, determine the magnitude, direction and position of the resultant force about A. 	**14**	**CO4**	**L3**
19	Six forces of magnitude 10 kN, 12 kN, 15 kN, 12 kN, 16 kN, and 10 kN are acting along the sides of the regular hexagon of side 2 m in order. Find the resultant force and its position about the centre O. 	**14**	**CO4**	**L3**
20	ABCD is rectangle in which AB=30mm, BC=20mm. 'E' is the midpoint of AB. Forces of magnitudes 16,14,18,8, 10 and 20N act along AB, BC,CD, DA, EC and DE respectively. Find the magnitude, direction and position with respect to ABCD of single	**14**	**CO4**	**L3**

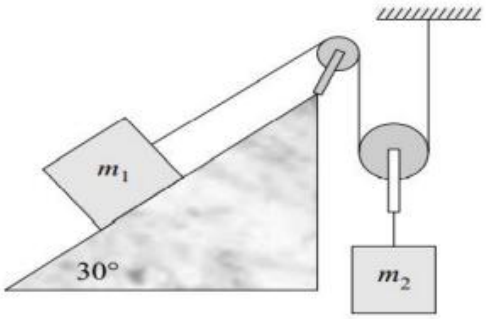
	force to keep the body in equilibrium. B is to the right side of A and taken in anticlockwise direction 			

Module 2,4 and 5

Sl. No.	Question	Marks	CO	BL
1	State Coulombs Laws of Friction.	**3**	**CO1**	**L1**
2	Enlist the properties of couple.	**3**	**CO1**	**L1**
3	State & explain D'Alembert's principle.	**3**	**CO1**	**L1**
4	Interpret the use of wedge friction for lifting a heavy object, using a neat sketch.	**3**	**CO1**	**L2**
5	A burglar's car had a start with an acceleration of 2 m/s^2. A police vigilant party came after 5 seconds and continued to chase the burglar's car with a uniform velocity of 20 m/s. Determine the time taken in which the police van will overtake the burglar's car.	**3**	**CO4**	**L2**
6	On turning a corner, a motorist rushing at 20 m/s, finds a child on the road 50 m ahead. He instantly stops the engine and applies brakes, so as to stop the car within 10 m of the child. Determine the retardation, and time required to stop the car.	**3**	**CO4**	**L2**
7	A stone is dropped from the top of a tower 70 m high. At the same time another stone is thrown up from the foot of the tower with a velocity of 30 m/s. At what distance from the top and after how much time the two stones cross each other?	**3**	**CO4**	**L2**
8	A lift has upward acceleration of 1.225 m/s^2. Determine the pressure exerted by a man weighing 500N on the floor of the lift. Calculate the pressure when the lift is moving with same acceleration in the downward direction.	**3**	**CO4**	**L2**
9	An elevator weighing 2.5 kN is moving vertically downward with a constant acceleration. Starting from rest, it travels a distance of 35 m during an interval of 10 seconds. Calculate the cable tension during this time.	**3**	**CO4**	**L2**
10	Calculate the increase in reaction under the feet of person of weight 600 N in a lift, if the lift accelerates upward with an acceleration 1m/s^2.			
11	For the beam with loading shown in the figure , determine the reaction at the support.	**10**	**CO3**	**L3**

				
12	For the beam with loading shown in figure, determine the reactions at the supports. 	**10**	**CO3**	**L3**
13	A beam 6m long is loaded as shown in figure. Calculate the reactions at A and B 	**10**	**CO3**	**L3**
14	A uniform ladder of 4m length rests against a wall which it makes an angle 45^0 as shown in the figure. The coefficient of friction between the ladder and the wall is 0.4 and between the ladder and the floor is 0.5. If a man whose weight is half of that of ladder ascends it, how high will he when the ladder slips. 	**10**	**CO3**	**L3**

15	A ladder 3m long weighs 180N, is placed against a wall with A at the floor level and B on the wall. The ladder is inclined at 60^0 with the floor. The coefficient of friction between the wall and the ladder is 0.25 and between the floor and the ladder is 0.35. In addition to the self weight of the ladder, it has to support a man weighing 900N at the top B. To prevent slipping a force is applied horizontally at the level of floor. Determine the minimum horizontal force in this condition	**10**	**CO3**	**L3**
16	A ladder 5m long and weighing 260N is placed against a vertical wall with an inclination of 30^0 with the wall. A man weighing 780N climbs the ladder. When he is at a distance of 1.64m along the ladder from the lower end, the ladder slips. What is the coefficient of friction assuming it to be the same for all contact surfaces?	**10**	**CO3**	**L3**
17	What should be the value of angle Θ for block B weighing 90N to impend down the plane? μ for all the surface is equal to 1/3. Block A weighs 30N. A is held in position as shown in figure. 	**10**	**CO3**	**L3**
18	Determine the tension in strings and acceleration of two blocks of masses 150kg and 50kg connected by a string and frictionless and weightless pulley as shown in figure. 	**14**	**CO4**	**L3**
19	Two blocks of mass 50 kg and 40 kg are connected by a light inextensible string as shown in Figure. Determine the acceleration of the system and tensions in the cable. Take μ = 0.3. 	**14**	**CO4**	**L3**

20	Determine the acceleration of the system of the blocks shown in Fig. The coefficient of kinetic friction between the block 1 and the inclined plane is 0.15. Also, determine the tension in the string. Take m1 = 75 kg, m2 = 50 kg.  	**14**	**CO4**	**L3**
21	A shaft is uniformly accelerated from 10 rev/s to 18 rev/s in 4 seconds. The shaft continues to accelerate at this rate for the next 8 seconds. Thereafter the shaft rotates with a uniform angular speed. Determine the total time to complete 400 revolutions.	**14**	**CO4**	**L3**
22	A flywheel rotates with constant retardation due to breaking. In the first 10 seconds, it made 300 revolutions. At t = 7.5 seconds, its angular velocity was 40π rad/s. Determine 1) Value of constant retardation. 2) Total time taken to come to rest. 3) Total revolutions made till it comes to rest.	**14**	**CO4**	**L3**
23	A wheel rotates for 5 seconds with a constant angular acceleration and describes during this time 100 radians. It then rotates with a constant angular velocity and during the next 5 seconds describes 80 radians. Find the initial angular velocity and the angular acceleration.	**14**	**CO4**	**L3**

Prepared By : ASHA K R, Course Faculty

Checked By: ……., Course committee Chairperson

Approved by : KANAKA XAVIER, VP- Academics

Course Code & Name: EST 130 Basics of Electrical and Electronics Engineering

1. Prescribed Syllabus

Module	Topic	Hours
1	Elementary Concepts of Electric Circuits- Elementary concepts of DC electric circuits: Basic Terminology including voltage, current, power, resistance, emf; Resistances in series and parallel; Current and Voltage Division Rules; Capacitors &Inductors: V-I relations and energy stored. Ohms Law and Kirchhoff's Laws-Problems; Star- delta conversion (resistive networks only-derivation not required)- problems.	1
2	Elementary Concepts of Magnetic circuits, Electromagnetic Induction and AC Fundamentals- Magnetic Circuits: Basic Terminology: MMF, field strength, flux density, reluctance – comparison between electric and magnetic circuits- Series and parallel magnetic circuits with composite materials, numerical problems. Electromagnetic Induction: Faraday's laws, problems, Lenz's law-statically induced and dynamically induced emfs - Self-inductance and mutual inductance, coefficient of coupling Alternating Current fundamentals: Generation of alternating voltages-Representation of sinusoidal waveforms: frequency, period, Average, RMS values and form factor of waveforms-Numerical Problems.	8
3	AC Circuits: Phasor representation of sinusoidal quantities. Trigonometric, Rectangular, Polar and complex forms. Analysis of simple AC circuits: Purely resistive, inductive & capacitive circuits. Inductive and capacitive reactance, concept of impedance. Average Power factor. Analysis of RL, RC and RLC series circuits-active, reactive and apparent power. Simple numerical problems. Three phase AC systems: Generation of three phase voltages; advantages of three phase systems, star and delta connections (balanced only), relation between line and phase voltages, line and phase currents- Numerical problems	8
4	Introduction to Semiconductor devices: Evolution of electronics – Vacuum tubes to nano electronics. Resistors, Capacitors and Inductors: types, specifications. Standard values, color coding. PN Junction diode: Intrinsic and extrinsic semiconductors, Principle of operation, V-I characteristics, principle of avalanche breakdown and working of Zener diode. Bipolar Junction Transistors: PNP and NPN structures, Principle of operation, relation between current gains in CE, CB and CC, input and output characteristics of common emitter configuration.	8
5	Basic electronic circuits and instrumentation: Rectifiers and power supplies: Block diagram description of a dc power supply, working	9

	of a full wave bridge rectifier, capacitor filter (no analysis), working of simple Zener voltage regulator. Amplifiers: Block diagram of Public Address system, Circuit diagram and working of common emitter (RC coupled) amplifier with its frequency response, Concept of voltage divider biasing. Electronic Instrumentation: Block diagram of an electronic instrumentation system, working of digital multimeter.	
6	Introduction to Communication Systems: Evolution of communication systems – Telegraphy to 5G. Radio communication: principle of AM & FM, frequency bands used for various communication systems, block diagram of super heterodyne receiver, Principle of antenna – radiation from accelerated charge, working of parabolic reflector. Mobile communication: basic principles of cellular communications, principle and block diagram of GSM.	7

2. Text Books (T)

T1. D P Kothari and I J Nagrath, "Basic Electrical Engineering", Tata McGraw Hill, 2010.
T2. D C Kulshreshtha, "Basic Electrical Engineering", Tata McGraw Hill, 2010.
T3. Chinmoy Saha, Arindham Halder and Debarati Ganguly, Basic Electronics - Principles and Applications, Cambridge University Press, 2018.
T4. M.S. Sukhija and T.K. Nagsarkar, Basic Electrical and Electronics Engineering, Oxford University Press, 2012.
T5. Wayne Tomasi and Neil Storey, A Textbook on Basic Communication and Information Engineering, Pearson, 2010.
T6. Imthias Ahamed T.P., "Basics of electrical engineering" T7. Babujan, "Basics of electrical engineering"

3. Reference Books (R)

R1. Del Toro V, "Electrical Engineering Fundamentals", Pearson Education.
R2. T. K. Nagsarkar, M. S. Sukhija, "Basic Electrical Engineering", Oxford Higher Education.
R3. Hayt W H, Kemmerly J E, and Durbin S M, "Engineering Circuit Analysis", Tata McGraw-Hill
R4. Hughes, "Electrical and Electronic Technology", Pearson Education.
R5. V. N. Mittle and Arvind Mittal, "Basic Electrical Engineering," Second Edition, McGraw Hill.
R6. Parker and Smith, "Problems in Electrical Engineering", CBS Publishers and Distributors.
R7. S. B. Lal Seksena and Kaustuv Dasgupta, "Fundamentals of Electrical Engineering", Cambridge University Press.
R8. Anant Agarwal, Jeffrey Lang, Foundations of Analog and Digital Electronic Circuits, Morgan Kaufmann Publishers, 2005.
R9. Bernard Grob, Basic Electronics, McGraw Hill.
R10. A. Bruce Carlson, Paul B. Crilly, Communication Systems: An Introduction to Signals and Noise in Electrical Communication, Tata McGraw Hill, 5th Edition.

4. Course Objectives

1. Equip the students with an understanding of the fundamental principles of Electrical engineering
2. Provide an overview of evolution of electronics, and introduce the working principle and examples of fundamental electronic devices and circuits
3. Provide an overview of evolution of communication systems and introduce the basic concepts in radio communication**.**

5. Course Pre / Co-requisite

Physics and Mathematics (Pre-university level)

6. Course Outcomes

After completion of the course, student will be able to

CO1: Apply fundamental concepts and circuit laws to solve simple DC electric circuits CO2: Develop and solve models of magnetic circuits
CO3: Apply the fundamental laws of electrical engineering to solve simple ac circuits in steady State
CO4: Describe working of a voltage amplifier.
CO5: Outline the principle of an electronic instrumentation system CO6: Explain the principle of radio and cellular communication.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO 3
CO1	**H**	**L**										**M**			
CO2	**H**	**L**										**M**			
CO3	**H**	**L**										**M**			
CO4	**H**														
CO5	**H**											**M**			
CO6	**H**											**M**			

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	PO1	Enables the students to apply the fundamental knowledge of electrical engineering and engineering mathematics for solving simple DC electric circuits
	PO2	Attributes towards the analysis of voltage and current of simple dc electrical circuits
	PO12	Enables the students to recognize the need for independent and lifelong learning in electrical field

CO2	PO1	Enhances the students to apply the knowledge of electrical engineering to solve series and parallel magnetic circuits
	PO2	Analyze the flux distributions in given magnetic circuit
	PO12	Enables the students to recognize the need and preparation for independent and lifelong learning in electrical discipline
CO3	PO1	Enables the students to apply the knowledge of electrical engineering to solve simple ac circuits in steady state
	PO2	Analyze the 1ph and 3ph ac circuits and its properties.
	PO12	Enables the students to recognize the need for independent and lifelong learning in electrical field
CO4	PO1	Knowledge in basic concepts of active and passive components will help the students to understand the working of a voltage amplifier. Hence a medium correlation is given.
CO5	PO1	Understanding the principle of an electronic instrumentation system will help the students to attain knowledge in the working of a transistor as a public address system. Hence a medium correlation is given.
	PO12	Knowledge about the fundamentals of public address systems & amplifiers will encourage students to learn advanced electronics instrumentation system in future. Hence a medium correlation is given.
CO6	PO1	Understanding the basics of radio & mobile communication will help the students to gain knowledge in fundamentals of communication techniques. Hence a medium correlation is given.
	PO12	Knowledge in principle of antenna and the modulation techniques will help the students to learn more advanced communication systems in future. Hence a medium correlation is given.

9. Curricular gaps (if any)

Energy stored in electric and magnetic field (Module 2)

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	Evolution of mobile technology	Invited Talk	PO1, PO12
2	Industrial Visit	Visit to Akashavani	PO1, PO12

11. Internal Assessment mark allocation (as per university curriculum)

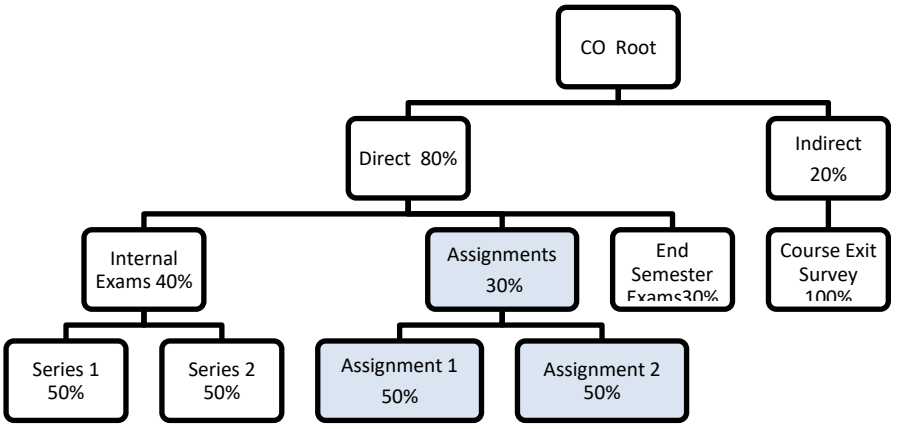
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		Weightage #	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6
Direct Assessment Tools**	Internal Exam(s) 40%	Series 1	20%	x			x		
		Series 2	20%	x	x	x	x	x	
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x			x	x	
		Assignment 2	15%		x	x			x
	End Semester Exam		30%	x	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
Module 1				
1	Introduction	1	T1	Lecture
2	Elementary Concepts: Current, Voltage,Resistance, Power, Energy. Series & Parallel circuits	1	T1	Lecture
3	Current and Voltage Division Rule	1	T1	Lecture
4	Current and Voltage Division Rule – Simple Numerical	1	T1	Lecture
5	Capacitor and Inductor: V-I Relations and Energy Stored	1	T1	Lecture
6	Ohm’s Law and Kirchhoff's laws	1	T1	Lecture
7	Mesh Analysis	1	T1	Lecture
8	Mesh Analysis-Matrix Method	1	T1	Lecture
9	Nodal Analysis	1	T1	Lecture
10	Nodal Analysis	1	T1	Lecture
11	Nodal Analysis-Matrix method	1	T1	Lecture
12	Star Delta Conversion	1	T1	Lecture
13	Star Delta Conversion	1	T1	Lecture
Module 2				
14	Magnetic circuit: Basic terminology	2	T1	Lecture
15	Comparison of electric and magnetic circuits, series magnetic circuit	2	T1	Lecture
16	Parallel magnetic circuit	2	T1	Lecture
17	Class Test	2	T1	Lecture
18	Electromagnetic Induction, Faraday's laws, Lenz's law; statically induced and dynamically induced emfs	2	T1	Lecture
19	Self-inductance and mutual inductance,	2	T1	Lecture
20	coefficient of coupling	2	T1	Lecture
21	Generation of alternating voltages	2	T1	Lecture

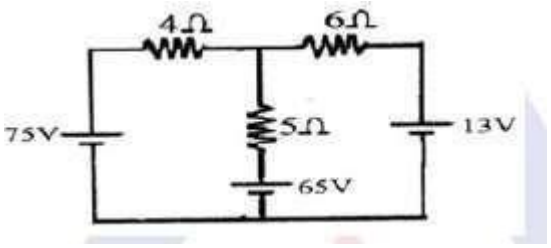
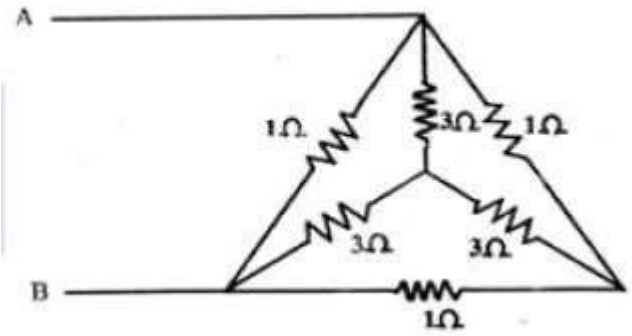
22	Representation of sinusoidal waveforms: frequency, period, average value, RMS value and form factor	2	T1	Lecture
23	Average value, RMS value and form factor Value - numerical problems	2	T1	Lecture
24	Average value, RMS value and form factor Value - numerical problems	2	T1	Lecture
Module 3				
25	AC Circuits: Phasor representation of	3	T1	Lecture
	sinusoidal quantities, Trigonometric, Rectangular, Polar and complex forms			
26	Analysis of AC Circuits: Purely resistive, inductive & capacitive circuits;	3	T1	Lecture
27	Inductive and capacitivereactance, concept of impedance	3	T1	Lecture
28	Analysis of RL and RC series circuit - power factor, active, reactive and apparent power.	3	T1	Lecture
29	Analysis of RLC series circuit - power factor, active, reactiveand apparent power.	3	T1	Lecture
30	RL, RC and RLC series circuits - numerical problems	3	T1	Lecture
31	RL, RC and RLC series circuits - numerical problems	3	T1	Lecture
32	Three phase AC systems: Generation of three phase voltages, advantages of Three-phase systems	3	T1	Lecture
33	Star and delta connections (balanced only), relation between line and phase voltages, line and phase currents	3	T1	Lecture
34	Star and delta connections (balanced only) - numerical problems	3	T1	Lecture
Module 4				
35	Evolution of electronics – Vacuum tubes to nano electronics (In evolutional perspective only)	4	T3, T4	Lecture
36	Resistors, Capacitors and Inductors: types, specifications.	4	T3, T4	Lecture

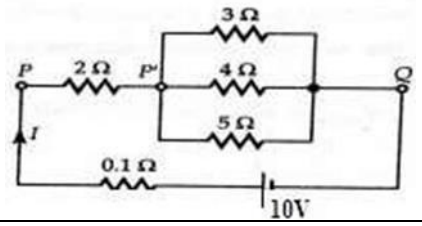
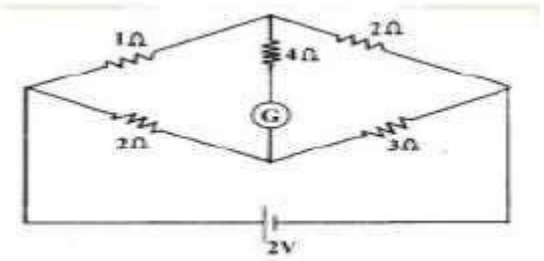
37	Standard values, color coding (No constructional features)	4	T3, T4	Lecture
38	PN Junction diode: Principle of operation, V-I characteristics	4	T3, T4	Lecture
39	principle of avalanche breakdown	4	T3, T4	Lecture
40	Bipolar Junction Transistors: PNP and NPN structures	4	T3, T4	Lecture
41	Principle of operation, relation between current gains in CE, CB and CC	4	T3, T4	Lecture
42	input and output characteristics of common emitter configuration	4	T3, T4	Lecture

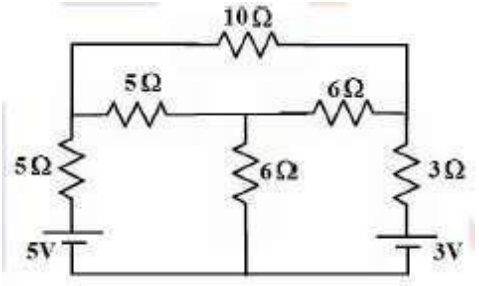
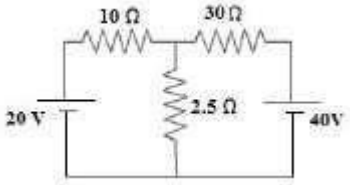
Module 5				
43	Rectifiers and power supplies: Block diagram description of a dc power supply	5	T3, T4	Lecture
44	Working of a full wave bridge rectifier, capacitor filter (no analysis)	5	T3, T4	Lecture
45	working of simple zener voltage regulator	5	T3, T4	Lecture
46	Amplifiers: Block diagram of Public Address system	5	T3, T4	Lecture
47	Circuit diagram and working of common emitter (RC coupled) amplifier with its frequency response	5	T3, T4	Lecture
48	Circuit diagram and working of common emitter (RC coupled) amplifier with its frequency response	5	T3, T4	Lecture
49	Concept of voltage divider biasing	5	T3, T4	Lecture
50	Electronic Instrumentation: Block diagram of an electronic instrumentation system	5	T3, T4	Lecture
Module 6				
60	Evolution of communication systems – Telegraphy to 5G	6	T3, T4	Lecture
61	Radio communication: principle of AM & FM	6	T3, T4	Lecture
62	frequency bands used for various communication systems	6	T3, T4	Lecture

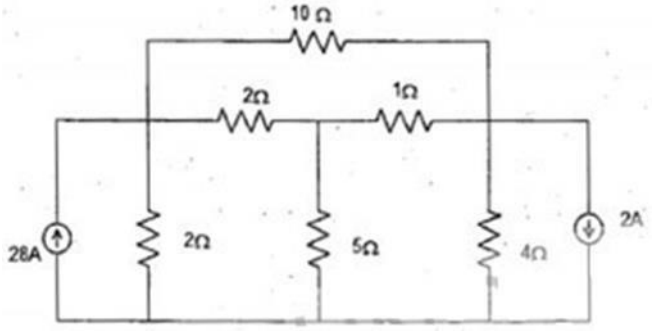
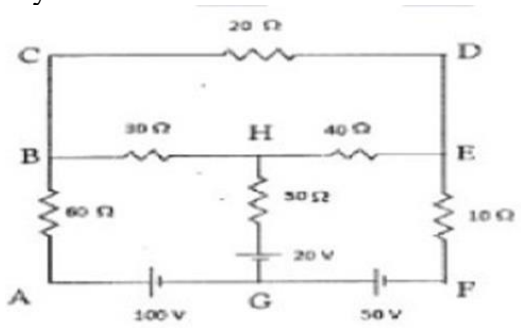
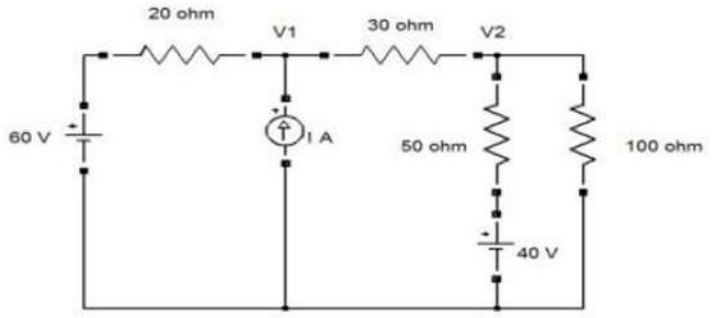
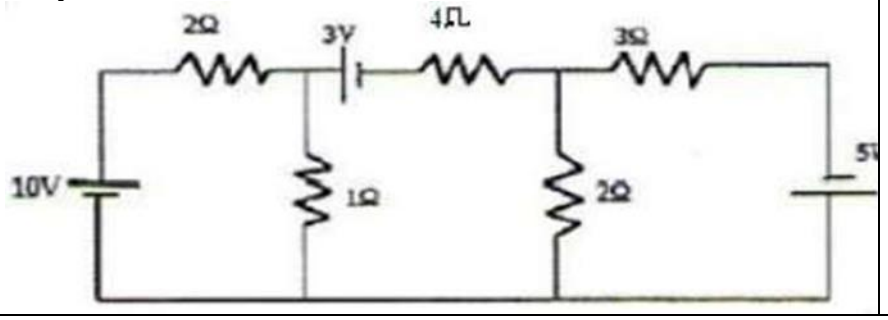
63	block diagram of super heterodyne receiver	6	T3, T4	Lecture
64	Principle of antenna – radiation from accelerated charge	6	T3, T4	Lecture
65	Mobile communication: basic principles of cellular communications	6	T3, T4	Lecture
66	principle and block diagram of GSM.	6	T3, T4	Lecture

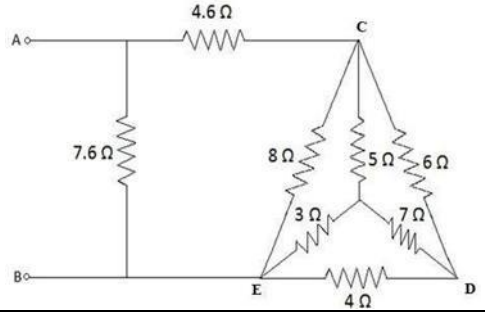
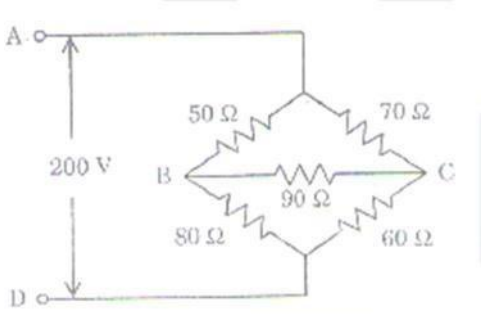
15. **Question Bank**

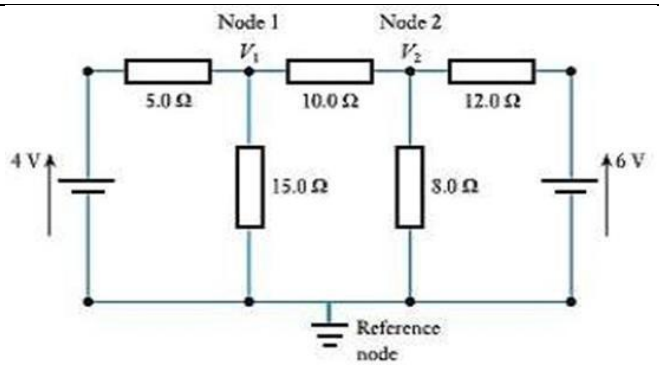
Module 1				
Sl. No	**Question**	**Marks**	**CO**	**BL**
1	State and explain Kirchhoff's laws.	4	CO1	L2
2	What are constant voltage and constant current sources? Voltage and current sources are mutually transferable. Explain. Derive the relationship between line and phase voltage in a star connected system.	4	CO1	L2
3	Find the current through 5ohm resistor using nodal analysis. 	4	CO1	L3
4	Determine the equivalent resistance RAB using star delta transformation. 	4	CO1	L3
5	A 50-ohm resistor is in parallel with a 100-ohm resistor. Current in 50 ohm is 7.2A. What is the value of third resistance to be added in parallel to this circuit to make the total current 12.1 A.	4	CO1	L3
6	Three resistors R1=20 ohm, R2=90 ohm and R3=10 ohm is connected in star. Obtain the equivalent delta circuit.	4	CO1	L2

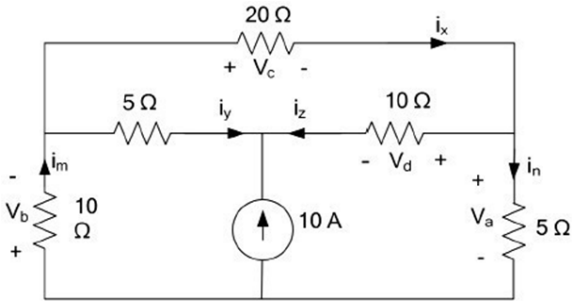
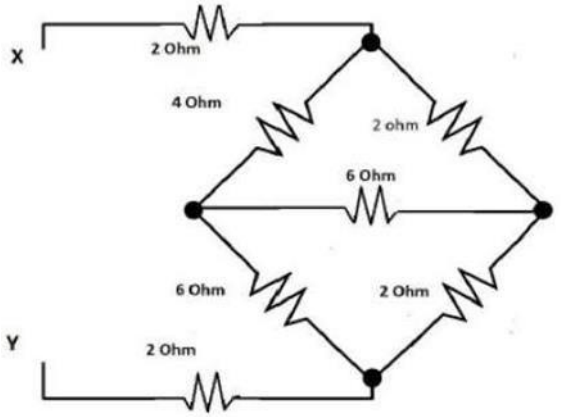
7	Calculate the current through the 4 Ω resistor in the circuit shown, applying current division rule 	4	CO1	L3
8	Calculate the current through the galvanometer (G) in the circuit shown 	4	CO1	L3

9	Find the current through 10Ω resistor in the following figure by Mesh Method 	4	CO1	L3
10	Calculate the current through the 2.5Ω resistor in the network of the following figure by mesh method. 	4	CO1	L3

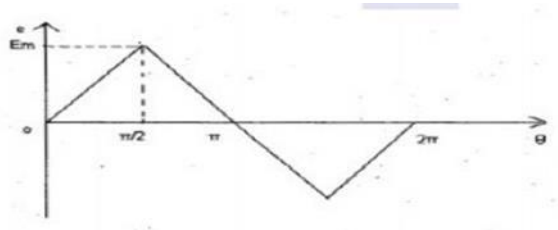
11	Using nodal analysis to form network equations and solve the nodal voltages using matrix method. Also calculate the current in different branches. 	10	CO1	L3
12	Calculate the current in each branch of the circuit using mesh analysis. 	10	CO1	L3
13	Find current in 100-ohm resistor using node analysis.			
		10	CO1	L3
14	Calculate the node voltages in the circuit shown, applying node analysis 	10	CO1	L3

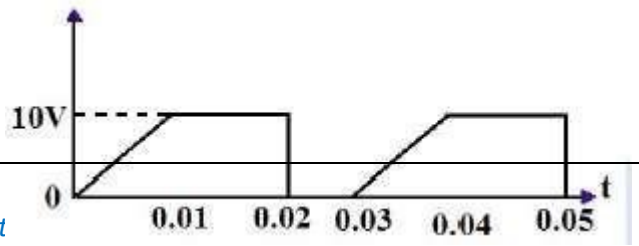
15	Find the resistance between A and B in the circuit shown below. 	10	CO1	L3
16	In the circuit shown below find the total current from the supply and current in 90Ω resistor. 	10	CO1	L3
17	Using the Node Voltage method, calculate the voltages $V1$ and $V2$ in the figure and hence calculate the current in the 8 Ω resistor.	10	CO1	L3

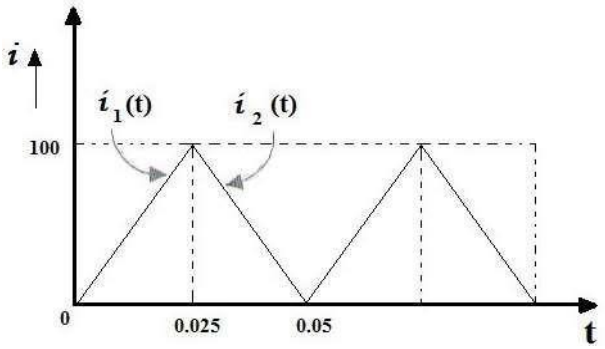
				

18	Use nodal analysis to find voltages Va, Vb, Vc , Vd 	10	CO1	L3
19	Find the equivalent resistance between terminal X-Y in the network 	10	CO1	L3
	Module 2			
1	Define the terms: i) MMF ii) magnetic field strength iii) magnet flux and iv) magnetic field density.	4	CO2	L2
2	An iron ring having cross-sectional area of 400mm^2 and mean circumference of 500mm carries a coil of 250 turns wound uniformly around it. Calculate (a) Reluctance of the ring. (b) Current required to produce a flux of 1000μWb in the ring. Relative permeability of iron is 400	4	CO2	L3
3	State and explain Faraday's laws and Lenz's laws.	4	CO2	L2
4	Distinguish between self-inductance and mutual inductance.	4	CO2	L2
5	Define MMF, magnetizing force, flux density, reluctance, permeability	4	CO2	L2
6	Compare electric and magnetic circuit	4	CO2	L2

7	Define rms and average value of an alternating quantity	4	CO2	L2
8	Calculate the RMS and average values of a purely sinusoidal current having peak value 15A	4	CO2	L3
9	Derive the amplitude factor and form factor of a purely sinusoidal waveform.	4	CO2	L3
10	Derive an expression for the energy stored in an inductor.	4	CO2	L3

11	A current wave is made up of two components-a 5A dc component and a 50Hz ac component, which is a sinusoidal wave with a peak value of 5A. Sketch the resultant waveform and determine its RMS and average values.	4	CO2	L3
12	An alternating current is represented by i(t)=14.14 sin (377t). Find (i)rms value (ii) frequency (iii)time period and (iv)instantaneous value of the current at t=3ms.	4	CO2	L3
13	A coil of 180 turns is linked with a flux of 0.03 Wb when carrying a current of 10A. Calculate the inductance of the coil. If the current is uniformly reversed in 0.04 sec, calculate the emf induced in the coil.	4	CO2	L3
14	Differentiate between statically and dynamically induced emf. A conductor of length 0.5m moves in a uniform magnetic field of flux density 1.1T at a velocity of 30m/s. Calculate the emf induced in the conductor if the direction of motion of the conductor is inclined at 60° to the direction of field.	4	CO2	L2
15	A coil of insulated wire 500 turns and of resistance 49ohm is closely wound on iron ring. The ring has a mean diameter of 0.25m and a uniform cross-sectional area of 70Omm².Calculate the total flux in the ring when a dc supply of 6V is applied to the end of the winding. Assume a relative permeability of 550.	4	CO2	L3
16	An iron ring of mean length 50cm has an air gap of 1mm and a winding of 200 turns. If the relative permeability of iron is 300 when a current of 1A flows through the coil, find flux density. Take permeability of air as 4π×10^-7H/m.	4	CO2	L3
17	Determine average value & rms value of symmetrical square wave also find the form factor.	4	CO2	L3
18	Find rms and average value of the given waveform 	4	CO2	L3

19	A ring-shaped electromagnet has an air gap of 6mm and cross sectional area of 12 cm2. The mean length of the core (excluding air gap) is 60cm. Calculate the mmf required to produce a flux density of 0.4 Wb/m2 in the gap. Take the relative permeability of the material as 400	4	CO2	L3
20	Define the term coefficient of coupling and write an expression for it.	4	CO2	L2
21	Two magnetically coupled coils have a mutual inductance of32mH. What is the average emf induced in one, if the current through the other changes from 3 to 15mA in 0.004 second? Given that one coil has twice the no: of turns in the other, Calculate the inductance of each coil. Neglect the leakage.	4	CO2	L3
22	A coil of 1200 turns and coil B of 800 turns lie near each other so that 60 percent of the flux produced in one links with the other. It is found that a current of 5A in coil A produces a flux of 0.25mWb while the same current in coil B produces a flux of 0.15mWb. Determine the mutual inductance and coefficient of coupling between the coils.	4	CO2	L3
23	The no: of turns in a coil is 250. When a current of 2A flows in this coil the flux in the coil is 0. 3mWb.When this current is reduced to zero in 2ms, the voltage induced in the nearby coil is 63.75V. The coefficient of coupling between the two coils is 0.75. Find the self-inductance of the two coils, mutual inductance and no: of turns in the second coil.	4	CO2	L3
24	A coil of 300 turns and resistance of 10Ω is wound uniformly over a steel ring of mean circumference 30cm and cross-sectional area 9 cm^2. It is connected to a 20 V dc supply if μ_r = 1500, find (i) mmf (ii) reluctance and (iii) magnetizing force.	4	CO2	L3
25	Define frequency, period and cycle.	4	CO2	L2
26	How is an alternating voltage generated? Derive the general expression for a sinusoidal ac voltage.	4	CO2	L2
27	A sinusoidal alternating current of frequency 50Hz has a rms value of 20A. Find the instantaneous value (i) 0.0025 sec, (ii) 0.0125 sec after passing through a positive maximum. At what time measured from the positive maximum; will the instantaneous current be 14.14A?	4	CO2	L3
28	Find the form factor and peak factor of the following waveform.  	10	CO2	L3

29	An iron ring has a cross-section area of 3 cm^2 and a mean diameter of 25 cm. An air gap of 0.5mm is cut across the section of the ring. The ring is wound with a coil of 200 turns through which a current of 3A is passed. If the total magnetic flux is 0.28 mWb, find the relative permeability of iron, assuming no magnetic leakage.	10	CO2	L3
30	The instantaneous value of an alternating voltage is given by v=110 sin 314t.Find the angular velocity, frequency, and time period of the voltage. Differentiate between statically and dynamically induced emfs.	10	CO2	L3
31	Find the rms and average values of the current wave shown in figure below.  	10	CO2	L3
32	An iron ring of mean diameter 100cm and a cross-sectional area of 6cm^2 is wound with 200 turns of wire. Calculate the current required to produce a flux of 0.6mWb in the ring, if $\mu_r = 2000$. If now a radial cut of 2mm is made in the iron ring, find the new value of current required to produce the same flux in the air gap. Neglect fringing and leakage flux.	10	CO2	L3
33	A steel ring of circular cross section of 1 cm in radius and having a mean circumference of 94.3 cm has an air gap of 1 mm long. It is uniformly wound with an exciting coil consisting of 600 turns and excited with a current or 2.5 A. Neglecting magnetic leakage Calculate: m.m.f Magnetic flux Reluctance Flux density Relative permeability of steel Assume that steel part takes about 40% of total ATs	10	CO2	L3
	Module 3			
1	Two impedances 25.23 3 37º and 18.65 3 -68º are connected in series across 230V, 50Hz supply. Find the current, power factor,	4	CO3	L3

	active power and apparent power.			
2	Define active, reactive & apparent power in an ac circuit with the help of power triangle.	4	CO3	L2
3	A Series R-C circuit takes a power of 7000W when connected to 200V, 50Hz supply. The voltage across the resistor is 130 V. Calculate i) Resistance ii) Current iii) Power factor iv) Capacitance v) Impedance Equations for instantaneous values of voltage and current.	4	CO3	L3
4	Derive the relation between line and phase current in three phase delta connected system	4	CO3	L2
5	A 10ohm resistor & 400uF capacitor are connected in series to a 240V sinusoidal ac supply. The circuit current is 5A. Calculate the supply frequency & phase angle between current & voltage.	4	CO3	L3
6	Explain the advantage of three phase system compared to single phase system.	4	CO3	L2
7	Draw the power triangle and define active, reactive and apparent powers in ac circuits. Draw the phasor diagram and waveform of RLC circuit.	4	CO3	L2
8	A resistance of 100Ω in series with 50μF capacitor is c onnected to supply of 200V, 50 Hz. Find impedance, current, power factor and phase angle Voltage across the resistance and capacitor. Draw phasor diagram.	4	CO3	L3
9	An alternating voltage of (80+j60) V is applied to an RX circuit and the current flowing through the circuit is (-4+j10) A. Calculate the impedance of the circuit in rectangular and polar forms. Also determine if X is inductive or capacitive.	4	CO3	L3
10	Derive the relation between line and phase values of voltage in a three-phase star connected system.	4	CO3	L2
11	Prove that the average power for a purely capacitive circuit is zero	4	CO3	L2
12	Prove that in a purely inductive circuit the current lags behind the applied voltage by 90 degree and the power consumed is zero.	4	CO3	L2

13	Explain the term power factor. What will be the power factor in a resistor, inductor and capacitor?	4	CO3	L2
14	Explain balanced 3 phase star connected system with phasor diagram.	4	CO3	L2
15	Derive the expression for the current in an ac series RLC circuit.	4	CO3	L2
16	Explain the generation of a three-phase voltage with necessary figures.	4	CO3	L2
17	A resistance of 10Ω, an inductance of 0.3 H, and a capacitance of 100μF are connected in series across 230V, 50 Hz single phase power supply. Calculate the impedance, current through and power factor of the circuit.	4	CO3	L2
18	A star connected, 3 phase load consists of three identical impedances. When the load is connected to a 3 phase, 400-volt supply, and the line current is 23.09A and p.f is 0.8 lagging. Calculate the total power taken by the load? If the load were reconnected in delta and supplied from the same three phase supply, calculate the current flowing in each line.	10	CO3	L3
19	A two-branch parallel circuit consists of R = 30Ω, L = 0.06H in series branch 1 1 and R = 50Ω, C=30μF in series branch 2. The circuit connected to 230V, 50Hz supply. Find (i) current in each branch, (ii) t current and (iii) power and power factor.	10	CO3	L3
20	Each phase of a 3- phase alternator produces a voltage of 6351 volts carry a current of 315 A. Find the line voltage, line current and the kVA capacity of the 3- phase alternator when it is (i) star connected delta connected.	10	CO3	L3
21	A balanced delta connected 3 phase load is fed from a 3 phase ,400 V, 50 Hz power supply. The line current is 20A and the total power absorbed by the load is 10kW. Calculate (i)the impedance in each branch (ii) the power factor and (iii) the total power consumed if the same impedances are star connected.	10	CO3	L3
22	Three identical resistors of 20 ohm each are connected in star to 415V, 50Hz three phase supply. Calculate (i) the total power consumed, (ii) total power consumed if they are connected in delta (iii) total power consumed, if one of the resistors is opened in both star connection and delta connections.	10	CO3	L3
23	Draw the power triangle and define active, reactive and apparent powers in ac circuits. Two coils A and B are connected in series across a 240V, 50Hz supply. The resistance of A is 5 Ω and the inductance of B is 0.015H. If the input from the supply is 3kW and 2kVAR, find the inductance of A and the resistance of B. Also calculate the voltage across each coil.	10	CO3	L3

24	A balanced three phase load consists of three coils each having resistance of 4Ω and inductance 0.02H. It is connected to a 415V, 50Hz, 3-phase ac supply. Determine the phase voltage, phase current, power factor and active power when the loads are connected in (i) star (ii) delta.	10	CO3	L3
Module 4				
1	Describe the evolution of electronics from vacuum tube to Nano electronics.	5	CO4	L2
2	Distinguish between Zener and Avalanche breakdown.	5	CO4	L2
3	Explain with diagram the principle of operation of an NPN transistor	5	CO4	L2
4	Describe with suitable sketches the input-output characteristics of a BJT when connected in common emitter configuration. [Sketch the output characteristic of a transistor and explain different regions of operation.]	5	CO4	L2
5	Derive an expression for current gain of CE, CB and CC configuration **Or** Derive the relation between α&β, α& γ, β& γ	6	CO4	L2
6	What is tolerance of a resistor? What are the specifications of a resistor? Define any three. Find the resistance range for carbon resistor having colour bands: yellow, violet, red and gold red black brown Blue red gold gold	6	CO4	L1
7	What is a diode? Explain the VI characteristics of PN junction diode in forward biased and reverse biased condition or Describe the forward and reverse characteristics of a diode.	8	CO4	L2
8	Compare and contrast various types of resistors, capacitors & inductors. Mention its applications.	10	CO4	L2
9	In a 4-band resistor the last colour in the colour band is gold. If the upper range of resistance is 3.465Ω find its colour code.	5	CO4	L1
10	Explain the working of a Zener diode.	5	CO4	L2
11	Explain intrinsic and extrinsic semiconductors with crystalline diagrams.	5	CO4	L2
12	Draw the energy band diagram of metals, semiconductors and insulators. Write examples.	3	CO4	L1
13	Explain the formation of potential barrier in a PN junction diode.	4	CO4	L2
14	Find the value of capacitor i) 2M2 ii)4k7 iii) 104 iv) 47K	4	CO4	L1
Module 5				

1	With neat block diagram, explain the working of a DC regulated power supply.	5	CO4	L1
2	With sufficient waveforms, explain the working of capacitor filter. [Narrate how capacitor filter eliminates ripples from the output of a rectifier.]	5	CO4	L1
3	Explain the working of Zener voltage regulator and draw its V-I characteristics. Define line regulation and load regulation.	8	CO4	L2
4	Explain the characteristics of an amplifier.	5	CO5	L2
5	Explain Public Address (PA) system with a neat block diagram.	6	CO5	L2
6	Draw the basic block diagram of an electronic measuring instrument and explain the functions of each block. [With a neat sketch explain the block diagram of an instrumentation system]	6	CO3	L2
7	Explain working of multimeter with necessary diagrams.	8	CO5	L2
8	Explain with neat diagrams working of half wave and full wave (Centre tapped, Bridge) rectifier.	10	CO4	L2
9	Define Peak inverse voltage and obtain the same for half wave and full wave rectifier.	5	CO4	L1
10	Derive expression for I_{max}, I_{DC}, I_{RMS}, V_{DC}, V_{RMS}, Form Factor, Peak Factor, Efficiency of Half wave and Full wave (Centre tapped, Bridge) rectifier.	10	CO4	L2
11	Compare half wave and full wave rectifiers.	6	CO4	L2
12	What do you mean by ripple factor? Find the ripple factor for half wave & full wave rectifier.	5	CO4	L1
13	Draw the circuit diagram and explain the working of R-C coupled amplifier, plot its frequency response. Describe gain and bandwidth of an RC coupled amplifier. [State the reason for reduction in gain at low and high frequencies. Explain the role of capacitors used in RC coupled Amplifier. Draw the circuit diagram of a CE amplifier and discuss the role of each component used in it.]	10	CO5	L2
14	What is the need for biasing? Analyze voltage divider arrangement for common emitter configuration.	10	CO5	L2
Module 6				
1	With the help of a block diagram, explain the working of Super heterodyne receiver for AM & FM. Explain the relevance of Intermediate Frequency in a superheterodyne receiver.	7	CO3	L2
2	Define Modulation and describe the need for modulation.	4	CO3	L1
3	Define Amplitude Modulation & Frequency Modulation. Derive an expression for modulated signal of AM & FM. Comment on the bandwidth requirement and modulation index.	10	CO3	L2

4	Define Modulation index? Find modulation index for AM & FM. Draw the frequency spectrum of an amplitude modulated (AM) wave. Given that modulating signal is of frequency fm and amplitude Vm and carrier is of frequency fc and amplitude Vc. Take modulation index as m. What is the bandwidth requirement of this AM wave?	5	CO3	L1
5	Define frequency deviation. Find the frequency deviation of FM wave.	5	CO3	L1
6	What are the merits AM compared to FM? The carrier amplitude of a given AM wave is 5V and the message signal amplitude is 3V. Find the modulation index.	5	CO3	L3
7	Describe the evolution of communication system from telegraphy to 5G.	6	CO3	L2
8	List five advantages and applications of communication systems.	5	CO3	L1
9	With neat sketches, explain a cellular communication system. [Explain the concept of cells in cellular communication.]	10	CO3	L2
10	Explain GSM communication with the help of its architecture. [Explain the call setup procedure in GSM.]	8	CO3	L2
11	Explain in detail parabolic reflector antenna	6	CO3	L2
12	Explain the concept of frequency reuse and handoff in cellular communication.	8	CO3	L2
13	Describe the principle of Antenna.	5	CO3	L2
14	List out the frequency bands and its uses.	5	CO3	L1

Prepared By: Dr. Linss T Alex, Reshma Mary Jose, Course
Faculty Checked By: Kanaka Xavier

Course Code & Name: HUN102 PROFESSIONAL COMMUNICATION

1. Prescribed Syllabus

Module	Topic	Hours
1	Use of language in communication: Significance of technical communication Vocabulary Development: technical vocabulary, vocabulary used in formal letters/emails and reports, Sequence words, misspelled words, compound words, finding suitable synonyms, paraphrasing, verbal analogies. Language Development: subject-verb agreement, personal passive voice, numerical adjectives, embedded sentences, clauses, conditionals, reported speech, active/passive voice. Technology-based communication: Effective email messages, slide presentations, editing skills using software. Modern day research and study skills: search engines, repositories, forums such as Git Hub, Stack Exchange, OSS communities (MOOC, SWAYAM, NPTEL), and Quora; Plagiarism.	8
2	Reading, Comprehension, and Summarizing: Reading styles, speed, valuation, critical reading, reading and comprehending shorter and longer technical articles from journals, newspapers, identifying the various transitions in a text, SQ3R method, PQRST method, speed reading. Comprehension: techniques, understanding textbooks, marking and underlining, Note-taking: recognizing non-verbal cues.	5
3	Oral Presentation: Voice modulation, tone, describing a process, Presentation Skills: Oral presentation and public speaking skills, business presentations, Preparation: organizing the material, self-Introduction, introducing the topic, answering questions, individual presentation practice, presenting visuals effectively. Debate and Group Discussions: introduction to Group Discussion (GD), differences between GD and debate; participating GD, understanding GD, brainstorming the topic, questioning and clarifying, GD strategies, activities to improve GD skills.	10
4	Listening and Interview Skills Listening: Active and Passive listening, listening: for general content, to fill up information, intensive listening, for specific information, to answer, and to understand. Developing effective listening skills, barriers to effective listening, listening to longer technical talks, listening to classroom lectures, talks on engineering /technology, listening to documentaries and making notes, TED talks. Interview Skills: types of interviews, successful interviews, interview etiquette, dress code, body language, telephone/online (skype) interviews, one-to-one interview & panel interview, FAQs related to job interviews.	10
5	Formal writing: Technical Writing: differences between technical and literary style. Letter Writing (formal, informal and semi-formal), Job applications, Minute preparation, CV preparation (differences between Bio-Data, CV and Resume), and Reports. Elements of style, Common Errors in Writing: describing a process, use of sequence words, Statements of Purpose, Instructions, Checklists. Analytical and issue-based Essays and Report Writing: basics of report writing;	11

	Referencing Style (IEEE Format), structure of a report; types of reports, references, bibliography.	

2. Text Books (T)

Nil

3. Reference Books (R)

R1. English for Engineers and Technologists (Combined edition, Vol. 1 and 2), Orient Blackswan 2010.
R2. Meenakshi Raman and Sangeetha Sharma,"Technical Communication: Principles and Practice", 2nd Edition, Oxford University Press, 2011
R3. Stephen E. Lucas, "The Art of Public Speaking", 10th Edition; McGraw Hill Education, 2012.
R4. Ashraf Rizvi, "Effective Technical Communication", 2nd Edition, McGraw Hill Education, 2017.
R5. William Strunk Jr. & E.B. White, "The Elements of Style", 4th Edition, Pearson, 1999.
R6. David F. Beer and David McMurrey, Guide to writing as an Engineer, John Willey. New York, 2004.
R7. Goodheart-Willcox, "Professional Communication", First Edition , 2017.
R8. Training in Interpersonal Skills: Tips for Managing People at Work, Pearson Education, India, 6 edition, 2015.
R9. The Ace of Soft Skills: Attitude, Communication and Etiquette for Success, Pearson Education; 1 edition, 2013.
R10. Anand Ganguly, "Success in Interview", RPH, 5th Edition, 2016.
R11. Raman Sharma, "Technical Communications", Oxford Publication, London, 2004.

4. Course Objectives

Clear, precise, and effective communication has become a sine qua non in today's information driven world given its interdependencies and seamless connectivity. Any aspiring professional cannot but master the key elements of such communication. The objective of this course is to equip students with the necessary skills to listen, read, write, and speak so as to comprehend and successfully convey any idea, technical or otherwise, as well as give them the necessary polish to become persuasive communicators.

5. Course Pre / Co-requisite

None.

6. Course Outcomes

After completion of the course, student will be able to

CO 1 Develop vocabulary and language skills relevant to engineering as a profession.

CO 2 Analyze, interpret and effectively summarize a variety of textual Content.

CO 3 Create effective technical presentations.

CO 4 Discuss a given technical/non-technical topic in a group setting and arrive at generalizations/consensus.

CO 5 Identify drawbacks in listening patterns and apply listening techniques for specific needs.

CO 6 Create professional and technical documents that are clear and adhering to all the necessary conventions.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO 3
CO1										**H**		**M**			
CO2										**L**		**H**			
CO3						**L**			**L**	**H**					
CO4										**H**		**L**			
CO5		**L**							**M**	**H**					
CO6	**L**					**L**			**L**	**H**					

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	PO10	Learning technical vocabulary enables us to communicate effectively about convoluted engineering problems with the professional community and society through presentations and discussions.
	PO12	developing technical language skills enhances lifelong learning of technological knowledge.
CO2	PO10	Knowledge of different comprehension techniques, valuation and critical reading helps to communicate with the engineering community and to give and receive clear instructions.
	PO12	Understanding the concepts like reading and comprehending shorter and longer techniques, enhances lifelong learning of engineering aspects in a broader sense
CO3	PO6	Learning different techniques of effective technical presentations helps to analyze and find out various societal issues and present it for verification.
	PO9	Knowledge of various presentation skills help to work effectively as a team member.
	PO10	Understanding the basic skills of presentation helps to communicate with the professionals through presentations and documentation of various issues related to engineering and community
CO4	PO10	By taking part in different group discussions, it will be easy to communicate effectively with the engineering community and society at large and discuss about the problems and find out the solutions needed.

	PO12	By developing the capacity to analyze and discuss a technical/non technical topic in a group, enables to recognize the need for life-long learning in the broadest context of technological knowledge.
CO5	PO2	Developing effective listening skills helps to analyze and understand various engineering problems.
	PO9	By understanding the concepts like active and passive listening it is easy to perform better as a part of diverse teams.
	PO10	Learning effective listening process helps to deliver productive communication with professional community by giving and receiving clear instructions.
CO6	PO1	Knowledge of technical writing can be applied to formulate solutions for various engineering problems.
	PO6	By learning different techniques of technical writing, it is easy to analyze health, safety and other societal issues through detail reports.
	PO9	Developing effective technical writing skills helps to perform better and be the part of a diverse team.
	PO10	Technical writing helps to communicate about engineering problems, through effective reports and documentation and present clear idea.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1			

11. Internal Assessment mark allocation (as per university curriculum)

(Provide details as mentioned in syllabus)

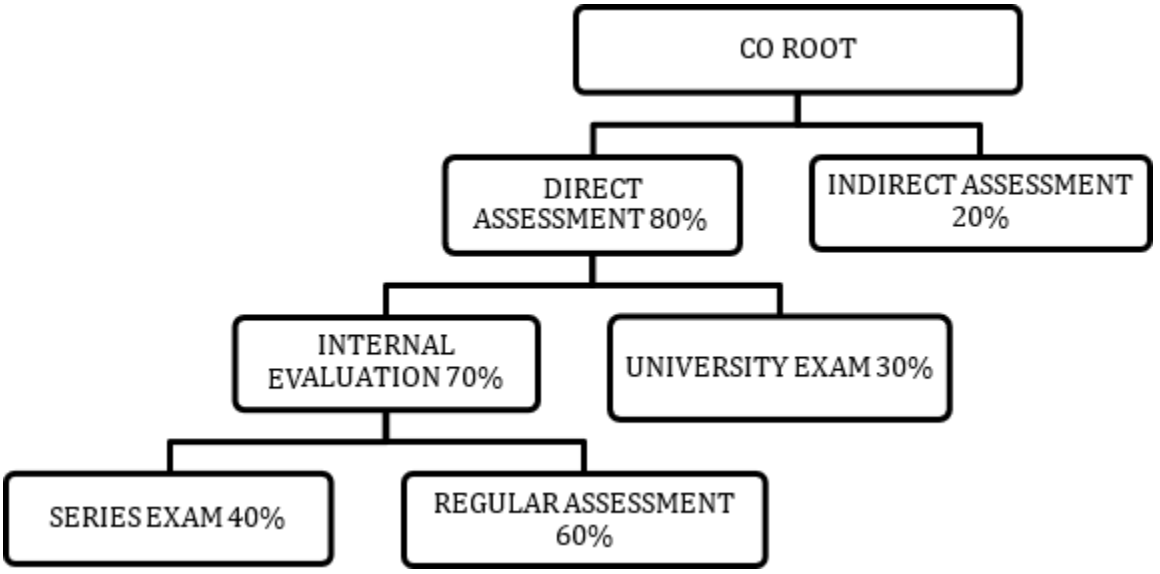
Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. Assessment – CO Mapping (Put‘ x’ if mapping is present)

	Tools		**Weightage#**	**CO 1**	**CO 2**	**CO 3**	**CO 4**	**CO 5**	**CO 6**
Direct Assessment Tools**	Internal Exam(s) 28%	Series 1	14%	x	x				
		Series 2	14%			x	x	x	X
	Assignment (s)/ Course Project /Quiz etc. 42%	Presentation	12%			X	x		
		Group Discussion	12%	X		X	X		

		Assignment 1	9%	x				X	
		Assignment 2	9%						X
	End Semester Exam		30%	x	x	x	x	x	X
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1	Use of language in communication: Significance of technical communication	1	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
2	subject-verb agreement, clauses, conditionals	1	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
3	numerical adjectives, embedded		Professional	

	sentences, reported speech, active/passive	1	Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
4	compound words, finding suitable	1	Benjamin (Author), Tintu P Joseph (Author)	Lecture
5	Technical vocabulary, vocabulary used in formal letters/emails and reports.	1	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
6	Technology-based communication: Effective email messages, slide	1	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
7	Modern day research and study skills: search engines, repositories, forums such	1	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
8	Revision-module 1	1	Benjamin (Author), Tintu P Joseph (Author)	Lecture
9	Introduction to Reading, Reading Styles	2	Benjamin (Author), Tintu P Joseph (Author)	Lecture
10	valuation, critical reading	2	Benjamin (Author), Tintu P Joseph (Author)	Lecture
11	Speed Reading	2	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph	Lecture

			(Author)	
12	Phonetics	3	Professional Communication by Deepak	Lecture
13	Oral Presentation: Voice modulation, tone, describing a process, Elevator pitch	3	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
14	public speaking skills, business presentations, Telephone etiquette	3	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
15	Introduction, introducing the topic, answering questions.	3	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
16	Individual presentation practice: Techniques for improving your delivery,	3	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
17	Presenting visuals effectively: Selecting the appropriate visuals, formatting and	3	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
18	Debate and Group Discussions: introduction to Group Discussion (GD),	3	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
19	brainstorming the topic, questioning and clarifying, GD strategies	3	Professional Communication by Deepak	Lecture

			Benjamin (Author), Tintu P Joseph (Author)	
20	confidence and overcoming nervousness, learning to listen actively, expressing	3	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
21	MMFS, Mirroring, Revision- module 3	3	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
22	importance of effective listening and interview skills in personal and professional	4	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
23	different types of listening for various purposes such as general content, filling up	4	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
24	Developing effective listening skills: Strategies for overcoming listening barriers, such as distractions, biases, and	4	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
25	Listening to longer technical talks: Techniques for staying engaged and focused while listening to technical or	4	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
26	Listening to classroom lectures: Tips for	4	Professional Communication by Deepak	Lecture

	staying focused and retaining information during classroom lectures or discussions.		Benjamin (Author), Tintu P Joseph (Author)	
27	Listening to documentaries and making notes: Techniques for taking effective notes	4	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
28	successful interviews, interview etiquette, dress code, body language,	4	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
29	telephone/online (skype) interviews, one- to-one interview & panel interview, FAQs	4	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
30	radio and podcasts. Listening to Song. practice and exercises	4	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
31	Revision-module 4	4	Benjamin (Author), Tintu P Joseph (Author)	Lecture
32	Formal Writing: The importance of technical writing and the differences	5	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
33	Letter Writing: Formal, informal, and semi- formal letter writing, with examples and tips for effective communication.	5	Professional Communication by Deepak Benjamin (Author),	Lecture

			Tintu P Joseph (Author)	
34	Job Applications: How to prepare a successful job application, including cover letters, resumes, and CVs (differences between Bio-Data, CV, and Resume).	5	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
35	Minute Preparation: Tips for preparing meeting minutes, including organization, formatting, and content.	5	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
36	Reports: The elements of a well-written report, including style, structure, and content.	5	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
37	writing, such as describing a process, use of sequence words, statements of purpose, instructions, and checklists.	5	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
38	essay writing, including structure, organization, and effective communication	5	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
39	Report Writing: Types of reports, referencing styles (IEEE format), and the structure and content of reports.	5	Professional Communication by Deepak Benjamin (Author),	Lecture

			Tintu P Joseph (Author)	
40	Bibliography and References: How to properly cite sources and create a	5	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture
41	Attending a meeting and Minute Preparation	5	Professional Communication by Deepak Benjamin (Author), Tintu P Joseph (Author)	Lecture

15. Question Bank

Module 1				
Sl. No	**Question**	**Marks**	**CO**	**BL**
1	Identify two types of compound words and give its examples.	2	CO1	L1
2	Define the following compound words. a) Wild life b) Son-in- law	2	CO1	L1
3	Identify two types of numeral adjectives and use it in a sentence.	2	CO1	L1
4	State the passive voice of the following sentences: A sound outside woke us all up Who broke the chair?	2	CO1	L1
5	Identify the main clause and embedded clause of the following sentences. The giraffe, which was the tallest in the zoo, towered over the other animals. Luke, as soon as he heard the news, rushed to the hospital.	2	CO1	L1
6	Identify the errors in the following sentences. Many peoples (A)/ attended the funeral (B)/ of the great man. (C)/ No Error (D) I saw Richard (A)/ when I'm (B)/ on the flight. (C)/ No Error (D)	2	CO1	L1
7	Restate as directed. Keerthy said, "Ritu is the topper of our class". (change to reported speech)	2	CO1	L2

	They know she has been working very hard. (change to impersonal passive voice)			
8	State the significance of Technical communication	3	CO1	L1
9	Outline the process of communication.	3	CO1	L1
10	Define 'conditionals' and cite examples	3	CO1	L1
11	Define clause. List the different types of clauses.	3	CO1	L1
12	Identify the suitable sequence words from the given options My sister was in the dentist's office for ten minutes. , I sat in the waiting room with an old magazine in my hands. (First, Meanwhile, Later) An hour passed but there was no sign of Mike. , we decided to go home. (Until, Before, Finally) We bumped into Salsa during our trip to Lang Island. A few weeks , we met him again (after, then, later)	3	CO1	L1
13	Identify the misspelled words from each set of words given. 1) a) acomodate b) accommadate c) acommodate d) accommodate a) deductible b) deductable c) deductuble d) deductabe a) license b) licence c) licens d) lisence	3	CO1	L1
14	Choose the right answer. Ten: Decimal A. Seven: Septet B. Four: Quartet C. Two:Binary D. Five: Quince Army: Logistics A. Business: Strategy B. Soldier: Students C. War: Logic D. Team:Individual 3. Corporeal: Spiritual A. Mesa: Plateau B. Moron: Savant C. Foreigner: Immigrant D.Pedagogue: Teacher	3	CO1	L2
15	The following passage has not been edited. There is one error in each line. Write the incorrect word and the correction in the answer sheet against the correct blank number. The aim for development must be of improve the conditions for the people and to ensure freedom of hunger and malnutrition. This gave the people opportunity in participate in productive endeavours.	3	CO1	L2
16				

	Fill in the blanks with suitable words. The.....(1) (earliest/earlier) sighting of this linen cloth (2). (is / was / were) in the 14th century in France. The shroud was (3)..... (believing / believed) to have been the cloth wrapped around Jesus when he (4) ..... (placed / was placed / had placed) in his tomb; when the cloth (5) ..... (is / was / had) removed, it (6) (bear / bore / borne) the image of Christ on it. When a bishop (7) . (proclaims / proclaimed / has proclaimed) it to be a scam, an artist confessed to painting the image on it, and Pope Clement VII officially (8) (declares / declared / has declared) the shroud a mere representation of Christ.	3	CO1	L2
17	Rewrite these sentences in passive voice instead of using "somebody" or "they" Somebody has cleaned the room They have postponed the concert They are building a new ring road around the city.	3	CO1	L2
18	Explain the social relevance of language.	3	CO1	L2
19	Explain Technology based communication with relevant examples.	3	CO1	L2
20	Describe the following terms: Repositories Stack Exchange Search Engines	3	CO1	L2
21	Explain the term Plagiarism by citing any two examples.	3	CO1	L2
22	State the importance of Sequence words with relevant examples.	4	CO1	L1
23	Explain the advantages of an effective e-mail and steps to draft an effective e-mail.	4	CO1	L2
24	Explain the advantages of search engines	4	CO1	L2
25	Choose the right answers for each question from the options provided. Light: Blind : : Speech: ? Dumb b) deaf c) sound d) voice Ten: Decimal : : Two: ? Double b) binary c) quartet d) pair Odometer: mileage: : Compass: ? Speed b) Hiking c) Direction d) Needle Reptile: Lizard: : Flower: ? Petal b) Stem c) Rose d) Leaves	4	CO1	L2

26	In the following the questions choose the word which best expresses the meaning of the given word. BRIEF Short b) little c) small d) limited ALERT Energetic b) Observant c) Intelligent d) Watchful WARRIOR Soldier b) Sailor c) Pirate d) Spy DISTANT Far b) removed c) separate d) reserved	4	CO1	L2
27	In each of the following questions, find the correctly spelt word. a) Accidentally b) Acidentally c) Accidentaly d) Accedentally a) Mischievis b) Misschievious c) Mischievous d) Mischivious a) Voluntiers b) Volenteers c) Volunteers d) Volantiers a) Nuisance b) Nuisense c) Nooisense d) Nooisance	4	CO1	
28	Fill in the blanks with suitable form of the words given in brackets. [because, really, is, laugh, at, too, interesting, should] One of my favorite vacation places (a) Mexico. I really like the weather there (b) it never gets cold. The people are very nice too. They never (c) at my bad Spanish. The food is (d) good. Mexico City is a very (e) place to visit. It has some great museums and lots of fascinating old buildings. The hotels are (f) expensive to stay but there are more affordable options. For example, you can stay (g) one of the beach resorts like Acapulco. If you are planning to visit Mexico, you (h) definitely see the Mayan temples near Merida	4	CO1	L2
29	Complete the passage using "was/were' in the blanks. Write the answer in your answer book against the correct blank number. Last summer I visited London. The voyage by plane a) long and tiring. I b) surprised by the size of Heathrow Airport. There c) many people. My friend d) waiting to receive me. In a few minutes we e) in a cab. The city f) fantastic. I g) perplexed by the posh cars and shops in the city. There h) many people walking down the streets.	4	CO1	L2
30	You need to make a Project presentation as a part of your internal evaluation. List the steps that you need to follow for preparing the slides effectively?	4	CO3	L1
31	Recall the benefits of non-linear editing methods.	4	CO3	L1
32	Explain the importance of editing softwares and editing skills	4	CO3	L2
33	Identify the correct form of the verb given in the bracket Somebody waiting at the door for you. (is / are)			

	Two ago, here is the place where the accident took place. (year/years) Fast food, like burgers and street food, harmful to our health. (is/are) All the students excited to visit the museum after school. (is/are) Neither Joseph nor his family French. (speaks/speak) Either Ross or Joey broken the glass. (has/have) If anybody for me, do let me know. (calls/call) The plumber, along with his helper , expected to come soon. (is/are) Several neighbours complained about the loud sound coming from that house. (has/have) Neither Penny nor Amy went to work. (has/have) The Olympics held every four years. (is/are) The people lived without electricity for many years. (has/have)	6	CO1	L1
34	Explain Technical vocabulary with relevant examples	6	CO1	L2
	Module 2			
1	Define Critical Reading.	2	CO2	L1
2	Define the terms: Skimming Scanning	2	CO2	L1
3	Define Reading Evaluation.	2	CO2	L1
4	Describe Speed Reading	2	CO2	L2
5	Explain any two key benefits of note-taking.	2	CO2	L2
6	Explain any two techniques of comprehension	2	CO2	L2
7	Describe Reading speed.	2	CO2	L2
8	List the steps involved in Critical Reading.	3	CO2	L1
9	Recall the differences between Intensive Reading and Extensive Reading.	3	CO2	L1
10	Explain the importance of transitions in a text	3	CO2	L2
13	Explain various Note making strategies.	3	CO2	L2
14	Explain different techniques for speed reading	4	CO2	L1
15	Outline the process of reading and comprehending long technical articles from journals	4	CO2	L1
16	List and define the four types of reading styles.	4	CO2	L1

17	" The difference between active and passive reading is your goal". Recall the differences between active and passive reading and prove the statement.	4	CO2	L1
18	Outline the steps involved in effective comprehension of textbooks.	4	CO2	L1
19	List and define any four non-verbal cues.	4	CO2	L1
20	Outline the steps involved in effective comprehension of newspaper articles	4	CO2	L1
21	Explain the SQ3R method of comprehension.	4	CO2	L2
22	Explain the PQRST method of comprehension	4	CO2	L2
23	Identify the key benefits of effective note-taking	6	CO2	L1
24	advantage of the fact that they did not know he was hiding in the branches, he decided to make a quick escape. He climbed down safely when they were not looking and ran for his life. But, he left behind the bundle of stolen jewels and money which dropped into Mike's lap. Mike opened it and jumped with joy when he saw the contents. The family gathered all their belongings and returned to the village. There was great excitement when they told everyone how they got rich. Morris thought that the tree was miraculous and this was a nice and quick way to earn some money. He ordered his family to pack some clothes and they set off as if on a journey. They also stopped under the same tree and Morris started commanding everyone as Mike had done. But no one in his family was willing to obey his orders. Being a rich family, they were used to having servants all around. So, the one who went to the river to fetch water enjoyed a nice bath. The one who went to get wood for fire went off to sleep. Morris's wife said " Everything is ready but what shall we eat ?" Morris raised his hands and said, " Don't worry. He is watching all of this from above. He will help us." As soon as he finished saying, the thief jumped down from the tree with a knife in hand. Seeing him, everyone started running around to save their lives. The thief stole everything they had and Morris and his family had to return to the village empty handed, having lost all their valuables that they had taken with them. Why did Mike and his family decide to rest under the thief's tree? Which of the following best describes Morris? What did Mike mean when he said "He is watching all this from above"? Why did the thief return to the tree? How did the fellow villagers react to Mike getting rich overnight?	6	CO2	L2

25	Explain reading Explain the four kinds of reading styles and when these styles are used.	6	CO2	L2
26	Help your friends to read and comprehend texts by explaining the SQ3R and PQRST methods of comprehension.	6	CO2	L2
	Module 3			
1	Identify the steps involved in makingan effective oral presentation.	3	CO3	L1
2	Define Oral Presentation Skills.	3	CO3	L1
3	List out the key components in a technical presentation.	3	CO3	L1
4	Identify the importance of self-introduction in a presentation.	3	CO3	L1
5	Explain the six steps to be followed for successful public speaking.	3	CO3	L2
6	You are one of the keynote speakers of an international conference. State the important measures you are adopting for making a successful presentation.	4	CO3	L1
7	You, as the sales manager, have to make a business presentation before the management of a company where you plan to sell your new product. What points are to be kept in mind while making the presentation?	4	CO3	L1
8	List the four main types of speech purposes.	4	CO3	L1
9	Recall the steps of preparation required for QnA session of an oral presentation.	4	CO3	L1
10	Explain the steps for practicing an oral presentation.	4	CO3	L2
11	Explain business presentations with examples.	4	CO3	L2
12	Explain the importance of non-verbal communication in making a presentation	4	CO3	L2
13	State the importance of visual aids in an oral presentation.	6	CO3	L1
14	Describe the key elements to consider while preparing for an oral presentation.	6	CO3	L2
15	Define voice modulation.	3	CO4	L1
16	Recall the significance of tone of voice.	3	CO4	L1
17	Define Group Discussion	3	CO4	L1
18	Recall the differences Group Discussion (GD) and debate	3	CO4	L1
19	Explain Brain storming	3	CO4	L2
20	State the importance of brainstorming in a GD	3	CO4	L2

21	List the steps involved in the process of a Group Discussion.	4	CO4	L1
22	List the do's and don'ts in a group discussion.	4	CO4	L1
23	Explain the etiquettes one must follow in GD	4	CO4	L2
24	Explain the strategies to adopt for effective participation in a GD.	4	CO4	L2
25	Define Voice modulation and state the five important elements that aid for effective voice modulation.	6	CO4	L1
26	Explain Group Discussion Explain the components of GD	6	CO4	L2
Module 4				
1	State the importance of listening in communication.	3	CO5	L1
2	List and define any three types of interviews.	3	CO5	L1
3	Identify the frequently asked questions in an interview.	3	CO5	L1
4	Give a brief explanation of TED talks.	3	CO5	L2
5	Explain the importance of listening to subject specific talks.	3	CO5	L2
6	Briefly explain the importance of dress code and body language in an interview.	3	CO5	L2
7	Recall the differences between active listening and passive listening.	4	CO5	L1
8	Identify the two types of listening for general content.	4	CO5	L1
9	Identify and define any four types of listening.	4	CO5	L1
10	Describe the steps for developing effective listening skills.	4	CO5	L2
11	Explain the benefits of listening to TED talks.	4	CO5	L2
12	Explain the terms: a) Phone Interview Skype Interview	4	CO5	L2
13	Identify the steps involved in gaining ability to listen to longer technical talks.	6	CO5	L1
14	List and define the six modes of documentary.	6	CO5	L1
15	Outlinethe steps of preparation required for successful interviews.	6	CO5	L1
16	Explain the importance of Effective Listening Explain the various barriers to Effective Listening	6	CO5	L2
17	Explain the types, features and narrative structures of documentaries.	6	CO5	L2
18	Explain: Interview	6	CO5	L2

	Types of interview			
19	Describe the etiquette to be followed during an interview.	6	CO5	L2
Module 5				
1	Define Technical Writing.	3	CO6	L1
2	State the importance of letter writing in a formal setting.	3	CO6	L1
3	Explain literary writing style.	3	CO6	L2
4	Explain the term 'Reference'.	3	CO6	L2
5	Recall the differences between technical writing and literary writing.	4	CO6	L1
6	Identify and define the three types of letter writing.	4	CO6	L1
7	Identify different measures to adopt to avoid common mistakes while writing a document.	4	CO6	L1
8	State the importance of using sequence words in writing.	4	CO6	L1
9	Briefly explain the importance of cover letters for applying for a job.	4	CO6	L2
10	Explain the basic structure of a technical report.	4	CO6	L2
11	Explain checklists and its importance.	4	CO6	L2
12	Describe 'bibliography' and explain its types.	4	CO6	L2
13	Define 'report' and its types.	6	CO6	L1
14	Define the concept of report and outline its structure.	6	CO6	L1
15	Define meeting minutes and the do's and don'ts of preparing mom.	6	CO6	L1
16	Recall the differences among CV, Resume and Biodata	6	CO6	L1
17	Describe the six elements of style in technical writing.	6	CO6	L2
18	Explain the format of semi-formal letters.	6	CO6	L2
19	You are required to apply for a job and submit your details to a firm. In what context you decide to submit a CV or Biodata or Resume. Write your answer explaining the structure of each and focusing on the differences between them.	6	CO6	L2

20	Explain Statement of Purpose.	6	CO6	L2
21	Explain: a) Instructions b) Checklists	6	CO6	L2
22	Explain IEEE Format of referencing style.	6	CO6	L2
23	You have been offered an internship in a much sought-after aerospace company and are very excited about it. However, the dates clash with your series tests. Compose a letter to the Manager – University Relations of the company asking them if they can change the dates to coincide with your vacation.	6	CO6	L6
24	You work in a well-reputed aerospace company as Manager – University Relations. You are in charge of offering internships. A student has sent you a letter requesting you to change the dates allotted to him since he has series exams at that time. But there are no vacancies available during the period he has requested for. Compose an e-mail informing him of this and suggest that he try to arrange the matter with his college.	6	CO6	L6
25	Write a letter to your Principal to grant you permission to attend a seminar on Climate Change at IIT Madras. Give all the information regarding the programme and benefits of attending the same.	6	CO6	L6
26	You are the purchase manager of Highway Plastics Ltd. The consignment you recently received does not meet the quality standards as mentioned in the Purchase order. You have to draft an email to the supplier regarding the issue. What points will you keep in mind while drafting the email?	6	CO6	L6

Prepared By: Merrina Margaret, Course Faculty

Checked By: Ms. Rose Paul, Course Committee Chairperson

Course Code & Name: EST102 Programming in C

1. Prescribed Syllabus

Module	Topic	Hours
1	Basics of Computer Architecture: processor, Memory, Input& Output devices Application Software & System software: Compilers, interpreters, High level and low level languages Introduction to structured approach to programming, Flow chart Algorithms, Pseudo code (bubble sort, linear search - algorithms and pseudocode)	7
2	Basic structure of C program: Character set, Tokens, Identifiers in C, Variables and Data Types , Constants, Console IO Operations, printf and scanf Operators and Expressions: Expressions and Arithmetic Operators, Relational and Logical Operators, Conditional operator, size of operator, Assignment operators and Bitwise Operators. Operators Precedence Control Flow Statements: If Statement, Switch Statement, Unconditional Branching using goto statement, While Loop, Do While Loop, For Loop, Break and Continue statements.(Simple programs covering control flow)	8
3	Arrays Declaration and Initialization, 1-Dimensional Array, 2-Dimensional Array String processing: In built String handling functions (strlen, strcpy, strcat and strcmp, puts, gets) Linear search program, bubble sort program, simple programs covering arrays and strings	6
4	Introduction to modular programming, writing functions, formal parameters, actual parameters Pass by Value, Recursion, Arrays as Function Parameters structure, union, Storage Classes, Scope and life time of variables, simple programs using functions	7
5	Basics of Pointer: declaring pointers, accessing data though pointers, NULL pointer,array access using pointers, pass by reference effect File Operations: open, close, read, write, append Sequential access and random access to files: In built file handlingfunctions (rewind() ,fseek(), ftell(), feof(), fread(), fwrite()), simple programs covering pointers and files.	7

2. Text Books (T)

T1. Schaum Series, Gottfried B.S.,Tata McGraw Hill,Programming with C
T2. E. Balagurusamy, Mcgraw Hill,Programming in ANSI C
T3. Asok N Kamthane, Pearson,Programming in C
T4. Anita Goel, Pearson, Computer Fundamentals

3. Reference Books (R)

R1. Anita Goel and Ajay Mittal, Pearson, Computer fundamentals and Programming in C
R2 Brian W. Kernighan and Dennis M. Ritchie, Pearson, C Programming Language
R3 Rajaraman V, PHI, Computer Basics and Programming in C
R4. Yashavant P, Kanetkar, BPB Publications, Let us C

4. Course Objectives

To prepare the Engineering Graduates capable of writing readable C programs to solve computational problems that they may have to solve in their professional life.

5. Course Pre / Co-requisite

Nil

6. Course Outcomes

After completion of the course, student will be able to

CO1: Analyze a computational problem and develop an algorithm/flowchart to find its solution.

CO2: Develop readable* C programs with branching and looping statements, which uses Arithmetic, Logical, Relational or Bitwise operators.

CO3: Write readable C programs with arrays, structure or union for storing the data to be processed.

CO4: Divide a given computational problem into a number of modules and develop a readable multi-function C program by using recursion if required, to find the solution to the computational problem.

CO5: Write readable C programs which use pointers for array processing and parameter passing.

CO6: Develop readable C programs with files for reading input and storing output.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO 3
CO1	H	H	H	M		M				M	H	H			
CO2	H	H	H	M	H					M		H			
CO3	H	H	H	M	H					M		H			
CO4	H	H	H	M	H					M	H	H			
CO5	H	H			H					M		H			
CO6	H	H			H					M		H			

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	PO1	As they apply knowledge in mathematics and engineering to analyze a computational problem
	PO2	As they analyze a computational problem to develop an algorithm / flowchart to find its solution using first principles of mathematics
	PO3	As they develop an algorithm / flowchart to find a solution for the specified computational problem
	PO4	As they use knowledge in algorithms / flowcharts to design a solution for analysis and interpretation of data to provide valid conclusions.

	PO6	As they develop an algorithm / flowchart to find a solution pertaining to the environment, health, safety, legal and public welfare
	PO10	As they demonstrate the ability to create algorithms / flowcharts to comprehend and communicate the solution procedure for the specified computational problem
	PO11	As the demonstrate an ability to plan and manage projects
	PO12	As they use their knowledge in algorithm and flowcharts to analyse more complex computational problems and develop solutions using advanced technologies.
CO2	PO1	As they apply knowledge in mathematics and engineering to a computational problem with branching and looping statements, which uses Arithmetic,Logical,Relational or Bitwise operators.
	PO2	As they analyze engineering problems with branching and looping statements, which uses Arithmetic,Logical,Relational or Bitwise operators to find solution to a computational problem using first principles of mathematics
	PO3	As they write C programs with branching and looping statements, which uses Arithmetic,Logical,Relational or Bitwise operators to find a solution for the specified computational problem
	PO4	As they use knowledge in programs with branching and looping statements, which uses Arithmetic,Logical,Relational or Bitwise operators to design a solution for analysis and interpretation of data to provide valid conclusions.
	PO5	As they use modern tools to write and execute programs which use branching and looping statements and also Arithmetic,Logical,Relational or Bitwise operators.
	PO10	As they use the concepts of branching and looping and also Arithmetic,Logical,Relational or Bitwise operators which are useful in writing more effective programs and thereby enabling effective communication of the design of solutions.
	PO12	As they are encouraged to engage in independent and lifelong learning with the concepts of branching and looping statements and also Arithmetic,Logical,Relational or Bitwise operators.
CO3	PO1	As they apply knowledge in mathematics and engineering to analyze a computational problem involving the data storage in arrays, structure or union
	PO2	As they analyze the data stored in arrays, structure or union to find solution to a computational problem using first principles of mathematics
	PO3	As they write C programs with arrays, structure or union to find a solution for a specified computational problem
	PO4	As they analyse and interpret data and synthesis information stored in arrays, structure or union while writing readable C programs
	PO5	As they select an appropriate user defined data type for storing data to be processed while writing C programs
	PO10	As they use the concepts of arrays and structure for data storage while designing solutions which is efficient for communicating the design to others

	PO12	As they are encouraged to engage in independent and lifelong learning with the concepts of arrays and structure which are used in all areas of research and industry
CO4	PO1	The concepts of dividing the complex problem into modules forming multi function programs and the concept of recursive functions are fundamental to our engineering specialization of problem solving.
	PO2	The concepts of dividing the complex problem into modules forming multi function programs and the concept of recursive functions are needed in analyzing complex engineering problems.
	PO3	The concepts of dividing the complex problem into modules forming multi function programs and the concept of recursive functions are inevitable when designing solutions to complex problems.
	PO4	The concepts of dividing the complex problem into modules forming multi function programs and the concept of recursive functions are used in the design of experiments and data interpretation.
	PO5	The concepts of dividing the complex problem into modules forming multi function programs and the concept of recursive functions are useful in usage of different tools since every tool makes use of these fundamentals.
	PO10	The concepts of dividing the complex problem into modules forming multi function programs and the concept of recursive functions are used in the design of solutions which is efficient for communicating the design to others
	PO11	The concepts of dividing the complex problem into modules forming multi function programs and the concept of recursive functions are fundamental to any application related to engineering.
	PO12	The concepts of dividing the complex problem into modules forming multi function programs and the concept of recursive functions are used in all areas of research as well as industry.
CO5	PO1	As they apply knowledge in mathematics and engineering to a computational problem involving the concepts of pointers for array processing and parameter passing.
	PO2	As they analyze complex engineering problems using the concepts of pointers for array processing and parameter passing
	PO5	As they use modern tools to write and execute programs which use concepts of pointers for array processing and parameter passing
	PO10	As they use the concepts of pointers for array processing and parameter passing which are useful in writing more effective programs and thereby enabling effective communication of the design of solutions.
	PO12	As they learn the concepts of pointers for array processing and parameter passing which are important in all areas of research and it also help in adapting to technological changes.
CO6	PO1	As they apply knowledge of Engineering using the concepts of files for data input and output which are very helpful in manipulating large amount of data input and output of complex problems.
	PO2	As they use the concept of files for data input and output in analyzing problems and reviewing the output obtained after doing complex programs in C.

	PO5	As they use tools to implement the concepts of files for data input and output which will be useful for data analysis.
	PO10	As they use files for data input and output which helps to store the results in an organized manner so that it can be effectively communicated to outside world.
	PO12	As they learn the concept of files for data input and output which can be used with almost every real life engineering problem in manipulating the data effectively.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs

11. Internal Assessment mark allocation (as per university curriculum)

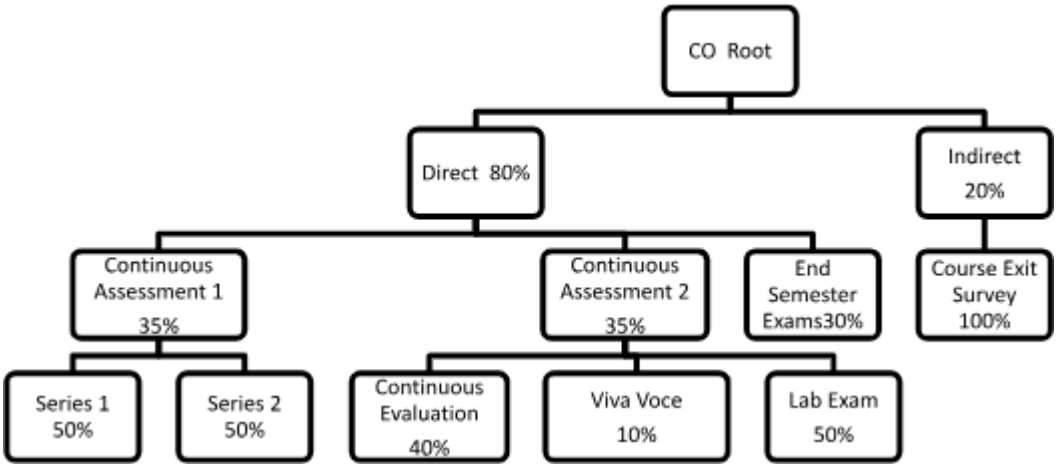
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test (for theory, for 2 hrs)	- 20 marks
Continuous Assessment Test 2 (for lab, internal examination, for 2 hrs)	- 20 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		Weightage#	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6
Direct Assessment Tools**	Continuous Assessment Test 1 - 35%	Series 1	17.5%	x	x	x			
		Series 2	17.5%				x	x	x
	Continuous Assessment Test 2 - 35%	Continuous Evaluation	14%	x	x	x	x	x	x
		Viva Voce	3.5%	x	x	x	x	x	x
		Lab Exam	17.5%	x	x	x	x	x	x
	End Semester Exam		30%	x	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1	Basics of Computer Architecture: Processor, Memory	1	T1, T2, R1	Lecture
2	Basics of Computer Architecture: Input & Output devices	1	T1, T2, R1	Lecture
3	Application Software & System software: Compilers, interpreters,	1	T1, T2, R1	Lecture
4	High level and low level languages	1	T1, T2, R1	Lecture
5	Introduction to structured approach to programming, Flow chart	1	T1, T2, R1	Lecture
6	Algorithms, Pseudo code	1	T1, T2, R1	Lecture
7	Bubble sort, linear search - algorithms and pseudocode	1	T1, T2, R1	Lecture
8	Tutorial 1: Algorithms and Flowcharts	1	T1, T2, R1	Tutorial
9	Basic structure of C program: Character set, Tokens, Identifiers in C	2	T1, T2, R1	Lecture
10	Variables and Data Types , Constants, Console IO Operations, printf and scanf	2	T1, T2, R1	Lecture
11	Operators and Expressions: Expressions and Arithmetic Operators, Relational and Logical Operators	2	T1, T2, R1	Lecture
12	Conditional operator, sizeof operator, Assignment operators and Bitwise	2	T1, T2, R1	Lecture

	Operators. Operators Precedence			
13	Control Flow Statements: If Statement	2	T1, T2, R1	Lecture
14	Tutorial 2: Simple C programs	2	T1, T2, R1	Tutorial
15	Lab	2	T1, T2, R1	Practical
16	Lab	2	T1, T2, R1	Practical
17	Switch Statement, Unconditional Branching using goto statement	2	T1, T2, R1	Lecture
18	While Loop, Do While Loop	2	T1, T2, R1	Lecture
19	For Loop, Break and Continue statements.(Simple programs covering control flow)	2	T1, T2, R1	Lecture
20	Tutorial 3: Control Statements	2	T1, T2, R1	Tutorial
21	Lab	2	T1, T2, R1	Practical
22	Lab	2	T1, T2, R1	Practical
23	Arrays Declaration and Initialization, 1-Dimensional Array	3	T1, T2, R1	Lecture
24	2-Dimensional Array	3	T1, T2, R1	Lecture
25	Tutorial 4: Control Statements -2	2	T1, T2, R1	Tutorial
26	Lab	3	T1, T2, R1	Practical
27	Lab	3	T1, T2, R1	Practical
28	String processing: In built String handling functions(strlen, strcpy, strcat and strcmp, puts, gets)	3	T1, T2, R1	Lecture
29	String processing: In built String handling functions(strlen, strcpy, strcat and strcmp, puts, gets) - 2	3	T1, T2, R1	Lecture
30	Linear search program	3	T1, T2, R1	Lecture
31	Tutorial 5: Arrays	3	T1, T2, R1	Tutorial
32	Lab	3	T1, T2, R1	Practical
33	Lab	3	T1, T2, R1	Practical
34	Bubble sort program	3	T1, T2, R1	Lecture
35	Simple programs covering arrays and strings	3	T1, T2, R1	Lecture
36	Tutorial 6: String functions	3	T1, T2, R1	Tutorial
37	Lab	3	T1, T2, R1	Practical
38	Lab	3	T1, T2, R1	Practical

39	Introduction to modular programming, writing functions	4	T1, T2, R1	Lecture
40	Formal parameters, actual parameters	4	T1, T2, R1	Lecture
41	Pass by Value, Recursion	4	T1, T2, R1	Lecture
42	Tutorial 7: Formal parameters	4	T1, T2, R1	Tutorial
43	Lab	4	T1, T2, R1	Practical
44	Lab	4	T1, T2, R1	Practical
45	Arrays as Function Parameters	4	T1, T2, R1	Lecture
46	Structure, union	4	T1, T2, R1	Lecture
47	Tutorial 8: Recursion	4	T1, T2, R1	Tutorial
48	Lab	4	T1, T2, R1	Practical
49	Lab	4	T1, T2, R1	Practical
50	Storage Classes, Scope and life time of variables	4	T1, T2, R1	Lecture
51	Simple programs using functions	4	T1, T2, R1	Lecture
52	Basics of Pointer: declaring pointers, accessing data though pointers	5	T1, T2, R1	Lecture
53	Tutorial 9: Structure, union	4	T1, T2, R1	Tutorial
54	Lab	5	T1, T2, R1	Practical
55	Lab	5	T1, T2, R1	Practical
56	NULL pointer,array access using pointers	5	T1, T2, R1	Lecture
57	Pass by reference effect	5	T1, T2, R1	Lecture
58	File Operations: open, close, read, write, append	5	T1, T2, R1	Lecture
59	Tutorial 10: Pointers	5	T1, T2, R1	Tutorial
60	Lab	5	T1, T2, R1	Practical
61	Lab	5	T1, T2, R1	Practical
62	Sequential access and random access to files: In built file handling functions (rewind() ,fseek(), ftell(), feof(), fread(), fwrite())	5	T1, T2, R1	Lecture
63	Simple programs covering pointers and files	5	T1, T2, R1	Lecture
64	Tutorial 11: Files	5	T1, T2, R1	Tutorial

15. Question Bank

Module 1				
Sl. No	**Question**	**Marks**	**CO**	**BL**
1	Explain processor and memory in a computer.	3	CO1	L2
2	What are the differences between compiled and interpreted languages? Give example for each.	3	CO1	L1
3	Draw a flow chart to find the position of an element in a given sequence, using linear searching technique. With an example explain how the flowchart finds the position of a given element.	10	CO1	L3
4	Write a pseudo code representing the flowchart for linear searching.	4	CO1	L3
5	With the help of a flow chart, explain the bubble sort operation. Illustrate with an example.	10	CO1	L3
6	Write an algorithm representing the flowchart for bubble sort.	4	CO1	L3
7	Differentiate between Application and System Software.	4	CO1	L1
8	Explain components of computer system.	6	CO1	L2
9	Differentiate between compiler and interpreter.	3	CO1	L1
10	Define structured programming.	3	CO1	L1
11	List the guidelines for drawing a flowchart.	3	CO1	L1
12	Differentiate between primary memory and secondary storage.	4	CO1	L1
13	Explain different levels of programming language.	4	CO1	L2
14	Explain flowchart.	4	CO1	L2
15	Differentiate machine language and assembly language.	4	CO1	L2
16	Differentiate RAM and ROM.	6	CO1	L1
17	List three functions of operating system.	3	CO1	L1
18	Draw a flowchart to print the largest and smallest number from a set of n numbers.	10	CO1	L3
19	Define and distinguish between algorithm and flowchart.	6	CO1	L2
20	Explain the working of compiler and interpreter.	4	CO1	L2
21	Distinguish between Top-down and Bottom-up approaches with examples.	6	CO1	L2
22	Discuss the purpose of memory in a computer.	4	CO1	L2
23	List the advantages and limitations of pseudocode.	3	CO1	L1
24	Draw the flowchart to find the sum of a list of numbers.	10	CO1	L3
25	Write a pseudocode to find the sum of n numbers.	6	CO1	L3
26	What are the advantages of High-Level languages? How a high-level language is converted to Machine language?	4	CO1	L1
27	Write an algorithm and draw flow chart for finding the Average mark for one subject in a class of 50 students.	10	CO1	L3
28	Compare between compiler and assembler.	3	CO1	L1
29	Draw the flowchart and develop the algorithm for finding the area of a triangle by reading three sides.	10	CO1	L3

30	Differentiate between machine language, assembly language and high-level languages?	4	CO1	L1
31	Draw a flowchart to find the sum of digits of an integer.	6	CO1	L3
32	Write an algorithm and draw flow chart for finding the number of numbers divisible by 3 between 100 and 200.	10	CO1	L3
33	Write an algorithm to check whether largest of 3 natural numbers is prime or not. Also, draw a flowchart for solving the same problem.	10	CO1	L3
34	Differentiate among compiler, interpreter and assembler.	3	CO1	L1
35	What is a flowchart? Draw the flow chart to check whether the given number is positive or negative.	3	CO1	L1
36	Write the algorithm and draw the flow chart to calculate the roots of a quadratic equation, take the coefficients as inputs.	10	CO1	L3
37	Explain bubble sort algorithm with an example.	10	CO1	L2
38	Explain different types of memories used in a computer.	4	CO1	L2
Module 2				
1	Describe the structure of a C program.	3	CO2	L1
2	Explain with examples the 'tokens' in C.	3	CO2	L1
3	Explain the syntax of 'scanf() ' statement and list out the various format specifiers.	4	CO2	L1
4	Distinguish between 'break' and 'continue' statements with examples.	4	CO2	L1
5	What are library functions in C? List any 5 library functions in C.	3	CO2	L1
6	Explain with examples the data types used in C.	3	CO2	L1
7	Explain the syntax of if- else statement with an example.	3	CO2	L1
8	Explain the use of 'Switch' statement with an example.	3	CO2	L1
9	Explain loop control statements with examples.	7	CO2	L1
10	Describe the various variable declaration rules to be followed in C.	3	CO2	L1
11	Prepare a C program to find the largest among three numbers.	7	CO2	L3
12	Prepare a C program to print the multiples of 3 and 5 from 1 to 100.	7	CO2	L3
13	Prepare a C program to find the reverse of a number.	7	CO2	L3
14	Prepare a C program to swap the values of A and B without using a temporary variable.	7	CO2	L3
15	Prepare a C program to find the Perimeter and area of a triangle.	7	CO2	L3
16	Prepare a C program that prints the even numbers from 1 to 100.	7	CO2	L3
17	Prepare a C program to find the average of a set of N numbers.	7	CO2	L3
18	Prepare a C program to check whether a number is prime or not.	7	CO2	L3
19	Prepare a C program to print the prime numbers between 1 and 100.	7	CO2	L3
20	Prepare a C program for decimal to binary conversion.	7	CO2	L3
21	Prepare a C program to print the Fibonacci Series.	7	CO2	L3

22	Prepare a C program to check whether a year is Leap Year or not.	7	CO2	L3
23	Prepare a C program to read a character from the keyboard and print it in opposite case.	7	CO2	L3
24	Prepare a C program to print first 50 prime numbers.	7	CO2	L3
25	Prepare a C program to check whether a number is Armstrong or not.	7	CO2	L3
26	Prepare a C program to calculate the average of the best three marks from the given four test marks.	7	CO2	L1
27	Prepare a C program to compute the roots of a quadratic equation.	7	CO2	L3
28	Prepare a C program using switch-case statements for checking the corresponding colour for the input character and print the name of the colour (Eg: R for Red, G for Green etc).	7	CO2	L1
29	Prepare a C program to develop a basic calculator.	7	CO2	L3
30	Prepare a C program to swap tow values using a temporary variable.	7	CO2	L1
31	Write the difference between 'while' and 'do -while' statements.	3	CO2	L2
32	Explain various formatted I/O statements in C.	3	CO2	L2
33	Write a menu driven program to find the area of square, triangle, circle and rectangle according to the choice given.	10	CO2	L3
34	Explain any four types of operators used in C.	7	CO2	L2
35	Write a program to generate the following pattern 1 1 2 1 2 3 1 2 3 4	7	CO2	L3
Module 3				
1	Write a program to read an array of integers and search for the occurrence of a given value.	3	CO3	L3
2	Write a C program to find the product of two matrices.	10	CO3	L3
3	Write a program to reverse a string without using string function.	6	CO3	L3
4	With suitable example, explain any three string manipulating functions in header file 'string.h'.	3	CO3	L2
5	Write a C program to find the transpose of a matrix.	6	CO3	L3
6	Explain different string handling function in C with examples?	3	CO3	L2
7	Explain how to initialize a 1-D numeric array and character array with examples.	3	CO3	L2
8	Write a C program to reverse a string.	6	CO3	L3
9	Explain how a 3-dimensional array is declared and initialised. How is a character array different from a string?	3	CO3	L2
10	Write a C program to count the number of characters, words and lines in a text.	6	CO3	L3

11	Write a C program to read a string and check whether it is palindrome or not.	8	CO3	L3
12	Give the syntax and example for two methods of reading a string.	3	CO3	L2
13	Write a C program to read a sentence through keyboard and to display the count of white spaces in the given sentence.	3	CO3	L3
14	Write a C program to check whether a given matrix is a diagonal matrix.	6	CO3	L3
15	Write a C program to perform bubble sort.	6	CO3	L3
16	Without using any built-in string processing function like strlen, strcat etc., write a program to concatenate two strings.	6	CO3	L3
17	Write a C program read a string (ending with a $ symbol), store it in an array and count the number of vowels, consonants and spaces in it.	3	CO3	L3
18	What are the different ways of declaring and initialising a single dimensional array?	3	CO3	L1
19	Implement string concatenation without using built in functions.	8	CO3	L3
20	Write a C program to accept a 2-D integer matrix and check whether it is symmetric or not (A matrix 'A' is symmetric if $A=A^T$).	6	CO3	L3
Module 4				
1	List the advantages of using functions in a program?	3	CO4	L1
2	Enumerate three advantages of using functions.	3	CO4	L2
3	List the advantages of functions? Explain how it is implemented in C Language.	4	CO4	L2
4	Explain the purpose of return statement.	3	CO4	L2
5	Explain the differences between pass by value and pass by reference with the help of examples.	4	CO4	L2
6	With a suitable example, explain the concept of pass by reference.	4	CO4	L2
7	What is recursion? Give an example.	4	CO4	L2
8	What is recursion? Write a recursive function to find factorial of a number.	6	CO4	L3
9	Explain recursive function with the help of an example program.	6	CO4	L2
10	Write a program to print all prime numbers between any two numbers entered by user, using functions.	10	CO4	L4
11	Write a C program to prepare a rank list based on marks for five subjects, using three separate functions to read the marks, prepare rank list and print the same.	10	CO4	L4
12	Write a function namely myFact in C to find the factorial of a given number. Also, write another function in C namelynCr which accepts two positive integer parameters n and r and returns the value of the mathematical function C(n,r)(n! / (r! x (n - r)!)). The function nCr is expected to make use of the	10	CO4	L3

	factorial function myFact.			
13	Explain the storage classes in C with appropriate examples.	6	CO4	L2
14	With a simple example program, explain scope and life time of variables in C.	4	CO4	L2
15	What is storage classes in C? Explain different storage classes in C with example.	4	CO4	L2
16	Explain four basic storage classes in C.	3	CO4	L2
17	What are the differences between Auto and Extern variables? Explain with example.	4	CO4	L2
18	What is the use of a static variable? Explain with example	3	CO4	L2
19	Compare structure and array and explain with an example.	6	CO3	L2
20	How does a structure differ from an array in C?	4	CO3	L2
21	With an example each, state the differences between structure and union.	6	CO3	L2
22	With a suitable example, explain the differences between a structure and a union in C.	6	CO3	L2
23	Define and explain a structure to store Roll no, Name, marks for three subjects of a group of 25 students. Write a program to read the data and print the same as a table.	10	CO3	L3
24	Write a C program to sort a set of mark sheets of 6 subjects. Make use of structure to develop the program and hence find the first three rank holders.	10	CO3	L4
25	Declare a structure namely Student to store the details (roll number, name, mark_for_C) of a student. Then, write a program in C to find the average mark obtained by the students in a class for the subject Programming in C (using the field mark_for_C). Use array of structures to store the required data	10	CO3	L4
26	Using structure, read and print data of n employees (Name, Employee Id and Salary)	10	CO3	L3
27	Declare a union containing 5 string variables (Name, House Name, City Name, State and Pincode) each with a length of C_SIZE (user defined constant). Then, read and display the address of a person using a variable of the union.	10	CO3	L3
28	Find the factorial of a given Natural Number n using recursive and non-recursive functions.	10	CO4	L3
29	Write a C program to sort a set of n integers and to find the number of unique numbers and the number of repeated numbers in the given set of numbers. Use a function which takes an integer array of n elements, sorts the array using the Bubble Sorting Technique and returns the number of unique numbers and the number of repeated numbers in the given array.	10	CO3 CO4 CO5	L4
30	Write a function in C which takes the address of a single dimensional array (containing a finite sequence of numbers) and the number of numbers stored in the array as arguments and stores the numbers in the same array in reverse order. Use	10	CO3 CO4	L4

	pointers to access the elements of the array.			
31	Write a C program to process the marks obtained by n students of a class and prepare their rank list based on the sum of the marks obtained. There are 3 subjects for which examinations are conducted and the third subject is an elective where a student is allowed to take any one of the two courses offered.	10	CO3 CO4	L4
32	Write a C program using pointers to sort an array of integers by calling a function.	10	CO3 CO4	L3
Module 5				
1	Write a function in C which takes the address of a single dimensional array (containing a finite sequence of numbers) and the number of numbers stored in the array as arguments and stores the numbers in the same array in reverse order. Use pointers to access the elements of the array.	3	CO5	L3
2	With an example, explain the different modes of opening a file.	3	CO6	L2
3	With a suitable example, explain how pointers can help in changing the content of a single dimensional array passed as an argument to a function in C.	8	CO5	L2
4	Differentiate between sequential files and random access files?	4	CO6	L1
5	Using the prototypes explain the functionality provided by the following functions: i. fseek() ii. ftell() iii. fread() iv. fwrite() v. rewind()	10	CO6	L2
6	Write a program in C to reverse a string by using pointer.	4	CO5	L3
7	What is a file? Explain how the file open and file close functions are handled in C.	4	CO6	L2
8	Write a C program to read and display a text from the file.	4	CO6	L3
9	What is a pointer? Explain how the pointer variable declared and initialized.	3	CO5	L2
10	Write a C program to swap two numbers using call by reference method.	5	CO5	L3
11	Explain the array of pointers with example.	4	CO5	L2
12	With an example, explain pass by reference method.	3	CO5	L2
13	What is the use of NULL pointer?	3	CO5	L1
14	What is the difference between Write and Append mode?	4	CO6	L2
15	Write a C program to read and display even numbers from a file containing even and odd numbers.	8	CO6	L3

16	Describe the concept of binary file.	4	CO6	L1
17	Write a C program to sort an array using pointers.	8	CO5	L3
18	Write a c program to copy the contents of one file to another.	8	CO6	L3
19	How is declaration int *a[10] different from (*a)[10] ?	3	CO5	L2
20	Write about any two file handling functions used to write data into text files.	4	CO6	L2
21	Write a c program to create a file and store information about a person like name, age and salary.	6	CO6	L3
22	Explain how a new file is opened. What are the 3 modes while opening an existing file?	6	CO6	L2
23	Write a c program to add two variables using pointers.	3	CO5	L3
24	Give the syntax of fscanf and fprintf. Illustrate with an example.	4	CO6	L1
25	What are the advantages of using pointers?	3	CO5	L2

Prepared By : Ms. Nisy John Panicker, Course Faculty

Checked By : Ms. Chinnu Edwin A, Course Committee Chairrman

Course Code & Name: PHL120 ENGINEERING PHYSICS LAB

1. Prescribed Syllabus

Module	Topic	Hours
1	CRO-Measurement of frequency and amplitude of wave forms	3
2	Measurement of strain using strain gauge and wheatstone bridge	3
3	LCR Circuit – Forced and damped harmonic oscillations	3
4	Meld's string apparatus- Measurement of frequency in the transverse and longitudinal mode	3
5	Wave length measurement of a monochromatic source of light using Newton's Rings method.	3
6	Determination of diameter of a thin wire or thickness of a thin strip of paper using air wedge method.	3
7	To measure the wavelength using a millimetre scale as a grating.	3
8	Measurement of wavelength of a source of light using grating.	3
9	Determination of dispersive power and resolving power of a plane transmission grating	3
10	Determination of the particle size of lycopodium powder	3
11	Determination of the wavelength of He-Ne laser or any standard laser using diffraction grating	3
12	Calculate the numerical aperture and study the losses that occur in optical fibre cable.	3
13	I-V characteristics of solar cell.	3
14	LED Characteristics.	3
15	Ultrasonic Diffractometer- Wavelength and velocity measurement of ultrasonic waves in a liquid	3
16	Deflection magnetometer-Moment of a magnet- Tan A position.	3

2. Text Books (T)

Lab Manual

3. Reference Books (R)

R1. S.L.Gupta and Dr.V.Kumar, "Practical physics with viva voice", Pragati Prakashan Publishers, Revised Edition, 2009
R2. M.N.Avadhanulu, A.A.Dani and Pokely P.M, "Experiments in Engineering Physics", S.Chand&Co,2008
R3. S. K. Gupta, "Engineering physics practical's", Krishna Prakashan Pvt. Ltd., 2014 R4. P. R. Sasikumar "Practical Physics", PHI Ltd., 2011.

4. Course Objectives

This course is designed (i) to impart practical knowledge about some of the

phenomena they have studied in the Engineering Physics course and (ii) to develop the experimental skills of the students.

5. Course Pre / Co-requisite

Higher secondary level Physics

6. Course Outcomes

After completion of the course, student will be able to

CO1: Develop analytical/experimental skills and impart prerequisite hands-on experience for engineering laboratories.

CO2: Understand the need for precise measurement practices for data recording.

CO3: Understand the principle, concept, working and applications of relevant technologies and comparison of results with theoretical calculations

CO4: Analyze the techniques and skills associated with modern scientific tools such as lasers and fibre optics

CO5: Develop basic communication skills through working in groups in performing the laboratory experiments and by interpreting the results

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO 3
CO1	H				H			L	M			L		H	
CO2	H				H			L	M			L		H	
CO3	H				H			L	M			L		H	
CO4	H				H			L				L		H	
CO5	H				H			L	M			L		H	

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	PO1	Develop analytical/experimental skills and impart prerequisite hands on experience for engineering laboratories based on the knowledge of mathematics and engineering fundamentals helps to solve complex engineering problems
	PO5	Analytical/experimental skills in engineering laboratories can be used for the creation of engineering and IT tools helps to create ,select and apply appropriate techniques
	PO8	Develop analytical/experimental skills and impart prerequisite hands-on experience for engineering laboratories helps to apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practices
	PO9	Develop analytical/experimental skills and impart prerequisite hands on experience for engineering laboratories helps to function effectively as an individual and a member in diverse teams and in multidisciplinary settings

	PO12	Develop analytical/experimental skills and impart prerequisite hands on experience for engineering laboratories help to recognize the need for engaging independent and lifelong learning the broadest contest of technological knowledge
CO2	PO1	Understand the need for precise measurement practices for data recording based on the knowledge of mathematics and engineering fundamentals helps to solve complex engineering problems;
	PO5	Understand the need for precise measurement practices for data recording helps to create ,select and apply appropriate techniques
	PO8	Understand the need for precise measurement practices for data recording helps to apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practices
	PO9	Understand the need for precise measurement practices for data recording helps to function effectively as an individual and a member in diverse teams and in multidisciplinary settings
	PO12	Understand the need for precise measurement practices for data recording help to recognize the need for engaging independent and lifelong learning the broadest contest of technological knowledge
CO3	PO1	Understand the principle, concept, working and applications of relevant technologies and comparison of results with theoretical calculations to solve complex engineering problems
	PO5	Understand the principle, concept, working and applications of relevant technologies and comparison of results with theoretical calculations helps to formulate and analyse complex engineering problems helps to create ,select and apply appropriate techniques
	PO8	Understand the principle, concept, working and applications of relevant technologies and comparison of results with theoretical calculations helps to apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practices
	PO9	Understand the principle, concept, working and applications of relevant technologies and comparison of results with theoretical helps to function effectively as an individual and a member in diverse teams and in multidisciplinary settings
	PO12	Understand the principle, concept, working and applications of relevant technologies and comparison of results with theoretical calculations help to recognize the need for engaging independent and lifelong learning the broadest contest of technological knowledge
CO4	PO1	Analyze the techniques and skills associated with modern scientific tools such as lasers and Fibre optics will help to solve complex engineering problems.
	PO5	Analyze the techniques and skills associated with modern scientific tools such as lasers and fibre optics helps to create ,select and apply appropriate techniques
	PO8	Analyze the techniques and skills associated with modern scientific tools such as lasers and fibre optics helps to apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practices

	PO9	Analyze the techniques and skills associated with modern scientific tools such as lasers and fibre optics helps to function effectively as an individual and a member in diverse teams and in multidisciplinary settings
	PO12	Analyze the techniques and skills associated with modern scientific tools such as lasers and fibre optics help to recognize the need for engaging independent and lifelong learning the broadest contest of technological knowledge
CO5	PO1	Develop basic communication skills through working in groups in performing the laboratory experiments and by interpreting the results helps to solve complex engineering problems
	PO5	Develop basic communication skills through working in groups in performing the laboratory experiments and by interpreting the results helps to analyse and formulate engineering problems helps to create ,select and apply appropriate techniques
	PO8	Develop basic communication skills through working in groups in performing the laboratory experiments and by interpreting the results helps to apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practices
	PO9	Develop basic communication skills through working in groups in performing the laboratory experiments and by interpreting the results helps to function effectively as an individual and a member in diverse teams and in multidisciplinary settings
	PO12	Develop basic communication skills through working in groups in performing the laboratory experiments and by interpreting the results help to recognize the need for engaging independent and lifelong learning the broadest contest of technological knowledge

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1.	NIL		

11. Internal Assessment mark allocation (as per university curriculum)

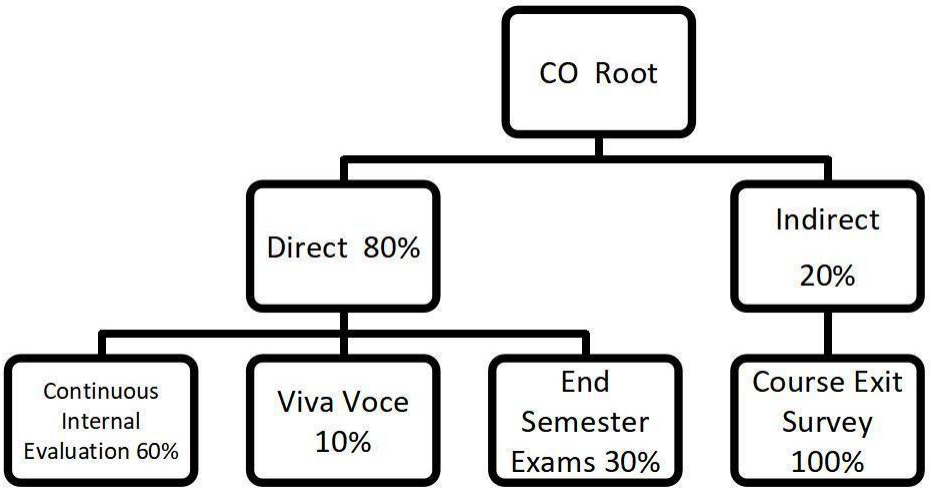
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools	Weightage#	CO 1	CO 2	CO 3	CO 4	CO 5
Direct Assessment Tools**	Continuous Evaluation - Experiment wise CO mapping	60%	x	x	x	x	x
	Viva – Voce - Experiment wise CO mapping	10%	x	x	x	x	x
	End Semester Exam	30%	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey	100%	x	x	x	x	x

13. Assessment Configuration



13. Course Plan

Weeks(W)	Experiments	Relevance to COs
1	CRO-Measurement of frequency and amplitude of wave forms.	CO 1
2	Melde's string apparatus- Measurement of frequency in the transverse and longitudinal mode	CO2
3	Wave length measurement of a monochromatic source of light using Newton's Rings method.	CO2
4	Determination of diameter of a thin wire or thickness of a thin strip of paper using air wedge method.	CO2
5	Measurement of wavelength of a source of light using grating.	CO2
6	Determination of the wavelength of He-Ne laser or any standard laser using diffraction grating	CO5
7	I-V characteristics of solar cell.	CO4
8	Determination of dispersive power and resolving power of a plane transmission grating	CO2

Prepared By: Ms. Sreeja C, Course Faculty

Checked By: Ms. Dhanya George P, Course Committee Chairman

Course Code & Name: ESL130 Electrical and Electronics Workshop

1. Prescribed Syllabus

Experiments	Topic	Hours
Electrical Workshop (Minimum 7 Experiments to be done)		
1	Demonstrate the precautionary steps adopted in case of Electrical shocks. Identify different types of cables, wires, switches, fuses, fuse carriers, MCB, ELCB and MCCB, familiarize the ratings.	3
2	Wiring of a simple light circuit for light/ fan point (PVC conduit wiring) and a 6A plug socket with individual control.	3
3	Wiring of light/fan circuit using two-way switches. (Staircase wiring)	3
4	Wiring of fluorescent lamp and a power plug (16 A) socket with a control switch.	3
5	Wiring of power distribution arrangement using single phase MCB distribution board with ELCB, main switch and Energy meter.	3
6	Familiarization of step up and step-down transformers, (use low voltage transformers) Measurement and representation of voltage and waveform to scale in graph sheet with the help of CRO	3
7	Familiarization of rheostats, measurement of potential across resistance elements and introducing the concept of relative potential using a DC circuit.	3
List of Electronics Experiments ((Minimum of 7 mandatory)		
1	Familiarization/Identification of electronic components with specification (Functionality, type, size, colour coding, package, symbol, cost etc. [Active, Passive, Electrical, Electronic, Electro-mechanical, Wires, Cables, Connectors, Fuses, Switches, Relays, Crystals, Displays, Fasteners, Heat sink etc.)	3
2	Drawing of electronic circuit diagrams using BIS/IEEE symbols and introduction to EDA tools (such as Dia or XCircuit), Interpret data sheets of discrete components and IC's, Estimation and costing.	3
3	Familiarization/Application of testing instruments and commonly used tools. [Multimeter, Function generator, Power supply, CRO etc.] [Soldering iron, De-soldering pump, Pliers, Cutters, Wire strippers, Screw drivers, Tweezers, Crimping tool, Hot air soldering and de-soldering station etc.]	3
4	Testing of electronic components [Resistor, Capacitor, Diode, Transistor and JFET using Multimeter]	3

5	Inter-connection methods and soldering practice. [Bread board, Wrapping, Crimping, Soldering - types - selection of materials and safety precautions, soldering practice in connectors and general-purpose PCB, Crimping.]	3
6	Printed circuit boards (PCB) [Types, Single sided, Double sided, PTH, Processing methods, Design and fabrication of a single sided PCB for a simple circuit with manual etching (Ferric chloride) and drilling.]	3
7	Assembling of electronic circuits using SMT (Surface Mount Technology) stations. Assembling of electronic circuit/system on general purpose PCB, test and show the functioning (Any Two circuits). 1. Fixed voltage power supply with transformer, rectifier diode, capacitor filter, Zener/IC regulator. 2. Square wave generation using IC 555 timer in IC base. 3. Sine wave generation using IC 741 OP-AMP in IC base. 4. RC coupled amplifier with transistor BC 107.	3

2. Textbooks (T)

T1. Electrical Design Estimating and Costing, K B Raina and S K Bhattacharya, New Age International Publishers, 2/e 2024.
T2. Electrical Systems Design, M K Giridharan, I K International Publishing House Pvt. Ltd, 3/e 2022.
T3. Basic Electrical Engineering, D P Kothari and I J Nagrath, Tata McGraw Hill, 4/e 2019. T4. Bell, D. A., Electronic Devices and Circuits, Oxford University Press
T5. Basics of Soldering, Armin Rahn.

3. Reference Books (R)

R1. R. P. Singh, Electrical Workshop: Safety, Commissioning, Maintenance & Testing of Electrical Equipment, I K International Publishing House
R2. Sunil S. Rao, R. K. Jain, H. L. Saluja, Electrical Safety, Fire Safety Engineering and Safety Management
R3. Hari Mohan Johri, Electrical Installations in Building, KW Publishers
R4. Boylested, R. L. and Nashelsky, L., Electronic Devices and Circuit Theory, Pearson education
R5. N. N. Bhargava, Basic Electronics and Linear Circuits
R6. J B Gupta, Electronics Devices and Circuits
R7. Ramakanth A Gayakwad, Op-amps and Linear Integrated Circuits.

4. Course Objectives

- To create awareness and familiarity with electrical wiring and safety measures to be taken.
- This course gives the basic introduction of electronic hardware systems.

- Provides hands-on training with familiarization, identification, testing, assembling, dismantling, fabrication and repairing such systems by making use of the various tools and instruments available in the Electronics Workshop.

5. Course Pre / Co-requisite

Nil

6. Course Outcomes

After completion of the course, student will be able to
CO1. Demonstrate safety measures against electric shocks.
CO2. Identify the tools used for electrical wiring, electrical accessories, wires, cables, batteries and standard symbols
CO3. Develop the connection diagram, identify the suitable accessories and materials necessary for wiring simple lighting circuits for domestic buildings
CO4: Identify and test various electronic components.
CO5: Draw circuit schematics with EDA tools.
CO6: Assemble and test electronic circuits on boards.
CO7: Work in a team with good interpersonal skills.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO 3
CO1						H						L			
CO2	M									L			L		
CO3	M			L		L		L	M	M		M	L	L	
CO4	H											M	H		
CO5	H				M							M	H		
CO6	H				M							L	H		

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	PO6	Apply the knowledge obtained from the practical course for the societal safety against electric shocks.
	PO12	Able to explore different protective measures and techniques against electric shock and thus to get engaged in life-long learning.
CO2	PO1	Apply the knowledge about the types of wires, accessories, batteries and standard symbols to put forward innovative solutions in electrical wiring.

	PO10	Suggest suitable electrical wires, battery, cables etc. for specific needs of the society.
	PSO1	Demonstrate safety measures against electric shocks by applying fundamental knowledge in Electrical and Electronics Engineering.
CO3	PO1	Design wiring system for domestic buildings and by that to apply the knowledge of engineering fundamentals.
	PO4	Analyze and provide solutions related to domestic wiring and thereby enhancing the capability to conduct investigations of complex problems.
	PO6	Able to identify the cost effective and safe measures of wiring practices for the society.
	PO8	Able to understand the responsibilities and ethical principles behind the wiring practices involved in domestic buildings.
	PO9	Able to work in team to design, estimate and wire the simple lighting circuits enables a student to be an effective team player.
	PO10	Able to write effective reports about the wiring practices of domestic buildings and there by permitting student to effectively communicate, comprehend and write effective reports about the wiring practices of domestic buildings.
	PO12	Able to recognize the need of cost and material estimation and apply it in surrounding buildings and thus to engage in lifelong learning.
	PSO1	Develop the connection diagram, identify the accessories and materials necessary for wiring using fundamental knowledge in Electrical and Electronics engineering.
	PSO2	Identify the accessories and materials necessary for wiring by analyzing components and processes.
CO4	PO1	Understanding the fundamentals of various active and passive components will help the students to identify and test various electronic components. Hence a high correlation is given.
	PO12	Knowledge in basic concepts of active and passive components will encourage students to design advanced electronics hardware circuits. Hence a medium correlation is given.
	PSO1	Understanding the fundamentals of various active and passive components will help students to apply contextual knowledge of Electronics and Communication Engineering in development of various electronic systems. Hence a high correlation is given
CO5	PO1	Understanding the fundamentals of various electronic components will help students to draw schematics with EDA tools. Hence a high correlation is given.
	PO5	By selecting appropriate modern engineering tools students will be able to draw schematics and understand its limitations. Hence a medium correlation is given.

	PO12	Knowledge of use of schematics with EDA tools will encourage students to engage in independent and lifelong learning in context of technological change. Hence a medium correlation is given.
	PSO1	Understanding the circuit schematics with EDA tools will help students to apply contextual knowledge of Electronics and Communication Engineering in the design of various electronic systems. Hence a high correlation is given.
CO6	PO1	Understanding the fundamentals of various components will help the students to assemble and test electronic circuits on boards. Hence a high correlation is given.
	PO5	By selecting appropriate resources and modern engineering tools, students will be able to assemble and test electronic circuits. Hence a medium correlation is given.
	PO12	Knowledge of assembly and testing of electronic circuit components will encourage students to engage in independent and lifelong learning. Hence a low correlation is given.
	PSO1	By assembling and testing electronic circuits on boards will help students to apply contextual knowledge of Electronics and Communication Engineering in development of various electronic systems. Hence a high correlation is given.
CO7	PO9	Conduct of experiments individually and in groups will enable students to function effectively as a member of a team or as a team leader. Hence a high correlation is given.
	PO10	Preparation of lab reports with reference to standard specifications and developing effective interpersonal communication skills will help students to prepare effective reports in real time projects and in making effective presentations. Hence a medium correlation is given.
	PO12	Working in a team and developing good interpersonal skills will encourage students to engage in life-long learning of changes and advancements in technology. Hence a medium correlation is given.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	Nil		

11. Internal Assessment mark allocation (as per university curriculum)

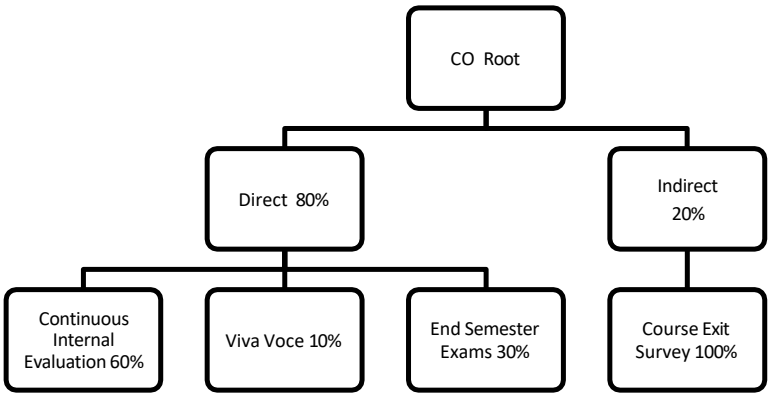
(Provide details as mentioned in syllabus)

Classwork/Assessment/Viva voce	- 50 marks
Attendance	- 20 marks
End Semester Examination	- 30 marks
Total	**-100 marks**

12. Assessment – CO Mapping (Put 'x' if mapping is present)

	Weightage#	Weightage	CO1	CO2	CO3	CO4	CO5	CO6	CO7
Direct Assessment Tools**	Viva	10%	x	x	x	x	x	x	x
	Classwork/ Assessment	60%	x	x	x	x	x	x	x
	End Semester Exam	30%	x	x	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey	100%	x	x	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Weeks (W)	Experiments	Relevance to COs
	Electrical Workshop	
1	a) Demonstrate the precautionary steps adopted in case of Electrical shocks. b) Identify different types of cables, wires, switches, fuses, fuse carriers, MCB, ELCB and MCCB, familiarize the ratings.	CO1
2	Wiring of a simple light circuit for light/ fan point (PVC conduit wiring) and a 6A plug socket with individual control.	CO3, CO7
3	Wiring of light/fan circuit using two-way switches. (Staircase wiring)	CO3, CO7
4	Wiring of fluorescent lamp and a power plug (16 A) socket with a control switch.	CO3, CO7

5	Wiring of power distribution arrangement using single phase MCB distribution board with ELCB, main switch and Energy meter.	CO3, CO7
6	Familiarization of rheostats, measurement of potential across resistance elements and introducing the concept of relative potential using a DC circuit.	CO2, CO7
7	a) Identify battery specifications using different types of batteries. (Lead acid, Li Ion, NiCd etc.) b) Familiarize different types of earthing (Pipe, Plate Earthing, Mat Schemes) and ground enhancing materials (GEM).	CO2
Electronics Experiments		
1	Familiarization/Identification of electronic components with specification (Functionality, type, size, color coding, package, symbol, cost etc.)	CO4, CO7
2	Drawing of electronic circuit diagrams using BIS/IEEE symbols and introduction to EDA tools (such as Dia or XCircuit), Interpret data sheets of discrete components and IC's, Estimation and costing.	CO5, CO7
3	Familiarization/Application of testing instruments and commonly used tools. [Multimeter, Function generator, Power supply, CRO etc.] [Soldering iron, De-soldering pump, Pliers, Cutters, Wire strippers, Screw drivers, Tweezers, Crimping tool, Hot air soldering and de-soldering station etc.]	CO4, CO7
4	Testing of electronic components [Resistor, Capacitor, Diode, Transistor and JFET using Multimeter]	CO4, CO7
5	Inter-connection methods and soldering practice. [Bread board, Wrapping, Crimping, Soldering - types - selection of materials and safety precautions, soldering practice in connectors and general-purpose PCB, Crimping.]	CO6, CO7
6	Printed circuit boards (PCB) [Types, Single sided, Double sided, PTH, Processing methods, Design and fabrication of a single sided PCB for a simple circuit with manual etching (Ferric chloride) and drilling.]	CO6, CO7
7	Assembling of electronic circuits using SMT (Surface Mount Technology) stations.	CO6, CO7
8	Assembling of electronic circuit/system on general purpose PCB, test and show the functioning of fixed voltage power supply with transformer, rectifier diode, capacitor filter, Zener/IC regulator.	CO6, CO7
9	Assembling of electronic circuit/system on general purpose PCB, test and show the functioning of square wave generation using IC 555 timer in IC base.	CO6, CO7

10	Assembling of electronic circuit/system on general purpose PCB, test and show the functioning of Sine wave generation using IC 741 OP-AMP in IC base.	CO6, CO7
11	Assembling of electronic circuit/system on general purpose PCB, test and show the functioning of RC coupled amplifier with transistor BC 107.	CO6, CO7

Prepared By: Prof. Reshma Mary Jose, Dr. Saju A, Prof. Lakshmi Babu, Course Faculty

Checked By: Dr. Lins T. Alex

Semester: 3

Curriculum

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT201	PARTIAL DIFFERENTIAL EQUATION AND COMPLEX ANALYSIS	3-1-0	4	4
B	MET201	MECHANICS OF SOLIDS	3-1-0	4	4
C	MET203	MECHANICS OF FLUIDS	3-1-0	4	4
D	MET205	METALLURGY & MATERIAL SCIENCE	3-1-0	4	4
E	EST200	DESIGN AND ENGINEERING	2-0-0	2	2
F	MCN201	SUSTAINABLE ENGINEERING	2-0-0	2	-
S	MEL201	COMPUTER AIDED MACHINE DRAWING	0-0-3	3	2
T	MEL203	MATERIALS TESTING LAB	0-0-3	3	2
TOTAL				26/30	22/26

Course Code & Name: MAT201 Partial Differential Equations and Complex Analysis

1. Prescribed Syllabus

Module	Topic	Hours
1	(Text 1-Relevant portions of sections 17.1, 17.2, 17.3, 17.4, 17.5, 17.7, 18.1, 18.2) Partial differential equations, Formation of partial differential equations –elimination of arbitrary constants-elimination of arbitrary functions, Solutions of a partial differential equations, Equations solvable by direct integration, Linear equations of the first order Lagrange's linear equation, Non-linear equations of the first order - Charpit's method, Solution of equation by method of separation of variables..	8
2	(Text 1-Relevant portions of sections 18.3,18.4, 18.5) One dimensional wave equation- vibrations of a stretched string, derivation, solution of the wave equation using method of separation of variables, D'Alembert's solution of the wave equation, One dimensional heat equation, derivation, solution of the heat equation	10
3	(Text 2: Relevant portions of sections13.3, 13.4, 17.1, 17.2 , 17.4) Complex function, limit, continuity, derivative, analytic functions, Cauchy-Riemann equations, harmonic functions, finding harmonic conjugate, Conformal mappings- mappings w = z^2 , w = e^z,. Linear fractional transformation w = 1/z , fixed points, Transformation w = $sinz$ (From sections 17.1, 17.2 and 17.4 only mappings, w = z^2 , w = e^z, w = 1/z ,w = $sinz$ and problems based on these transformations need to be discussed)	9
4	(Text 2- Relevant topics from sections14.1, 14.2, 14.3, 14.4,15.4) Complex integration, Line integrals in the complex plane, Basic properties, First evaluation method-indefinite integration and substitution of limit, second evaluation method-use of a representation of a path, Contour integrals, Cauchy integral theorem (without proof) on simply connected domain, Cauchy integral theorem (without proof) on multiply connected domain Cauchy Integral formula (without proof), Cauchy Integral formula for derivatives of an analytic function, Taylor's series and Maclaurin series.,	9
5	(Text 2- Relevant topics from sections16.1, 16.2, 16.3, 16.4) Laurent's series(without proof), zeros of analytic functions, singularities, poles, removable singularities, essential singularities, Residues, Cauchy Residue theorem (without proof), Evaluation of definite integral using residue theorem, Residue integration of real integrals – integrals of rational functions of $cos\theta$ and $sin\theta$, integrals of improper integrals of the form ∫_(-∞)^∞▒〖f(x) dx 〗 with no poles on the real axis. (∫_A^B▒〖f(x) dx 〗 whose integrand become infinite at a point in the interval of integration is excluded from the syllabus)	9

2. Text Books (T)

T1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 44th Edition, 2018.
T2. Erwin Kreyszig, Advanced Engineering Mathematics, 10th Edition, John Wiley & sons, 2016.

3. Reference Books (R)

R1. Peter V. O'Neil, Advanced Engineering Mathematics, Cengage, 7th Edition, 2012

4. Course Objectives

This course introduces basic ideas of partial differential equations which are widely used in the modelling and analysis of a wide range of physical phenomena and has got application across all branches of engineering. To understand the basic theory of functions of a complex variable, residue integration and conformal transformation.

5. Course Pre / Co-requisite

A basic course in partial differentiation and complex numbers

6. Course Outcomes

At the end of the course students would be able to

CO1: Understand the concept and the solution of partial differential equation.
CO2: Analyse and solve one dimensional wave equation and heat equation.
CO3: Understand complex functions, its continuity differentiability with the use of Cauchy Riemann equations.
CO4: Evaluate complex integrals using Cauchy's integral theorem and Cauchy's integral formula, understand the series expansion of analytic function
CO5: Understand the series expansion of complex function about a singularity and apply residue theorem to compute several kinds of real integrals.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	H	H	H	H	M	L				M		M			
CO2	H	H	H	H	M	L				M		M			
CO3	H	H	H	H	M	L				M		M			
CO4	H	H	H	H	M	L				M		M			
CO5	H	H	H	H	M	L				M		M			

8. Justification for CO-PO-PSO Correlation

CO1-PO1	The concept and the solution of partial differential equations will help to solve problems arising in engineering
CO1-PO2	Fundamental knowledge of partial differential equations and its solution will help to formulate and analyze problems with high complexity in Engineering
CO1-PO3	Understanding of solution of partial differential equations helps in the development of solutions for complex engineering problems
CO1-PO4	Knowledge of partial differential equations and its solution will help in the investigations of certain engineering problems.
CO1-PO5	Various methods for the solution of partial differential equation will help to select appropriate techniques in complex engineering activities.
CO1-PO6	The concept of partial differential equations will help to assess the issues related to society
CO1-PO10	Understanding of partial differential equations and its solution will help to communicate effectively on complex engineering activities.
CO1-PO12	Practical application of partial differential equations will enhance the ability to engage in lifelong learning process.
CO2-PO1	Fundamental knowledge of one-dimensional wave equation and heat equation will help to solve problems arising in engineering
CO2-PO2	Application of one-dimensional wave equation and heat equation of helps to analyse problems with high complexity in Engineering.
CO2-PO3	Understanding of one-dimensional wave equation and heat equation are used to design solutions for complex engineering problems
CO2-PO4	The concept of solution of one-dimensional wave equation and heat equation helps to conduct investigation of complex problems
CO2-PO5	The solution of one-dimensional wave equation and heat equation will help to solve complex engineering problems by including the prediction and modelling of those problems.
CO2-PO6	Theory of one-dimensional wave equation and heat equation helps to assess issues and responsibilities relevant to the professional engineering practice
CO2-PO10	Knowledge about solution of one-dimensional wave equation and heat equation will help to communicate effectively on complex engineering activities.
CO2-PO12	The concept of solution of one-dimensional wave equation and heat equation will help to recognise the need for independent and lifelong learning in the broadest context of technological knowledge.
CO3-PO1	The knowledge of complex functions can be used to solve complex problems in electrical engineering
CO3-PO2	The knowledge of Cauchy Riemann equations can be used to identify, formulate and analyse real life problems and provide eco-friendly solutions
CO3-PO3	The concept of complex functions, its continuity, differentiability with the use of Cauchy Riemann equations can be used to design solutions that are at par with the needs of society so as to address societal and environmental concerns

CO3-PO4	The concept of Cauchy Riemann equations can be used to conduct investigations of complex problems involving the synthesis of data to provide valid conclusions
CO3-PO5	The Concept of complex functions and Cauchy Riemann equations will help to select appropriate techniques in complex engineering activities with the understanding of the limitations.
CO3-PO6	The concept of complex functions, its continuity, differentiability with the use of Cauchy Riemann equations can be used to assess the issues related to the society
CO3-PO10	The knowledge of complex functions will help to communicate effectively on complex engineering activities
CO3-PO12	The theory of Cauchy Riemann equations will help to recognise the need for independent and lifelong learning in the broadest context of technological knowledge
CO4-PO1	The fundamental knowledge of Cauchy's integral theorem and Cauchy's integral formula can be used to solve complex engineering problems
CO4-PO2	The concept of evaluation of complex integrals using Cauchy's integral theorem and Cauchy's integral formula can be used to identify, formulate and analyse complex engineering problems
CO4-PO3	The knowledge of series expansion of analytic functions can be used to design solutions for complex engineering problems
CO4-PO4	The concept of evaluation of complex integrals using Cauchy's integral theorem and Cauchy's integral formula can be used to conduct investigation of complex problems including design of experiments, analysis and interpretation of data to provide valid conclusions
CO4-PO5	The concept of evaluation of complex integrals are used to create, select and apply appropriate techniques, modern engineering tools including prediction and modelling to complex engineering activities.
CO4-PO6	The knowledge of Cauchy's Integral Theorem and Cauchy's Integral Formula will help to assess societal health, safety and legal issues involved in various engineering problems
CO4-PO10	The concept of evaluation of complex integrals using Cauchy's integral theorem and Cauchy's integral formula will help to communicate effectively on the stability of electrical systems
CO4-PO12	The knowledge of evaluation of complex integrals using Cauchy's integral theorem and Cauchy's integral formula will give awareness about the need for lifelong learning and continuous upgradation of technical knowledge.
CO5-PO1	The concept of residue Theorem can be used to solve complex engineering problems in Control Theory
CO5-PO2	The knowledge of the series expansion of analytic function about a singularity can be used to identify, formulate and analyse complex engineering problems

CO5-PO3	Theory of residue Theorem can be used to design solutions of electrical systems
CO5-PO4	The knowledge of residue theorem can be used to conduct investigation on complex engineering problems including problems on Quantum mechanics
CO5-PO5	The concept of series expansion of complex functions and applications of residue theorem to compute several kinds of real integrals will help to select appropriate techniques in complex engineering activities.
CO5-PO6	The concept of residue theorem and their applications can be used to apply reasoning to assess issues and responsibilities relevant to the professional engineering practice
CO5-PO10	Methods of solving real integrals using residue theorem will help to communicate effectively on complex engineering activities.
CO5-PO12	Theory of residue Theorem will help to engage in independent and lifelong learning

9. Curricular gaps (if any)

Sl No	Description	Proposed Actions
1 .	Basic concepts of complex analysis	Reading graduate level text book on Complex Analysis

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1.	Complex Analysis by Prof. Pranav Hardas https://onlinecourses.nptel.ac.in/noc23_ma51/preview	NPTEL, IIT Madars	PO1, PO2

11. Internal Assessment mark allocation (as per university curriculum)

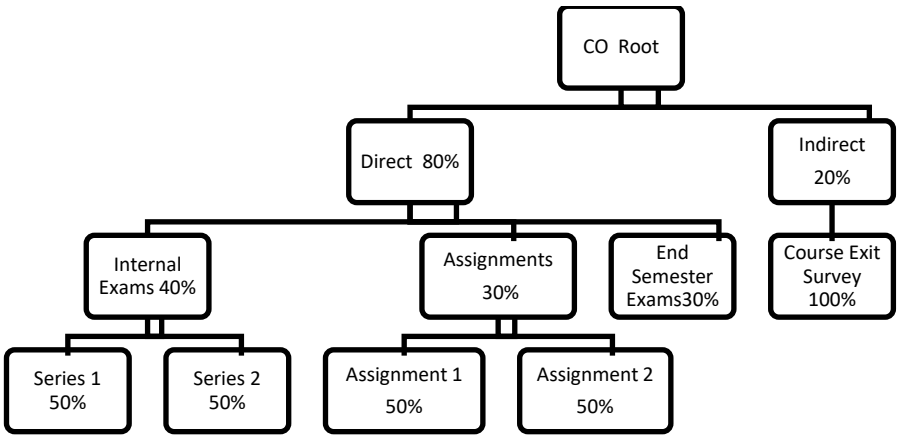
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		Weightage#	CO1	CO2	CO3	CO4	CO5
Direct Assessment Tools	Internal Exam(s) 40%	Series 1	20%	x	x			
		Series 2	20%			x	x	x
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x	x			
		Assignment 2	15%			x	x	x
	End Semester Exam		30%	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1	Partial differential equations, Formation of partial differential equations – elimination of arbitrary constants- elimination of arbitrary functions	1	T1	Lecture

2	Solutions of a partial differential equations	1	T1	Lecture
3	Equations solvable by direct integration	1	T1	Tutorial
4	Linear equations of the first order- Lagrange's linear equation	1	T1	Lecture
5	Linear equations of the first order- Lagrange's linear equation, Non-linear equations of the first order - Charpit's method	1	T1	Lecture
6	Non-linear equations of the first order - Charpit's method	1	T1	Tutorial
7	Boundary value problems, Method of separation of variables	1	T1	Lecture
8	Boundary value problems, Method of separation of variables	1	T1	Lecture
9	One dimensional wave equation- vibrations of a stretched string, derivation	1	T1	Group Discussion
10	Solution of wave equation using method of separation of variables	2	T1	Lecture
11	Fourier series solution of boundary value problems involving wave equation	2	T1	Lecture
12	Fourier series solution of boundary value problems involving wave equation	2	T1	Lecture
13	D'Alembert's solution of the wave equation	2	T1	Tutorial
14	One dimensional heat equation, derivation	2	T1	Lecture
15	Solution of the heat equation, using method of separation of variables	2	T1	Lecture
16	Fourier series solutions of boundary value problems involving heat equation	2	T1	Lecture
17	Fourier series solutions of boundary value problems involving heat equation	2	T1	Lecture
18	Fourier series solutions of boundary value problems involving heat equation	2	T1	Tutorial
19	Complex function, limit, continuity, derivative	3	T2	Lecture
20	Complex function, limit, continuity, derivative	3	T2	Lecture
21	Analytic functions, Cauchy-Riemann equations	3	T2	Lecture
22	Analytic functions, Cauchy-Riemann equations	3	T2	Tutorial
23	Harmonic functions, finding harmonic conjugate	3	T2	Lecture
24	Harmonic functions, finding harmonic conjugate	3	T2	Tutorial

25	Conformal mappings- mappings of, $w = z^2$, $w = e^z$, $w = \frac{1}{z}$,$w = sinz$	3	T2	Lecture
26	Conformal mappings- mappings of, $w = z^2$, $w = e^z$, $w = \frac{1}{z}$,$w = sinz$	3	T2	Lecture
27	Conformal mappings- mappings of , $w = z^2$, $w = e^z$, $w = \frac{1}{z}$,$w = sinz$	3	T2	Lecture
28	Complex integration, Line integrals in the complex plane, Basic properties	4	T2	Lecture
29	First evaluation method, second evaluation method	4	T2	Lecture
30	Second evaluation method, use of representation of a path	4	T2	Lecture
31	Second evaluation method, use of representation of a path	4	T2	Tutorial
32	Contour integrals, Cauchy integral theorem (without proof) on simply connected domain, on multiply connected domain(without proof) .Cauchy Integral formula (without proof)	4	T2	Lecture
33	Contour integrals, Cauchy integral theorem (without proof) on simply connected domain, on multiply connected domain(without proof) .Cauchy Integral formula (without proof)	4	T2	Lecture
34	Cauchy Integral formula for derivatives of an analytic function	4	T2	Lecture
35	Cauchy Integral formula for derivatives of an analytic function	4	T2	Tutorial
36	Taylor's series and Maclaurin series.	4	T2	Lecture
37	Laurent's series(without proof)	5	T2	Lecture
38	Laurent's series(without proof)	5	T2	Tutorial
39	zeros of analytic functions, singularities, poles, removable singularities, essential singularities	5	T2	Lecture
40	Residues	5	T2	Lecture
41	Cauchy Residue theorem (without proof), Evaluation of definite integral using residue theorem	5	T2	Lecture
42	Cauchy Residue theorem (without proof), Evaluation of definite integral using residue theorem	5	T2	Lecture

43	Residue integration of real integrals – integrals of rational functions of $cos\theta$ and $sin\theta$	5	T2	Tutorial
44	Residue integration of real integrals – integrals of rational functions of $cos\theta$ and $sin\theta$, integrals of improper integrals of the form $\int_{-\infty}^{\infty} f(x)\,dx$ with no poles on the real axis	5	T2	Lecture
45	Integrals of improper integrals of the form $\int_{-\infty}^{\infty} f(x)\,dx$ with no poles on the real axis. ($\int_A^B f(x)\,dx$ whose integrand become infinite at a point in the interval of integration is excluded from the syllabus)	5	T2	Lecture

15. Question Bank

Module 1				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	What is the difference between complete integral and singular integral of a partial differential equation	**3**	**CO1**	**L2**
2	Solve $\frac{\partial^2 z}{\partial x \partial y} = x^2 y$	**3**	**CO1**	**L2**
3	Solve $\frac{\partial^2 u}{\partial x \partial t} = e^{-t}\, cosx$	**3**	**CO1**	**L2**
4	Solve $\frac{\partial^3 z}{\partial x^2 \partial y} = \cos(2x + 3y)$	**3**	**CO1**	**L2**
5	Solve $\frac{\partial^3 z}{\partial x^2 \partial y} = \cos(3x + 4y)$	**3**	**CO1**	**L2**
5	Solve $\frac{\partial^2 z}{\partial x \partial y} = \sin(3x + 4y)$.	**3**	**CO1**	**L2**
6	Solve $3z = xp + yq$	**3**	**CO1**	**L2**
7	Solve $xp+yq=z$.	**3**	**CO1**	**L2**

8	Form a partial differential equation from the relation $z = (x + y)f(x^2 - y^2)$.	**3**	**CO1**	**L2**
9	Form the partial differential equation by eliminating arbitrary functions from the following equation z =f $(x^2 + y^2)$	**3**	**CO1**	**L2**
10	Form the partial differential equation by eliminating arbitrary functions from the following equation $z = f\left(\frac{xy}{z}\right)$	**3**	**CO1**	**L2**
11	Form the partial differential equation by eliminating arbitrary constants from the following equation $\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} = 1$.	**3**	**CO1**	**L2**
12	Form the partial differential equation by eliminating arbitrary constants from the following equation $(x - a)^2 + (y - b)^2 = z^2 cot^2 \alpha$	**3**	**CO1**	**L2**
13	Form the p.d.e by eliminating arbitrary function from $z = f(x + at) + g(x - at)$	**3**	**CO1**	**L2**
14	Find the differential equation of all spheres of fixed radius having their centres in the XY-plane	**7**	**CO1**	**L2**
15	Find the differential equation of all spheres whose centre lie on the z-axis	**7**	**CO1**	**L2**
16	Form the partial differential equations by eliminating arbitrary function from $f(x^2 + y^2, z - xy)$=0	**7**	**CO1**	**L2**
17	Form the partial differential equation by eliminating the arbitrary function f from the relation $xyz = f(x + y + z)$.	**7**	**CO1**	**L2**
18	Solve $\frac{\partial u}{\partial x} + \frac{\partial u}{\partial y} = u$ with the initial condition $u(x, 0) = e^{2x}$ by applying method of separation of variables.	**7**	**CO1**	**L2**
19	Solve $\frac{\partial^2 u}{\partial x \partial y} = \cos(x) \cos(y)$ given that $\frac{\partial u}{\partial y} = e^{-y}$ when $x = 0$ and $u = 0$ when $y = 0$.	**7**	**CO1**	**L2**
20	Solve $\frac{\partial^2 z}{\partial x^2} + z = 0$ given that when $x = 0, z = e^y$ and $\frac{\partial z}{\partial x}$=1	**7**	**CO1**	**L2**

21	Using the method of separation of variables, solve $\frac{\partial u}{\partial x} = 2\frac{\partial u}{\partial t} + u$ where $u(x,0) = 6e^{-3x}$	**7**	**CO1**	**L2**
22	Solve $\frac{\partial u}{\partial x} = 2\frac{\partial u}{\partial t} + u$ where $u(x,0) = 3e^{5x}$ by method of separation of variables.	**7**	**CO1**	**L2**
23	Solve $\frac{\partial^3 z}{\partial x^2 \partial y} + 18xy^2 + \sin(2x - y) = 0$	**7**	**CO1**	**L2**
24	Solve the Lagrange's Linear Equation $p - 2q = 3x^2 \sin(y + 2x)$	**7**	**CO1**	**L2**
25	Solve : $\frac{y^2 z}{x} p + xzq = y^2$	**7**	**CO1**	**L2**
26	Solve : (mz-ny) p+(nx-lz) q=ly-mx	**7**	**CO1**	**L2**
27	Solve : $(x^2 - y^2 - z^2)p + 2xyq = 2xz$	**7**	**CO1**	**L2**
28	Solve $pq + 2x(y+1)p + y(y+2)q - 2(y+1)z = 0.$	**7**	**CO1**	**L2**
29	Solve : $p - q = \log(x + y)$	**7**	**CO1**	**L2**
30	Solve : $x^2(y - z) + y^2(z - x) = z^2(x - y)$	**7**	**CO1**	**L2**
31	Solve: $x(y - z)p + y(z - x)q = z(x - y)$	**7**	**CO1**	**L2**
32	Use Charpit's method to solve $q + xp = p^2$	**7**	**CO1**	**L2**
33	Solve : $(p^2 + q^2)$y =qz	**7**	**CO1**	**L2**
34	Solve : $2xz - px^2 - 2qxy + pq = 0$ using Charpit's Method	**7**	**CO1**	**L2**
35	Solve : $pxy + pq + qy = yz$	**7**	**CO1**	**L2**
36	Solve : $xp - yq = y^2 - x^2$	**7**	**CO1**	**L2**
37	Solve the PDE $x(y^2 - z^2)p + y(z^2 - x^2)q = z(x^2 - y^2).$	**7**	**CO1**	**L2**

38	Solve by Method of Separation of variable $\frac{\partial u}{\partial x}+\frac{\partial u}{\partial t}=0, u(x,0)=4e^{-3x}$.	**7**	**CO1**	**L2**
39	Solve $(y^2+z^2)p-xyq=xz$	**7**	**CO1**	**L2**

Module 2

Sl. No.	Question	Marks	CO	BL
1	Write down the possible solutions of one-dimensional wave equation	**3**	**CO2**	**L1**
2	Write down the possible solutions of one-dimensional heat equation	**3**	**CO2**	**L1**
3	Write down the important assumptions used in the derivation of one-dimensional wave equation	**3**	**CO2**	**L1**
4	Write down the fundamental postulates used in the derivation of one-dimensional heat equation	**3**	**CO2**	**L1**
5	Find the deflection of a vibrating string of unit length having fixed ends with initial velocity zero and initial deflection $f(x)=k(sinx-sin2x)$ using D'Alembert's method.	**3**	**CO2**	**L2**
6	Find the steady state temperature distribution in a rod of length 25 cm, if the ends of the rod are kept at $20°c$ *and* $70°c$.	**3**	**CO2**	**L2**
7	Find the steady state temperature distribution in a rod of length 30 cm if the ends are kept at 100 C and 1000 C.	**3**	**CO2**	**L2**
8	A tightly stretched string of length 50 cm has its ends fastened at x=0 and x =50. The midpoint of the string is then taken to height h and then released from rest in that position. Find the initial position of the string.	**3**	**CO2**	**L2**
9	Derive one dimensional wave equation	**7**	**CO2**	**L2**
10	Solve one dimensional wave equation $\frac{\partial u}{\partial t}=c^2\frac{\partial^2 u}{\partial x^2}$ using the method of separation of variables	**7**	**CO2**	**L2**
11	A tightly stretched homogenous string of length 'l' with its fixed ends fastened at $x=0, x=l$ executes transverse vibrations. Motion starts with zero initial velocity by displacing the string in	**7**	**CO2**	**L2**

	the form $f(x) = k(x^2 - x^3)$.Find the deflection $y(x,t)$ at any time t.			
12	A tightly stretched string with fixed points $x = 0$ and $x = l$ is initially at rest in the equilibrium position. If each of its points is given a velocity $\lambda x(l-x)$,find the displacement of the string at any distance x from one end at any time t.	**7**	**CO2**	**L2**
13	A tightly stretched string of length l has its ends fastened at $x = 0, x = l$.The midpoint of the string is then taken to height h and then released from rest in that position. Find the lateral displacement of a point of the string at time t	**7**	**CO2**	**L2**
14	A tightly stretched flexible string has its ends fixed at x=0 and x=l.At time t=0,the string is given a shape defined by $f(x) = \mu x(l-x)$ where μ is a constant and then released.Find the displacement of any point x of the string at any time t> 0	**7**	**CO2**	**L2**
15	A string is stretched and fastened to two points l apart. Motion is started by displacing the string in the form $y =$ a sin $(\frac{\pi x}{l})$ from which it is released at time t=0.Show tat the displacement of any point at a distance x from one end at time t is given by $y =$ a sin $\left(\frac{\pi x}{l}\right)$ cos $(\frac{\pi ct}{l})$	**7**	**CO2**	**L2**
16	A tightly stretched string of length l with fixed ends is initially in equilibrium position. It is set vibrating by giving each point a velocity $V_0 Sin^3(\frac{\pi x}{l})$.Find the displacement of the string at any time t.	**7**	**CO2**	**L2**
17	Solve the one dimensional wave equation $\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}$ With the boundary conditions u(0,t)=0,u(l,t)=0 for all t and initial conditions $u(x,0) = f(x), \left(\frac{\partial u}{\partial t}\right)_{t=0} = g(x), 0 < x < l$	**7**	**CO2**	**L2**
18	A uniform elastic string of length 60cm is subjected to a constant tension of 2kg.If the ends are fixed, the initial displacement $u(x,0) = 60x - x^2, 0 < x < 60$ and the initial velocity zero, find the displacement u (x,t).	**7**	**CO2**	**L2**
19	Derive one dimensional heat equation	**7**	**CO2**	**L2**
20	Solve one dimensional heat equation $\frac{\partial u}{\partial t} = c^2 \frac{\partial^2 u}{\partial x^2}$ using the method of separation of variables	**7**	**CO2**	**L2**

21	Find the temperature $u(x,t)$ in a bar which is perfectly insulated laterally whose ends are kept at $0^{\circ}C$ and whose initial temperature (in degree Celsius) is $f(x) = x(10-x)$ given that its length is 10cm and specific heat is 0.05cal/gram deg	**7**	**CO2**	**L2**
22	A homogenous rod of conducting material of length 100cm has its ends kept at zero temperature and the temperature initially is $u(x,0) = \begin{matrix} x, & 0 \le x \le 50 \\ 100-x, & 50 \le x \le 100 \end{matrix}$ .Find the temperature $u(x,t)$ at any time t.	**7**	**CO2**	**L2**
23	Find the temperature distribution in a rod of length 2m whose end points are maintained at temperature zero and the initial temperature $f(x) = 100(2x - x^2)$	**7**	**CO2**	**L2**
24	Find the temperature distribution in a rod of length π which is totally insulated including the ends and the initial temperature distribution is 100 cos$x$	**7**	**CO2**	**L2**
25	An insulated rod of length l has its ends A and B maintained at $0^{\circ}C$ and $100^{\circ}C$ respectively until steady state condition prevails. If the temperature at B is suddenly reduced to $0^{\circ}C$ and maintained at $0^{\circ}C$.Find the temperature at a distance x from A at time t.	**7**	**CO2**	**L2**
26	A tightly stretched string of length one cm is fastened at both ends. Find the displacement of a string if it is released from rest from the position $\sin \pi x + 5 \sin 3\pi x$.	**7**	**CO2**	**L2**
27	A rod of $30\,cm$ long has its ends A and B kept at $30°c$ and $90°c$ respectively until steady state temperature prevails. The temperature at each end is then suddenly reduced to zero temperature and kept so. Find the resulting temperature function $u(x,y)$, taking $x = 0$ at A.	**7**	**CO2**	**L2**
28	A tightly stretched homogeneous string of unit length with its fixed ends at $x = 0$ *and* $x = 1$ executes transverse vibrations. The initial velocity is zero and the initial deflection is given by $u(x,0) = \begin{cases} 1, & 0 \le x < \frac{1}{2} \\ -1, & \frac{1}{2} \le x \le 1 \end{cases}$. Find the deflection $u(x,t)$ at any time t.	**7**	**CO2**	**L2**

29	Solve the one dimensional heat equation $\frac{\partial u}{\partial t} = c^2 \frac{\partial^2 u}{\partial x^2}$ with boundary conditions $u(0,t) = 0°C, u(1,t) = 0°C$ and the temperature initially is $u(x,0) = x(1-x)$.	**7**	**CO2**	**L2**
30	A homogeneous rod of conducting material of length l has its ends kept at zero temperature and the temperature initially is $u(x,0) = f(x)$. Find the temperature $u(x,t)$ at any time.	**7**	**CO2**	**L2**
31	Solve the one dimensional wave equation $\frac{\partial^2 u}{\partial t^2} = c^2 \frac{\partial^2 u}{\partial x^2}$ subject to $u(0,t) = 0, u(1,t) = 0, u(x,0) = 3sin(2\pi x), \frac{\partial u}{\partial t}(x,0) = 0.$	**7**	**CO2**	**L2**

Module 3

Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	Separate the real and imaginary part of $f(z) = \frac{1}{1+z}$	**3**	**CO3**	**L1**
2	If f=u+iv is analytic,then show that u and v are harmonic functions	**3**	**CO3**	**L1**
3	Find the real part and imaginary part of the function $f(z) = 5z^2 - 12z + 3 + 2i$ and find their values at z = 4-3i .	**3**	**CO3**	**LI**
4	Show that the function $f(z) = \begin{cases} \frac{Im\, z}{\lvert z \rvert} & z \neq 0 \\ 0 & z = 0 \end{cases}$ is not continuous at $z = 0$	**3**	**CO3**	**L1**
5	Show that the function $f(z) = \begin{cases} \frac{Re\, z^2}{\lvert z \rvert^2} & z \neq 0 \\ 0 & z = 0 \end{cases}$ is not continuous at $z = 0$	**3**	**CO3**	**L1**
6	Show that the function $f(z) = \begin{cases} \frac{Im\, z^2}{\lvert z \rvert^2} & z \neq 0 \\ 0 & z = 0 \end{cases}$ is not continuous at $z = 0$	**3**	**CO3**	**L1**

7	Show that the function $f(z) = \begin{cases} \frac{Re\, z^2}{\lvert z\rvert} & z \neq 0 \\ 0 & z = 0 \end{cases}$ is not continuous at $z = 0$	**3**	**CO3**	**L1**
8	Check whether the function $f(z) = \left\{ \begin{matrix} \frac{Re(z)}{1-\lvert z\rvert}, & z \neq 0 \\ 0, & z = 0 \end{matrix} \right\}$ is continuous at $z = 0$.	**3**	**CO3**	**L1**
9	Check whether $f(z) = z - \bar{z}$ is analytic or not.	**3**	**CO3**	**L1**
10	Find the fixed points of $w = \frac{i}{2z-1}$	**3**	**CO3**	**L1**
11	Prove that the function $u(x, y) = x^3 - 3xy^2 - 5y$ is harmonic everywhere. Find its harmonic conjugate.	**3**	**CO3**	**L1**
12	Determine whether $w = \cos z$ is analytic.	**3**	**CO3**	**L1**
13	Check whether the function xy^2 is the real part of an analytic function.	**3**	**CO3**	**L1**
14	Check whether the following function is analytic or not. Justify your answer(i) $f(z) = z + \bar{z}$ (ii) $\lvert z\rvert^2$ (iii) $f(z) = \bar{z}$	**3**	**CO3**	**L2**
15	Determine a so that the function $\omega = e^{-\pi x} \cos ay$ is harmonic. Find its harmonic conjugate.	**3**	**CO3**	**L2**
16	Define an analytic function and prove that an analytic function of constant modulus is constant	**7**	**CO3**	**L1**
17	Show that every analytic function $f(z) = u + iv$ defines two families of curves $u(x, y) = c_1$ and v$(x, y) = c_2$ which forms an orthogonal system	**7**	**CO3**	**L1**
18	Show that function $f(z) = u + iv$ is analytic, if its real part is analytic.	**7**	**CO3**	**L1**
19	Show that function $f(z) = u + iv$ is analytic, if its imaginary part is analytic.	**7**	**CO3**	**L1**

20	Show that $f(z) = e^{-x}\cos y - ie^{-x}\sin y$ is differentiable everywhere and find its derivative.	**7**	**CO3**	**L2**
21	Show that $f(z) = sin\, z$ is analytic for all z. Find $f'(z)$	**7**	**CO3**	**L2**
22	Show that $f(z) = cosh\, z$ is analytic for all z. Find $f'(z)$	**7**	**CO3**	**L2**
23	Show that $f(z) = e^{x+iy}$ is analytic for all z. Find $f'(z)$	**7**	**CO3**	**L2**
24	Let $f(z) = u(x,y) + iv(x,y)$ be defined and continuous in some neighbourhood of a point $z = x + iy$ and differentiable at z itself. Then prove that the first order partial derivatives of u and v exist and satisfy the Cauchy Riemann equations	**7**	**CO3**	**L2**
25	Show that the function u=cos$x$cosh$y$ is harmonic and find its harmonic conjugate.	**7**	**CO3**	**L2**
26	Show that $f(z)$=e^z is analytic for all z in the complex plane and find its derivative.	**7**	**CO3**	**L2**
27	Show that the function $f(z)$=$\frac{1}{z}$ is analytic except at z=0.	**7**	**CO3**	**L2**
28	Find all points where the Cauchy-Riemann equations are satisfied for the function $f(z)$=xy and where it is analytic. Give reasoning for your answers.	**7**	**CO3**	**L2**
29	Show that u=2+3x−y+x^2−y^2−4xy is harmonic. Also find its conjugate harmonic function v.	**7**	**CO3**	**L2**
30	Find image of the circle $\left\|z-\frac{1}{2}\right\| \le \frac{1}{2}$ under the transformation $w = \frac{1}{z}$.	**7**	**CO3**	**L3**
31	Find the image of the semi circle $y = \sqrt{4-x^2}$ under the transformation $w = z^2$.	**7**	**CO3**	**L3**
32	Show that $u = x^2 - y^2 - y$ is harmonic. Also find the corresponding harmonic conjugate function.	**7**	**CO3**	**L3**
33	Find the image of the circle $\|z-1\| = 1$ under the mapping $w = \frac{1}{z}$.	**7**	**CO3**	**L3**

34	If $f(z) = u(x,y) + iv(x,y)$ is analytic and $uv = 2023$, then show that $f(z)$ is a constant	**7**	**CO3**	**L3**
35	Prove that $u = sin\ x\ cos\ hy$ is harmonic. Hence find its Harmonic conjugate	**7**	**CO3**	**L3**
36	Find the image of the infinite strip $0 \leq y \leq \pi$ under the mapping $\omega = e^z$	**7**	**CO3**	**L3**
37	Find the image of $\left\|z - \frac{1}{3}\right\| \leq \frac{1}{3}$ under the transformation $\omega = 1/z$. Also find the fixed points of the transformation $\omega = 1/z$	**7**	**CO3**	**L3**
38	Find the image of $\|z - 2i\| = 2$ under the transformation $\omega = 1/z$.	**7**	**CO3**	**L3**
39	Find the image of $0 < x < 1$, $\frac{1}{2} < y < 1$ under the mapping $\omega = e^z$	**7**	**CO3**	**L3**
40	Find the images of the lines $x = a$ and $y = b$ where a and b are constants under the transformation $\omega = z^2$	**7**	**CO3**	**L4**
41	Find the images of the lines $x = c$ and $y = k$, where c and k are constants under the transformation $\omega = \sin z$	**7**	**CO3**	**L4**
42	Under the transformation $\omega = z^2$ find the image of the triangular region bounded by $x = 1, y = 1\ and\ x + y = 1$	**7**	**CO3**	**L4**

Module 4

Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	Solve $\int_c tanz\, dz$, where c is |z|=1	**3**	**CO4**	**L3**
2	Solve $\int_c \frac{e^z}{z^2+9}\, dz$,where c is |z|=2	**3**	**CO4**	**L3**
3	Solve $\int_c cosz\, dz$, where c is |z|=π	**3**	**CO4**	**L3**
4	Solve $\int_c \frac{1}{z} dz$, where c is |z|=1	**3**	**CO4**	**L3**
5	Find the Taylor series of f(z)=$\frac{1}{z}$ about z=2	**3**	**CO4**	**L3**

6	Evaluate $\int_0^{1+i}(x-iy)dz$ along the straight line path from 0 to 1+i	**3**	**CO4**	**L3**
7	Evaluate $\int_C \frac{dz}{(z^2+1)(z-1)}$ when C is $\|z\| = 0.5$	**3**	**CO4**	**L3**
8	Evaluate $\oint_C \frac{\cos z}{z^2+9}dz$,where C is the circle $\|z\| = 1$.	**3**	**CO4**	**L3**
9	Find the value of the integral $\int_C z\,dz$ where C is the part of the unit circle from –i to i in the right half plane.	**3**	**CO4**	**L3**
10	Using Cauchy's integral formula, Evaluate $\int_C \frac{z^2+1}{z^2-1}dz$ where C is the circle of unit radius with centre at $z = 1$.	**3**	**CO4**	**L3**
11	Expand $f(z) = \frac{z+1}{z-1}$ as a Taylor series about $z = -1$	**7**	**CO4**	**L3**
12	Find the value of $\int_c \exp(z^2)\,dz$, where c is |z|=1	**7**	**CO4**	**L3**
13	Using Cauchy's Integral Formula evaluate $\int_c \frac{5z+7}{z^2+2z-3}dz$, where c is |z-2|=2	**7**	**CO4**	**L3**
14	Find the Maclaurin series expansion of f(z)=$\frac{i}{1-z}$ and state the region of convergence	**7**	**CO4**	**L3**
15	Find the Maclaurin series expansion of $f(z) = coshz$	**7**	**CO4**	**L3**
16	Find the Maclaurin series expansion of $e^z \sin z$.	**7**	**CO4**	**L3**
17	Expand f(z)=1/(z+1) as a Taylor series about $z = 2$ and state the validity of expansions	**7**	**CO4**	**L3**
18	Expand f(z)=$1/z^2$ as a Taylor series about $z = 3$	**7**	**CO4**	**L3**
19	Find the Taylor series expansion of $f(z)$=sin2z about z=π /2	**7**	**CO4**	**L3**

20	Verify Cauchy's integral theorem for z^2taken over the boundary of the rectangle with vertices -1,1,1+i,-1+i in the counter clockwise sense	**7**	**CO4**	**L4**
21	Evaluate $\int_C$ Re z dz where C is a straight line from 0 to 1+2i.	**7**	**CO4**	**L5**
22	Evaluate $\int_0^{2+i}(\bar{z})^2\,dz$, along the real axis to 2 and then vertically to 2+i	**7**	**CO4**	**L5**
23	Evaluate $\int Im\, z^2 dz$ counter clockwise around the triangle with vertices $0, 2, i$.	**7**	**CO4**	**L5**
24	Evaluate $\int_c Rez^2\ dz$ over the boundary C of the square with vertices 0, i,1+i,1	**7**	**CO4**	**L5**
25	Evaluate $\int_C \lvert z\rvert\, dz$ where C is the part of the circle $\lvert z\rvert = 3$ from 3 to -3 in the upper half plane.	**7**	**CO4**	**L5**
26	Evaluate $\int_C \frac{2z+1}{z^2-2z} dz$ where $\lvert z\rvert = 1$.	**7**	**CO4**	**L5**
27	Evaluate $\int_C \frac{e^{3z}}{(z+1)^4} dz$ where C is the circle $\lvert z-1\rvert = 3$.	**7**	**CO4**	**L5**
28	Evaluate $\int_C \frac{1}{(z+4i)(z+i)}\, dz$, where C is $\lvert z\rvert = 2$ using Cauchy's integral formula.	**7**	**CO4**	**L5**
29	Evaluate $\int_C \frac{z^2+z+1}{(z-1)^2} dz$, where C is the circle $\lvert z\rvert = 3$ using Cauchy's integral formula.	**7**	**CO4**	**L5**
30	Evaluate $\int_c \frac{sinz}{z+4iz}\ dz$ where C is |z-4-2i|=6.5	**7**	**CO4**	**L5**
31	Evaluate $\int_c \frac{sin^2 z}{(z-\frac{\pi}{6})^3} dz$, where c is |z|=1	**7**	**CO4**	**L5**
32	Evaluate $\oint_c \frac{\ln(z+1)}{z^2+1}$ where c: |z-i|=1.4	**7**	**CO4**	**L5**
33	Using Cauchy's Integral Formula evaluate	**7**	**CO4**	**L5**

	$\int_c \frac{sin\pi z^2 + cos\pi z^2}{(z-1)(z-2)}\, dz$			
34	Using Cauchy's integral formula, Evaluate the integral $\int_C \frac{2z+3}{z^2} dz$, where C is a circle $\|z-i\| = 2$ counter clockwise.	**7**	**CO4**	**L5**
35	Evaluate $\int_C (z^2+3z)\, dz$ along the circle $\|z\| = 2$ from (2,0) to (0,2) in counter-clockwise direction.	**7**	**CO4**	**L5**
36	Using Cauchy's integral formula, Evaluate $\oint_C \frac{e^{2z}}{(z+1)^4}\, dz$ where C is the circle $\|z\| = 2$.	**7**	**CO4**	**L5**

Module 5

Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	Find all the singular points and residues of the functions $f(z) = \frac{sinz}{z^4}$	**3**	**CO5**	**L2**
2	Find the poles and corresponding residues of the functions $f(z) = tanz$	**3**	**CO5**	**L2**
3	Using Residue Theorem, Evaluate $\oint_c \frac{tanz}{z^2-1}\, dz$	**3**	**CO5**	**L2**
4	Evaluate $\oint_c \frac{4-3z}{z(z-1)}$ dz where C is the circle $\|z\| = \frac{3}{2}$	**3**	**CO5**	**L2**
5	State Residue Theorem with examples	**3**	**CO5**	**L2**
6	State Cauchy's integral formula and Cauchy's residue theorem	**3**	**CO5**	**L2**
7	Find the zeros and their order of the function $sin^2(z)$.	**3**	**CO5**	**L2**
8	Find the Laurent series expansion of $\frac{1}{1-z^2}$ about z=0	**3**	**CO5**	**L2**

9	Find the singularities and nature of singularities of the function $f(z) = z^2 \cos\frac{1}{z}$	**3**	**CO5**	**L2**
10	Find the residue of $z\cos\left(\frac{1}{z}\right)$ at $z = 0$	**3**	**CO5**	**L2**
11	Find the Laurent series of $z^2 e^{1/z}$ about $z = 0$ and determine the region of convergence.	**3**	**CO5**	**L2**
12	Find the poles and residues of the function $f(z) = \frac{z^2-2z}{(z+1)^2(z^2+4)}$	**7**	**CO5**	**L2**
13	Find the Laurent series expansion of $f(z) = \frac{1}{1-z^2}$ about $z = 1$ in the regions (i) $0 < \|z-1\| < 2$ (ii) $\|z-1\| > 2$	**7**	**CO5**	**L2**
14	Obtain the Laurent series expansion of $\frac{1}{(z-2)(z-3)}$ in the region $(i)\|z\| < 1$ $(ii)\ 2 < \|z\| < 3$ $(iii)\ \|z\| > 3$	**7**	**CO5**	**L2**
15	Find Laurent series expansion $f(z) = \frac{-2z+3}{(z^2-3z+2)}$ valid in i. $1 \le \|z\| \le 2$ ii. $\|z\| \ge 2$	**7**	**CO5**	**L2**
16	Find all the singular points and residues of the functions $f(z) = \frac{z^2-2z}{(z+1)^2(z^2+4)}$	**7**	**CO5**	**L3**
17	Using Residue Theorem, Evaluate $\oint_c \frac{z-23}{z^2-4z-5}\,dz$ where C: $\|z-2-i\| = 3.2$	**7**	**CO5**	**L3**
18	Using Residue Theorem evaluate $\oint_c \frac{z^2}{(z-1)^2(z+2)}\,dz$	**7**	**CO5**	**L3**
19	Evaluate $\oint_c \frac{dz}{(z^4+1)}$ where C: $\|z-1\| = 1$	**7**	**CO5**	**L3**
20	Using Residue theorem evaluate $\int \frac{z^2}{(z-1)^2(z+2)}\,dz$ over the circle $\|z\| = 3$	**7**	**CO5**	**L3**

21	Using Residue theorem evaluate $\int_c \frac{5z+7}{z^2+2z-3}dz$, where C is the circle $\|z-2\|=2$	**7**	**CO5**	**L3**
22	Evaluate $\int \frac{\sin z}{z^6}dz$ over the circle $\|z\|$=2 using Cauchy's residue theorem	**7**	**CO5**	**L3**
23	Evaluate $\int_0^{2\pi} \frac{1}{2+\cos\theta}d\theta$	**7**	**CO5**	**L3**
24	Evaluate $\int_0^{2\pi} \frac{1}{5-3\sin\theta}d\theta$	**7**	**CO5**	**L3**
25	Show that $\int_{-\infty}^{\infty} \frac{1}{(1+x^2)^3}dx=\frac{3\pi}{8}$	**7**	**CO5**	**L3**
26	Evaluate $\int_{-\infty}^{\infty} \frac{x^2}{(x^2+1)(x^2+4)}dx$	**7**	**CO5**	**L3**
27	Evaluate $\int_0^{\infty} \frac{1}{1+x^2}dx$.	**7**	**CO5**	**L3**
28	Find the poles and residues of the function $\frac{1}{z^4-1}$	**7**	**CO5**	**L3**
29	Evaluate $\int_0^{2\pi} \frac{1}{3+2\sin\theta}d\theta$	**7**	**CO5**	**L3**
30	Evaluate $\oint_c \frac{e^z}{z^2(z+1)}dz$, over the circle $\|z\|=2$	**7**	**CO5**	**L3**
31	Evaluate $\int_c \tan z\, dz$ where C is circle $\|z\|=2$.	**7**	**CO5**	**L3**
32	Evaluate $\int_0^{2\pi} \frac{d\theta}{\sqrt{2}-\cos\theta}$	**7**	**CO5**	**L4**
33	Using contour integration, evaluate $\int_{-\infty}^{\infty} \frac{x^2-x+2}{x^4+10x^2+9}dx$	**7**	**CO5**	**L4**
34	Determine and classify the singular points of the following functions $f(z)=\frac{\sin z}{(z-\pi)^2}$ (ii) $g(z)=(z+i)^2\, e^{\frac{1}{z+i}}$	**7**	**CO5**	**L4**

35	Evaluate $\oint_c \left(\frac{ze^{\pi z}}{(z^4-16)} + ze^{\pi/z}\right)$ dz where C is the ellipse $9x^2+y^2 = 9$	**7**	**CO5**	**L5**
36	Using Cauchy's Residue theorem, Evaluate $\int_C \frac{30z^2-23z+5}{(2z-1)^2(3z-1)}dz$ where C is the circle $\|z\| = 1$ counter-clockwise.	**7**	**CO5**	**L5**

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Course Code & Name: MET201 Mechanics of Solids

1. Prescribed Syllabus

Module	Topic	Hours
1	Deformation behaviour of elastic solids in equilibrium under the action of a system of forces, method of sections. Stress vectors on Cartesian coordinate planes passing through a point, stress at a point in the form of a matrix. Equality of cross shear, Cauchy's equation. Displacement, gradient of displacement, Cartesian strain matrix, strain- displacement relations (small-strain only), Simple problems to find strain matrix. Stress tensor and strain tensor for plane stress and plane strain conditions. Principal planes and principal stress, meaning of stress invariants, maximum shear stress. Mohr's circle for 2D case.	**9**
2	Stress-strain diagram, Stress–Strain curves of Ductile and Brittle Materials, Poisson's ratio. Constitutive equations-generalized Hooke's law, equations for linear elastic isotropic solids in terms of Young's Modulus and Poisson's ratio, Hooke's law for Plane stress and plane strain conditions Relations between elastic constants E, G, ν and K(derivation not required). Calculation of stress, strain and change in length in axially loaded members with single and composite materials, Effects of thermal loading – thermal stress and thermal strain. Thermal stress on a prismatic bar held between fixed supports	**9**
3	Torsional deformation of circular shafts, assumptions for shafts subjected to torsion within elastic deformation range, derivation of torsion formula Torsional rigidity, Polar moment of inertia, and basic design of transmission shafts. Simple problems to estimate the stress in solid and hollow shafts. Shear force and bending moment diagrams for cantilever and simply supported beams. Differential equations between loads, shear force and bending moment. Normal and shear stress in beams: Derivation of flexural formula, section modulus, flexural rigidity, numerical problems to evaluate bending stress, economic sections. Shear stress formula for beams: (Derivation not required), shear stress distribution for a rectangular section	**9**
4	Deflection of beams using Macauley's method. Elastic strain energy and Complementary strain energy. Elastic strain energy for axial loading, transverse shear, bending and torsional loads. Expressions for strain energy in terms of load, geometry and material properties of the body for axial, shearing, bending and torsional loads. Castigliano's second theorem, reciprocal relation (Proof not required for Castigliano's second theorem, reciprocal relation). Simple problems to find the deflections using Castigliano's theorem.	**8**
5	Fundamentals of bucking and stability, critical load, equilibrium diagram for buckling of an idealized structure. Buckling of columns with pinned ends, Euler's buckling theory for long columns. Critical stress, slenderness ratio, Rankine's formula for short columns.	**8**

	Introduction to Theories of Failure, Rankine's theory for maximum normal stress, Guest's theory for maximum shear stress, Saint-Venant's theory for maximum normal strain, Hencky-von Mises theory for maximum distortion energy, Haigh's theory for maximum strain energy	

2. Text Books (T)

T1. Mechanics of materials in S.I.units, R .C. Hibbeler, Pearson Higher Education 2018
T2. Advanced Mechanics of Solids, L. S. Srinath, TMH
T3. Design of Machine Elements, V. B Bhandari
T4. S.Jose, Sudhi Mary Kurian, Mechanics of Solids, Pentagon
T5. J Benjamin, Mechanics of Solids, Pentex Publishers

3. Reference Books (R)

R1. Strength of Materials, Surendra Singh, S. K. Kataria & Sons
R2. Engineering Mechanics of Solids, Popov E., PHI 2002
R3. Mechanics of Materials S. I. units, Beer, Johnston, Dewolf, McGraw Hills 2017
R4. Mechanics of Materials, Pytel A. and Kiusalaas J. Cengage Learning India Private Limited, 2nd Edition, 2015
R5. Strength of Materials, Rattan, McGraw Hills 2011
R6. R. K. Bansal, Mechanics of solids, Laxmi Publications, 2004

4. Course Objectives

This course helps the students to understand the concept of stress and strain in different types of structure/machines under various loading conditions. The course also covers simple and compound stresses due to forces, stresses and deflection in beams due to bending, torsion in circular section, strain energy, different theories of failure, stress in thin cylinder thick cylinder and spheres due to external and internal pressure.

5. Course Pre / Co-requisite

EST 100 Engineering Mechanics

6. Course Outcomes

After completion of the course, student will be able to

On successful completion of this course students shall be able to
CO1: Determine the stresses, strains and displacements of structures by tensorial and graphical (Mohr's circle) approaches.
CO2: Analyse the strength of materials using stress-strain relationships for structural and thermal loading.
CO3: Perform basic design of shafts subjected to torsional loading and analyse beams subjected to bending moments.

CO4: Determine the deformation of structures subjected to various loading conditions using strain energy methods.
CO5: Analyse column buckling and appreciate the theories of failures and its relevance in engineering design.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**H**	**H**	**M**									**M**	**M**	**M**	**H**
CO2	**H**	**H**	**M**									**M**	**M**	**M**	**H**
CO3	**H**	**H**	**L**									**H**	**M**	**M**	**H**
CO4	**H**	**H**	**L**									**M**	**M**	**H**	**H**
CO5	**H**	**H**	**L**									**M**	**M**	**H**	**H**

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	**PO1**	Developing skills to solve problems related to stress and strain contributes to skills in solving engineering problems. High correlation is due to the fact that this involves in-depth knowledge of mathematics, science and engineering fundamentals to solve complex engineering problems.
	PO2	Knowledge about tensorial and graphical methods to determine the stresses, strains and displacements of structures will help the students to formulate and analyse complex engineering problems. High correlation is due to the fact that this involves in-depth knowledge of first principles of mathematics, science and engineering.
	PO3	Formulating graphical methods to determine the stresses, strains and displacements of structures will help the students to design solutions for complex engineering problems. Medium correlation is due to the fact that this involves standard knowledge of design and development.
	PO12	Studying basic tensorial and graphical methods to determine the stresses, strains and displacements of structures will help the students to cultivate an ability to engage in independent and lifelong learning in the broadest context of technological knowledge. Medium correlation is due to the fact that this involves basic lifelong learning.
	PSO1	Knowledge about tensorial and graphical methods to determine the stresses, strains and displacements of structures will help the students to demonstrate the knowledge of concurrent technologies to solve the practical problems. Medium correlation is due to the fact that this involves standard principles of sustainable development.
	PSO2	Formulating graphical methods to determine the stresses, strains and displacements of structures contributes to managing engineering projects as a professional team with ethical attitude. Medium correlation is due to the fact that this involves standard principles of scientific management.

	PSO3	Complete and detailed study of tensorial and graphical methods to determine the stresses, strains and displacements of structures will help the students to design and analyze multi-disciplinary systems. High correlation is due to the fact that this involves in depth knowledge on the principles of mathematics, science and engineering.
CO2	**PO1**	Developing skills to solve problems related to structural and thermal loading will help the students to solve various complex engineering problems. High correlation is due to the fact that this involves in-depth knowledge of mathematics, science and engineering fundamentals.
	PO2	Analytical knowledge about structural and thermal loading will help the students to formulate and analyse complex engineering problems. High correlation is due to the fact that this involves in-depth knowledge of first principles of mathematics, science and engineering.
	PO3	Designing the required strength of material using stress-strain relationships will help the students to design solutions for complex engineering problems. Medium correlation is due to the fact that this involves standard knowledge of design and development.
	PO12	Basic knowledge about the strength of a material using stress-strain relationships for structural and thermal loading will help the students to cultivate an ability to engage in independent and lifelong learning in the broadest context of technological knowledge. Medium correlation is due to the fact that this involves standard lifelong learning.
	PSO1	Knowledge about the strength of a material using stress-strain relationships for structural and thermal loading will help the students to demonstrate the knowledge of concurrent technologies to solve the practical problems. Medium correlation is due to the fact that this involves standard principles of sustainable development.
	PSO2	Formulating the strength of a material using stress-strain relationships for structural and thermal loading contributes to managing engineering projects as a professional team with ethical attitude. Medium correlation is due to the fact that this involves standard principles of scientific management.
	PSO3	Complete and detailed study of material strength using stress-strain relationships will help the students to design and analyze multi-disciplinary systems. High correlation is due to the fact that this involves in depth knowledge on the principles of mathematics, science and engineering.
CO3	**PO1**	Developing skills to solve problems related to torsional loading and bending moment of beams contributes to skills in solving engineering problems. High correlation is due to the fact that this involves in-depth knowledge of mathematics, science and engineering fundamentals to solve complex engineering problems.
	PO2	Knowledge on how to design shafts subjected to torsional loading and bending moments will help the students to formulate and analyse complex engineering problems. High correlation is due to the fact that this involves in-depth knowledge of first principles of mathematics, science and engineering.
	PO3	Formulating basic design of shafts subjected to torsional loading and bending moments will help the students to design solutions for complex engineering problems. Low correlation is due to the fact that this involves basic knowledge of design and development.
	PO12	Performing basic design of shafts subjected to torsional loading and bending moments will help the students to cultivate an ability to engage in independent

		and lifelong learning in the broadest context of technological knowledge. High correlation is due to the fact that this involves in depth lifelong learning
	PSO1	Knowledge about the basic design of shafts subjected to torsional loading and bending moments will help the students to demonstrate the knowledge of concurrent technologies to solve the practical problems. Medium correlation is due to the fact that this involves standard principles of sustainable development.
	PSO2	Formulating the basic design of shafts subjected to torsional loading and bending moments contributes to managing engineering projects as a professional team with ethical attitude. Medium correlation is due to the fact that this involves standard principles of scientific management.
	PSO3	Detailed and complete design of shafts subjected to torsional loading and bending moments will help the students to design and analyze multi-disciplinary systems. High correlation is due to the fact that this involves in depth knowledge on the principles of mathematics, science and engineering.
CO4	**PO1**	Developing skills to solve problems related to strain energy methods contributes to skills in solving engineering problems. High correlation is due to the fact that this involves in-depth knowledge of mathematics, science and engineering fundamentals to solve complex engineering problems.
	PO2	Knowledge on how to design structures subjected to various loading conditions will help the students to formulate and analyse complex engineering problems. High correlation is due to the fact that this involves in-depth knowledge of first principles of mathematics, science and engineering.
	PO3	Formulating basic design of structures subjected to various loading conditions will help the students to design solutions for complex engineering problems. Low correlation is due to the fact that this involves basic knowledge of design and development.
	PO12	Basic knowledge about the deformation of structures subjected to various loading conditions using strain energy methods will help the students to cultivate an ability to engage in independent and lifelong learning in the broadest context of technological knowledge. Medium correlation is due to the fact that this involves standard lifelong learning.
	PSO1	Knowledge about the deformation of structures subjected to various loading conditions using strain energy methods will help the students to demonstrate the knowledge of concurrent technologies to solve the practical problems. Medium correlation is due to the fact that this involves standard principles of sustainable development.
	PSO2	Formulating the deformation of structures subjected to various loading conditions using strain energy methods contributes to managing engineering projects as a professional team with ethical attitude. High correlation is due to the fact that this involves in depth principles of scientific management.
	PSO3	Complete and detailed study of the deformation of structures subjected to various loading conditions using strain energy methods will help the students to design and analyze multi-disciplinary systems. High correlation is due to the fact that this involves in depth knowledge on the principles of mathematics, science and engineering
CO5	**PO1**	Developing skills to solve problems related to bucking and theories of failure contributes to skills in solving engineering problems. High correlation is due to the fact that this involves in-depth knowledge of mathematics, science and engineering fundamentals to solve complex engineering problems

	PO2	Knowledge on how to design structures according to various theories of failure will help the students to formulate and analyse complex engineering problems. High correlation is due to the fact that this involves in-depth knowledge of first principles of mathematics, science and engineering.
	PO3	Designing the structures based on the theories of failures will help the students to design solutions for complex engineering problems. Low correlation is due to the fact that this involves basic knowledge of design and development.
	PO12	Basic knowledge about column buckling and theories of failures will help the students to cultivate an ability to engage in independent and lifelong learning in the broadest context of technological knowledge. Medium correlation is due to the fact that this involves standard lifelong learning.
	PSO1	Knowledge about the structures based on the theories of failures will help the students to demonstrate the knowledge of concurrent technologies to solve the practical problems. Medium correlation is due to the fact that this involves standard principles of sustainable development.
	PSO2	Formulating the structures based on the theories of failures contributes to managing engineering projects as a professional team with ethical attitude. High correlation is due to the fact that this involves in depth principles of scientific management.
	PSO3	Complete study of column buckling and theories of failures will help the students to design and analyze multi-disciplinary systems. High correlation is due to the fact that this involves in depth knowledge on the principles of mathematics, science and engineering

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	SFD and BMD	NPTEL Lecture Videos	PO5, PO8

11. Internal Assessment mark allocation (as per university curriculum)

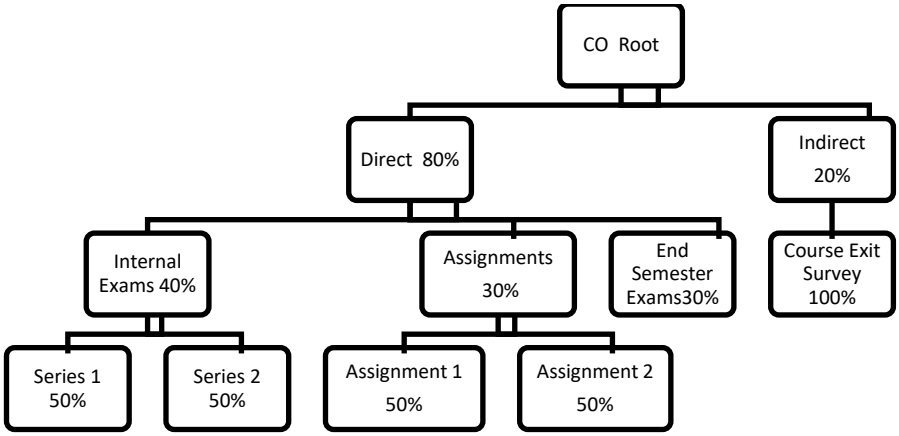
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		Weightage#	CO1	CO2	CO3	CO4	CO5
Direct Assessment Tools	Internal Exam(s) 40%	Series 1	20%	x	x			
		Series 2	20%			x	x	x
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x	x			
		Assignment 2	15%			x	x	x
	End Semester Exam		30%	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x

13. **Assessment Configuration**



14. Course Plan

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1	Describe the deformation behaviour of elastic solids in equilibrium under the action of a system of forces.	1	T4, R1	Lecture
2	Stress vectors on Cartesian coordinate planes passing through a point and	1	T4, R1	Lecture

	writing stress at a point in the form of a matrix.			
3	Write Cauchy's equation, Equality of cross shear	1	T4, R1	Lecture
4	Normal and shear stress on a plane given stress tensor and direction cosines	1	T4, R1	Lecture
5	Displacement, gradient of displacement, Cartesian strain matrix, Write strain displacement relations	1	T4, R1	Lecture
6	Concepts of principal planes and principal stress, characteristic equation of stress matrix	1	T4, R1	Lecture
7	evaluation of principal stresses and principal planes as an eigen value problem, meaning of stress invariants, maximum shear stress	1	T4, R1	Tutorial
8	Mohrs circle for 2D case	1	T4, R1	Lecture
9	find principal stress, planes, stress on an arbitrary plane, maximum shear stress graphically using Mohrâ€™s circle	1	T4, R1	Tutorial
10	Stress-strain diagram, Stress-Strain curves of Ductile and Brittle Materials, Poissons ratio	2	T4, R1	Lecture
11	Constitutive equations-generalized Hookes law, equations for linear elastic isotropic solids in in terms of Youngs Modulus and Poissons ratio (3D).	2	T4, R1	Lecture
12	Hookes law for Plane stress and plane strain conditions	2	T4, R1	Lecture
13	Relations between elastic constants E, G, and K	2	T4, R1	Lecture
14	Calculation of stress, strain and change in length in axially loaded members	2	T4, R1	Lecture
15	Numerical problems for axially loaded members	2	T4, R1	Tutorial
16	Effects of thermal loading	2	T4, R1	Lecture
17	thermal stress and thermal strain.	2	T4, R1	Lecture
18	Thermal stress on a prismatic bar held between fixed supports	2	T4, R1	Tutorial
19	Torsional deformation of circular shafts, assumptions for shafts subjected to torsion within elastic deformation range, derivation of torsion formula	3	T4, R1	Lecture
20	Torsional rigidity, Polar moment of inertia, comparison of solid and hollow shaft. Simple problems to estimate the stress in solid and hollow shafts	3	T4, R1	Lecture

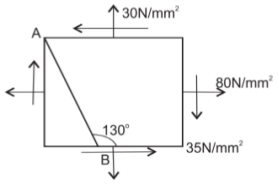
21	Numerical problems for basic design of circular shafts subjected to externally applied torques	3	T4, R1	Tutorial
22	Shear force and bending moment diagrams for cantilever	3	T4, R1	Lecture
23	simply supported beams subjected to point load, moment, UDL and linearly varying load	3	T4, R1	NPTEL Videos
24	Differential equations between load, shear force and bending moment.	3	T4, R1	Lecture
25	Normal and shear stress in beams:	3	T4, R1	Lecture
26	Derivation of flexural formula, section modulus, flexural rigidity	3	T4, R1	Lecture
27	Shear stress formula for beams: numerical problem to find shear stress distribution for rectangular section	3	T4, R1	Tutorial
28	Deflection of cantilever and simply supported beams subjected to point load, moment and UDL using Macauleys method	4	T4, R1	Lecture
29	procedure and problems with multiple loads	4	T4, R1	Tutorial
30	Linear elastic loading, elastic strain energy and Complementary strain energy	4	T4, R1	Lecture
31	Elastic strain energy for axial loading, transverse shear, bending and torsional loads	4	T4, R1	Lecture
32	Expressions for strain energy in terms of load, geometry and material properties of the body	4	T4, R1	Lecture
33	axial, shearing, bending and torsional loads	4	T4, R1	Lecture
34	Castiglianos second theorem to find displacements, reciprocal relation	4	T4, R1	Lecture
35	Simple problems to find the deflections using Castiglianos theorem	4	T4, R1	Tutorial
36	Fundamentals of bucking and stability, critical load, Eulers formula for long columns, assumptions and limitations	5	T4, R1	Lecture
37	effect of end conditions (derivation only for pinned ends), equivalent length	5	T4, R1	Lecture
38	Critical stress, slenderness ratio	5	T4, R1	Lecture
39	Rankines formula for short columns	5	T4, R1	Lecture

40	Problems of Rankines formula	5	T4, R1	Tutorial
41	Introduction to Theories of Failure. Rankines theory for maximum normal stress	5	T4, R1	Lecture
42	Guests theory for maximum shear stress, Saint-Venants theory for maximum normal strain	5	T4, R1	Lecture
43	Hencky-von Mises theory for maximum distortion energy, Haighs theory for maximum strain energy	5	T4, R1	Tutorial

15. Question Bank

Module 1				
Sl. No.	Question	Marks	CO	BL
1	Give the Cauchy's equations of stresses with necessary explanations of terms	**3**	**CO1**	**L1**
2	For a three-dimensional stress system, write the differential equations of equilibrium. Write down the tensorial representation also.	**3**	**CO1**	**L1**
3	Why is the stress tensor symmetric? Express the stress tensor (3 X 3) for simple axial loading of a rod, with x-axis coinciding with the axis of loading.	**3**	**CO1**	**L1**
4	What are stress invariants? Why would they remain invariant?	**3**	**CO1**	**L1**
5	What is a stress tensor? Write the stress tensor for plane stress condition.	**3**	**CO1**	**L1**
6	Express the stress invariants in terms of Cartesian components of stresses and principal stresses.	**3**	**CO1**	**L2**
7	Differentiate between the terms Plane stress and Principal stress	**3**	**CO1**	**L2**
8	Explain the state of Plane stress condition with appropriate sketches.	**3**	**CO1**	**L2**
9	Explain principal stresses and principal strains?	**3**	**CO1**	**L2**
10	Prove that the Cross shears are equal (Prove the Equality of cross shears)	**3**	**CO1**	**L2**
11	The displacement field for a body is given by u= $(x^2 + y)i + (3 + z)\,j + (x^2 + 2y)k$. What is the deformed position of a point originally at (3, 1, –2)? Write the strain tensor at the point (−3,−1,2).	**8**	**CO1**	**L3**
12	The displacement field in a body is given by $\left[(x^2+y^2+2)\mathbf{i}+(3x+4y^2)\mathbf{j}+(2x^3+4z)\mathbf{k}\right]\times10^{-4}$. Obtain the components of strain at location (1,2,3).	**14**	**CO1**	**L3**

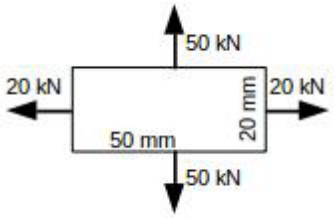
13	If the displacement field is given by $U_x = kxy$, $U_y = kxy$ and $U_z = 2k(x + y)z$, where k is a constant. Write down the strain matrix	**14**	**CO1**	**L3**
14	The state of plane stress at a point is given by σxx = 40 MPa, σyy = 20MPa and τxy = 16 M Pa. Using Mohr's circle determine the i) principal stresses and principal planes and ii) maximum shear stress	**14**	**CO1**	**L3**
15	a) A rod of length 1.5 m and diameter 30 mm is centrally bored for 500 mm length, the bore diameter being 10 mm. Under a load of 30 kN, if the extension of rod is 0.2 mm, find the modulus of elasticity b) Draw the stress-strain diagram for a ductile and brittle material and explain the salient points.	**14**	**CO1**	**L3**
16	The components of stress at a point are given by the following stress tensor. $[\sigma] = \begin{bmatrix} 5 & 2 & 1 \\ 2 & 3 & 4 \\ 1 & 4 & 2 \end{bmatrix}$ MPa . Determine the normal and shear stress components on an inclined plane whose direction cosines are $\frac{1}{\sqrt{3}}, \sqrt{\frac{2}{3}}$ and 0.	**14**	**CO1**	**L3**
17	At a point in a stressed material, the cartesian stress components are σ_x =40, σ_y =80, σ_z =120, τ_{xy} =72, τ_{yz} =46 and τ_{xz} =32 MPa. Calculate the normal, shear and resultant stress on a plane whose normal makes an angle of 48° with x-axis and 61° with y-axis.	**14**	**CO1**	**L3**
18	a) Write down the Cauchy's strain – displacement relationships. b) Distinguish between the states of plane stress and plane strain conditions.	**14**	**CO1**	**L2**
19	If the stress tensor at a point is given by σxx=0, σyy=0, σzz=0, τxy=10, τxz= -10, τyz=20, find stress invariants, characteristic equation, principal stresses and the principal plane associated with the maximum principal stress. If the displacement field is (3x2+y) i+ (2y2+z) j+ (4z2+x) k, obtain the Strain tensor at (2,1,1).	**14**	**CO1**	**L3**
20	At a point in a bracket the stresses on two mutually perpendicular planes are 140 N/mm2 and 90 N/mm2 both tensile. The shear stress across these planes is 50 N/mm2. Find using the Mohr's stress circle the (i) Principal stresses and (ii) Maximum shear stress and location of plane of maximum shear	**14**	**CO1**	**L3**
21	The state of stress at a point is given by σ_x =70MPa, σ_y =10MPa, σ_z =-20 MPa, τ_{xy} =-40 MPa, τ_{yz} = τ_{xz} =20MPa. Determine the principal stresses, direction of maximum principal stress and maximum shear stress.	**14**	**CO1**	**L3**

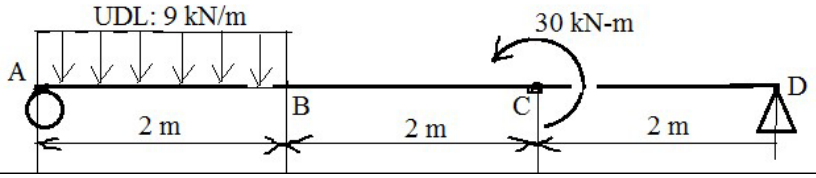
22	At a point in a stressed material, the principal stresses were obtained as σ_1 =-100 N/mm², σ_2 = 100 N/mm² and σ_3 = 200 N/mm². The direction cosines of the principal planes are l=m=n=0.577. Determine the resultant stresses and stress invariants.	**14**	**CO1**	**L3**
23	In a strained element, the biaxial stresses are as shown in figure. Determined (i) principal stresses and its planes (ii) maximum shear stress and its plane. (iii) normal and tangential stress on plane AB. 	**14**	**CO1**	**L3**
24	At a certain point in a strained material, there is a tensile stress of 50 N/mm² upon a vertical plane and a compressive stress of 35 N/mm² upon a horizontal plane. There is also a shear stress of 40 N/mm² upon each of these planes. Determine the principal stresses and locate the principal planes. Also determine the maximum shear stress. Use only the Mohr's circle method.	**14**	**CO1**	**L3**

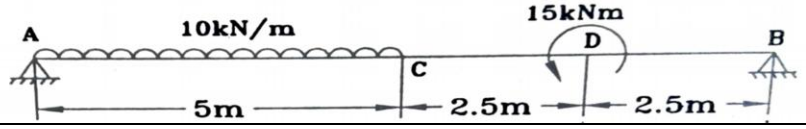
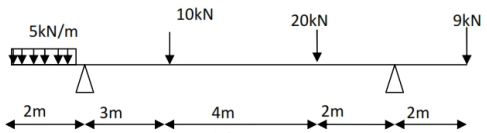
Module 2

Sl. No.	Question	Marks	CO	BL
1	Write down the general expression for temperature stress and explain the terms in it.	**3**	**CO2**	**L1**
2	Define the terms: i) Young's Modulus ii) Poisson's Ratio iii) Hooke's law iv) Constitutive equation of a tri-axial stress system with diagram	**3**	**CO2**	**L1**
3	Write two points each on linear strain and shear strain?	**3**	**CO2**	**L1**
4	Draw the stress-strain curve of a mild steel bar in tension test and show the salient points?	**3**	**CO2**	**L1**
5	State Hooke's law for linearly elastic isotropic material.	**3**	**CO2**	**L1**
6	Determine the Modulus of Rigidity, if the values of Young' s modulus & Bulk modulus are same & is equal to 200 GPa.	**3**	**CO2**	**L2**
7	Differentiate between engineering-stress-strain curve and true-stress-strain curve and comment on the applicability of the engineering stress strain curve in the design of mechanical engineering components.	**3**	**CO2**	**L2**
8	Differentiate between i) Linear (longitudinal) strain & lateral strain ii) Bulk Modulus & Shear Modulus	**3**	**CO2**	**L2**
9	Explain the stress – strain curve of a mild steel bar in tension test.	**3**	**CO2**	**L2**
10	Derive the expression for the deformation of a bar of varying cross section & thus deduce the expression for a bar of uniform cross section.	**5**	**CO2**	**L2**

11	A steel rod 15 mm diameter is enclosed in a copper tube of 50 mm external diameter and 40 mm internal diameter. The tube is closed at each end by rigid plates of negligible thickness. The nuts are tightened on the projecting parts of the rod. . If the temperature of the assembly is raised by 60◦ C, calculate the stresses developed in copper and steel. The modulus of rigidity of steel and copper are 210 kN/ mm 2 and 105 kN/ mm2 respectively. Coefficient of thermal expansion of steel =12 x10 -6/°C. Coefficient of thermal expansion for brass = 18 X 10 -6 /° C	**14**	**CO2**	**L3**
12	A compound bar of length 500 mm consists of a strip of aluminium 50 mm wide x 20 mm thick and a strip of steel 50 mm wide x 15 mm thick rigidly joined at ends. If the bar is subjected to a load of 50 kN, find the stress developed in each material and the extension of the bar. Take the elastic modulus of aluminium and steel as 1x105 N/ mm2 and 2x 105 N/ mm2	**14**	**CO2**	**L3**
13	A straight bar 650 mm long is 60 mm in diameter for the first 350 mm length & 20 mm diameter for the remaining length. If the bar is subjected to an axial pull of 15kN, find the maximum & minimum stresses produced in it & the total extension of the bar. Take E = 2 x 10^5 N/mm^2.	**14**	**CO2**	**L3**
14	A bar of 30 mm diameter is subjected to a pull of 60 kN. The measured extension on gauge length of 200 mm is 0.1mm and change in diameter is 0.004 mm. Calculate: (i) Young's modulus (ii) Poisson's Ratio & (iii) Bulk Modulus	**14**	**CO2**	**L3**
15	A steel flat 1m long, 10 mm wide & 50 mm thick is subjected to an axial pull of 25 kN. Find the extension in length and the contraction in width & thickness under the pull if E = 200 GPa & Poisson's ratio is 0.3. Also calculate the change in volume.	**14**	**CO2**	**L3**
16	Calculate Modulus of Rigidity and Young's Modulus of a cylindrical bar of diameter 30 mm and of 1.5 m length if the longitudinal strain in a bar during a tensile stress is four times the lateral strain. Find the change in volume when the bar is subjected to a hydrostatic pressure of 100 N/mm^2 . Take E = 10^5 N/mm	**14**	**CO2**	**L3**
17	A straight bar 450 mm long is 40 mm in diameter for the first 250 mm length and 20 mm diameter for the remaining length. If the bar is subjected to an axial pull of 15 kN find the maximum axial stress produced and the total extension of the bar. Take E = 2x10^5 N/mm^2	**14**	**CO2**	**L3**
18	Two plates of thickness 2 mm each are joined using a single rivet. The plates are subjected to a tensile load of 314 N. If the material of the rivet is having allowable shear strength of 100 MPa, determine the diameter of the rivet pin?	**14**	**CO2**	**L3**
19	a. Define Poisson's ratio. b. An aluminum alloy plate of size 50 mm x 20 mm with thickness 5 mm is loaded as shown. Find the change in	**14**	**CO2**	**L3**

	thickness? What must be the load to be applied to have the same change in thickness if load is applied only along thickness direction? Take Young's modulus as 1 x 10^5 MPa and Poisson's ratio as 0.25 			
20	A bar of circular cross section 20 mm diameter is subjected to an axial compressive load of 100 kN. The increase in diameter is found to be 0.0082 mm. Calculate the values of Poisson's ratio and modulus of elasticity. Take modulus of rigidity as 8 x 10^4 N/mm^2.	**14**	**CO2**	**L3**
21	a) Find the modulus of rigidity & Bulk modulus of a circular rod of diameter 20 mm and length 2 m, if the longitudinal strain in the rod during a tensile stress is four times the lateral strain. Take Modulus of Elasticity = 2.1 x 10^5 N/mm^2	**14**	**CO2**	**L3**
22	A steel rod 20mm in diameter screwed at the ends passes through a copper tube of inner diameter 25 mm and outer diameter 30mm. The temperature of the assembly was at 115oC when they were assembled and was relieved of all stresses. Find the stresses in the rod and the tube when the temperature has fallen to 15°C. Esteel = 2.1 X 10^5 N/mm2, Ecopper = 1.0 X 10^5 N/mm^2, αsteel=0.000012/deg.C and αcopper =0.0000175/deg.C .	**14**	**CO2**	**L3**
23	A rod consisting of two cylindrical portions AB and BC is restrained at both ends. Portion AB is made of steel (E_s = 205 GPa, α_s = 11.7 X 10 -6/ oC) and portion BC is made of brass (E_b = 100 GPa, αb = 20.9 X 10^{-6}/ °C). Knowing that the rod is initially unstressed, determine the compressive force induced in ABC when there is a temperature rise of 60 °C.	**14**	**CO2**	**L3**
Module 3				
Sl. No.	Question	**Marks**	**CO**	**BL**
1	List any three important assumptions in the theory of torsion.	**3**	**CO3**	**L1**
2	Write the significance of flexural rigidity and section modulus in the analysis of beams.	**3**	**CO3**	**L1**
3	List any three important assumptions in the theory of simple bending	**3**	**CO3**	**L1**
4	Define the following terms:- (a) Point of contraflexure, (b) Flexural Rigidity and (c) Section Modulus	**3**	**CO3**	**L1**
5	Define Flexural rigidity. What is its importance?	**3**	**CO3**	**L1**
6	List down the importance of section modulus	**3**	**CO3**	**L1**

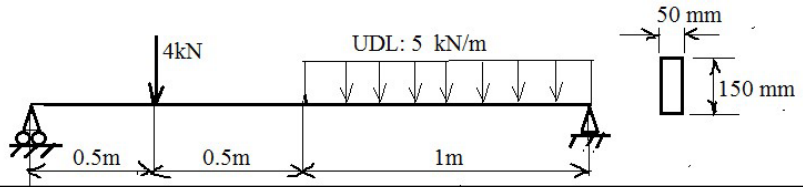
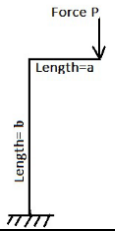
7	State the assumptions involved in deriving Elastic Flexure Formula	**3**	**CO3**	**L1**
8	State the assumptions involved in deriving Torsion Formula for circular shafts	**3**	**CO3**	**L1**
9	Derive the relation between intensity of loading, shear force and bending moment at a section of a uniformly loaded beam?	**3**	**CO3**	**L2**
10	Explain the 'Theory of Simple Bending'.	**3**	**CO3**	**L2**
11	a) What are the assumptions taken while deriving Torsion equation b) Derive the "Torsion equation" $T/J = G\theta/L = fS/R$. Notations having their usual meanings	**14**	**CO3**	**L2**
12	Derive an expression for the strain energy stored in an element having length L , flexural rigidity EI and Torsional rigidity GJ when subjected to under a) Bending, M and b) Torsion, T	**14**	**CO3**	**L2**
13	Draw Shear Force and Bending Moment Diagram for the beam shown: 	**14**	**CO3**	**L3**
14	A T- shaped cross section bar having top section having dimensions 150 x 25 mm and web section 20 x 200 mm is subjected to a vertical shear force of 50 kN. Moment of inertia of the cross section about the horizontal neutral axis is 1.086 x 108 mm^4 Calculate the shear stress acting a) on the top surface b) on the intersection of top and bottom flange c) on the neutral axis (maximum shear stress) and d) draw the stress distribution diagram	**14**	**CO3**	**L3**
15	A solid shaft is proposed to be replaced by a hollow shaft (of the same length and the same material) for transmitting a torque of 30 kNm. If the allowable shear stress of the material used is 100 N/mm^2, find the ratio of the weight of hollow shaft to the solid one, if the inner diameter for hollow one is to be 0.5 times its outer diameter.	**14**	**CO3**	**L3**
16	A solid shaft of 6m length is securely fixed at each end. A torque of 80 Nm is applied to the shaft at a section 2 m from one end a) Find the fixing torques set up at the ends of the shaft. (4) b) If the shaft is of 50 mm diameter, find the maximum shear stresses in the two portions. (4) c) Find the angle of twist for the section where the torque is applied. (2) Take $C = 10^5$ N/mm^2.	**14**	**CO3**	**L3**
17	a. List six important assumptions in the theory of torsion. b. A shaft of 50 mm diameter is made of a material having allowable shear stress of 120 MPa. If the shaft is run at 300 rpm,	**14**	**CO3**	**L3**

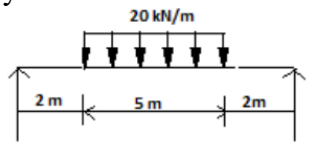
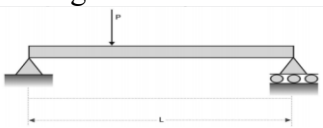
	what is the maximum power that can be carried by the shaft before failure?			
18	A solid aluminium shaft 1 m long and 50 mm diameter is to be replaced by a tubular steel shaft of the same length and the same outside diameter such that each of the two shafts could have the same angle of twist per unit torsional moment over the total length. What must the inner diameter of the tubular steel shaft be? Modulus of rigidity of the steel is three times that of aluminium.	**14**	**CO3**	**L3**
19	Compare the strength of a hollow shaft of diameter ratio 0.75 to that of a solid shaft by considering the permissible shear stress. Both the shafts are of same material, of same length and weight.	**14**	**CO3**	**L3**
20	The propeller shaft for a small ship is of solid steel bar 100mm diameter. If the permissible shear stress is 50MPa and angle of twist is 0.8°/metre length, calculate the maximum torque that can be applied on the shaft. G=80GPa.	**14**	**CO3**	**L3**
21	Determine the diameter of a solid shaft which will transmit 90 kW at 160 rpm if the shear stress in the shaft is limited to 60 N/mm^2. Find also the length of the shaft, if the twist must not exceed 1 degree over the entire length. Take modulus of rigidity = 8 X 10^4 N/mm^2.	**14**	**CO3**	**L3**
22	Draw the shear force and bending moment diagram for the simply supported beam shown in the figure. 	**14**	**CO3**	**L3**
23	A composite shaft has an aluminium tube of external diameter 50 mm and internal diameter 40 mm closely fitted to a steel rod of 40 mm. If the permissible stress is 50 N/mm^2 in aluminium and 120 N/mm^2 in steel , find the maximum torque carrying capacity of the compound bar.. Take Modulus of rigidity for aluminium and steel as 27 x 10^3 N/mm^2 and 80 x 10^3 N/mm^2 respectively.	**14**	**CO3**	**L3**
24	Draw the shear force and bending moment diagrams for the given overhanging beam. Locate the points of contraflexure. Also determine the maximum bending moment.  Fig. 2	**14**	**CO3**	**L3**
25	A simply supported beam of length 4m carries a udl of 3kN/m over the central 2m length and 2 point loads 2kN and 3kN at distances 0.5m and 3.5m from the left support. Draw the SFD and BMD. Locate the point of maximum bending moment and find out the maximum bending moment.	**14**	**CO3**	**L3**

26	A composite shaft has an aluminium tube of external diameter 50 mm and internal diameter 40 mm closely fitted to a steel rod of 40 mm. If the permissible stress is 50 N/mm^2 in aluminium and 120 N/mm^2 in steel, find the maximum torque carrying capacity of the compound bar. Take Modulus of rigidity for aluminium and steel as 27 x 10^3 N/mm^2 and 80 x 10^3 N/mm^2 respectively.	**14**	**CO3**	**L3**

Module 4

Sl. No.	Question	Marks	CO	BL
1	Define elastic strain energy & complementary strain energy.	**3**	**CO4**	**L1**
2	Define Castigliano's second theorem	**3**	**CO4**	**L1**
3	Write down the expression for the strain energy stored in a body subjected to axial loading condition	**3**	**CO4**	**L1**
4	Define point of inflection and point of contraflexure	**3**	**CO4**	**L1**
5	Make a short note on deflection analysis by Castiglianos' method. What is the limitation regarding the material behaviour, while applying this method?	**3**	**CO4**	**L1**
6	Explain double integration method to find the deflection of a cantilever beam with a point load at the free end.	**3**	**CO4**	**L2**
7	Express the strain energy for a cantilever beam subjected to a transverse point load at free end.	**3**	**CO4**	**L2**
8	Discuss reciprocal relation for multiple loads on a structure.	**3**	**CO4**	**L2**
9	State Castigliano's second theorem and explain its significance.	**3**	**CO4**	**L2**
10	Derive strain energy expressions in terms of the geometry, material property and load during (i) Bending and (ii) Torsion.	**6**	**CO4**	**L2**
11	A beam of length 6m is simply supported at its ends and carries 2-point loads of 48kN & 40kN at a distance of 1m and 3m respectively from the left support. Find the deflection under each load and the maximum deflection by Macaulay's method. Given E = 2 x 10^5 N/mm^2 and I = 85 x 10^6 mm^4.	**14**	**CO4**	**L3**
12	A beam section is 10 m long and is simply supported at the ends. It carries concentrated loads of 100 kN and 60 kN at distances of 2 m and 5 m respectively from the left end. Calculate the deflection under each load using Macaulay's method. Find also the maximum deflection. Take moment of inertia as 18 X 10^8 mm^4 and E = 200 kN /mm^2	**14**	**CO4**	**L3**
13	A simply supported beam of 6 m span carries a uniformly distributed load of 2 kN/m from the left end up to the mid span and a concentrated load of 10 kN at a distance of 2 m from the right end. Determine the deflection at the point of application of point load using Castigliano's theorem?	**14**	**CO4**	**L3**

14	Find deflection at the mid-span, if E=12GPa and cross section as shown 	**14**	**CO4**	**L3**
15	A horizontal girder of steel having uniform section is 14 m long and is simply supported at its ends. It carries concentrated loads of 120 kN and 80 kN at two points 3 m and 4.5 m from the two ends respectively. Moment of inertia for the section of the girder is 16×10^8 mm^4 and Es = 210 kN / mm2. Calculate the deflection of the girder at points under the two loads and maximum deflection using Macaulay's method.	**14**	**CO4**	**L3**
16	A structure as shown is loaded by a vertically downward force 'P at the free end'. Find deflection at the free end, in the direction of the load using Castigliano's method. Consider strain energy due to Bending Moment Alone (Neglect other effects). Use a=2m, b=4m, P=30 X 103N, EI (applicable for both legs) is 30 X 10^6 Nm^2. 	**14**	**CO4**	**L3**
17	A horizontal girder of steel having uniform section is 14 m long and is simply supported at its ends. It carries concentrated loads of 120 kN and 80 kN at two points 3 m and 4.5 m from the two ends respectively. Moment of inertia for the section of the girder is 16×10^8 mm^4 and Es = 210 kN/mm^2 . Calculate the deflection of the girder at points under the two loads and maximum deflection using Macaulay's method.	**14**	**CO4**	**L3**
18	A beam section is 10 m long and is simply supported at the ends. It carries concentrated loads of 100 kN and 60 kN at distances of 2 m and 5 m respectively from the left end. Calculate the deflection under each load using Macaulay's method. Find also the maximum deflection. Take moment of inertia as 18 X 108 mm4 and E = 200 kN /mm2	**14**	**CO4**	**L3**
19	A cantilever of uniform section has a length of AB = 6m, A is the free end and carries a point load W, while B is the fixed end. Find the deflection at a point C distant 1/3rd length from the free end A.	**14**	**CO4**	**L3**
20	A simply supported beam of span 6m carries a UDL of 2kN/m over the full span and a concentrated load of 6kN at one third span from left support. Calculate the slope at supports and deflection at mid span. EI=3x 10^4 kN m^2.	**14**	**CO4**	**L3**
21	A simply supported beam of span 9 m carries a uniformly distributed load 20 kN/m as shown in fig 1. Determine deflection	**14**	**CO4**	**L3**

	of beam at midpoint of beam and also maximum deflection. Take flexural rigidity = 10 x 10^4 kN m^2  Fig:1			
22	Derive the expressions for elastic strain energy in terms of applied load/moment and material property for the cases of a) Axial force b) Bending moment.	**14**	**CO4**	**L3**
23	Calculate the displacement in the direction of load P applied at a distance of L/3 from the left end for a simply supported beam of span L as shown in the figure. 	**14**	**CO4**	**L3**
24	A cantilever of uniform section has a length of AB = 6m, A is the free end and carries a point load W, while B is the fixed end. Find the deflection at a point C distant 1/3rd length from the free end A.	**14**	**CO4**	**L3**
25	A uniform metal bar has a cross sectional area of 600 mm^2 and a length of 2m. If the stress at the elastic limit is 170N/mm^2, what will be its proof resilience? Determine also the maximum value of an applied load, which can be suddenly applied without exceeding the elastic limit. Calculate the value of the gradually applied load which will produce the same extension as that produced by the suddenly applied load determined earlier.	**14**	**CO4**	**L3**
26	Derive an expression for the strain energy stored in an element having length L , flexural rigidity EI and Torsional rigidity GJ when subjected to under a) Bending, M and b) Torsion, T	**14**	**CO4**	**L3**

Module 5

Sl. No.	Question	Marks	CO	BL
1	What is slenderness ratio? What is the effective length of columns with both ends fixed?	**3**	**CO5**	**L1**
2	State Hencky-von Mises theory for maximum distortion energy	**3**	**CO5**	**L1**
3	What is the importance of Slenderness ratio in the study of column?	**3**	**CO5**	**L1**
4	What is Rankine's theory for Normal stress?	**3**	**CO5**	**L1**
5	List down the fundamental difference between the deformation behaviour in (i) bending of beams and (ii) buckling of columns.	**3**	**CO5**	**L1**
6	State yield criterion as per Max. Normal Strain Theory. Why didn't it get acceptability?	**3**	**CO5**	**L1**

7	Derive the Euler's formula for long columns with both ends hinged or pinned.	**3**	**CO5**	**L2**
8	Explain the maximum normal stress theory, maximum strain energy theory and maximum shear stress theory of failure.	**3**	**CO5**	**L2**
9	Explain the Rankine's theory for maximum normal stress, Haigh's theory for maximum strain energy and Tresca's yield theory of failure.	**3**	**CO5**	**L2**
10	Recall the fundamental differences between deformation behaviour in (a) bending and (b) buckling of structures.	**3**	**CO5**	**L1**
11	Discuss Saint-Venant's theory of failure.	**3**	**CO5**	**L2**
12	a) Derive Euler's Buckling load for the long column subjected to the end conditions as both ends are hinged. b) What are the limitations of Euler's Buckling theorem?	**14**	**CO5**	**L3**
13	A machine element is subjected to the following stresses σxx = 60 MPa, σyy = 45 MPa and τxy = 30 MPa. Determine the failure stress value using the following theories of failure a) Rankine's theory for maximum normal stress & Guest's theory for maximum shear stress	**14**	**CO5**	**L3**
14	Compare the strengths of a solid steel column to that of hollow one of same area of cross – section. Internal diameter of hollow column is 2/3 of its external diameter. Columns have same length and end conditions. Use Euler's approach.	**14**	**CO5**	**L3**
15	A round steel rod of diameter 15 mm and length 2 m is subjected to a gradually increasing axial compressive load. Using Euler's formula, find the buckling load. Find also the maximum lateral deflection corresponding to the buckling condition. Both ends of the rod may be taken as hinged. Take E = 2.1 x 10^5 N/mm^2 and yield stress of steel = 250 N/mm^2 .	**14**	**CO5**	**L3**
16	A straight bar of alloy 900 mm long & 12.7 x 4.8 mm in section is mounted in a strut testing machine and loaded axially till it buckles. Assuming Euler's formula for pinned ends to apply, estimate the maximum central deflection before the material attains its yield point at 300 N/mm^2 . Take E = 7.7 x 10^4 N/mm^2	**14**	**CO5**	**L3**
17	Find the Euler's critical load for a hollow cylindrical cast iron column of 250mm external diameter and 30mm thickness. It is 5cm long and hinged at both ends. Value of E = 8 x 10^4 N/mm^2. For what length the critical load by Euler's and Rankine's formula be equal. Take Rankine's constant as 1/1600 and σc = 600 N/mm^2	**14**	**CO5**	**L3**
18	Find the crippling load for a hollow steel column 50mm internal diameter and 5mm thick. The column is 5m long with one end fixed and other end hinged. Use Rankine's formula and Rankine's constant as 1/7500 and σc = 335 N/mm^2 . Compare this load by crippling load given by Euler's formula. Take E = 110 GPa.	**14**	**CO5**	**L3**

19	A bolt is subjected to a tensile load of 18 kN and a shear load of 12 kN. The material has an yield stress of 328.6 MPa. Taking factor of safety as 2.5, determine the core diameter of bolt according to the following theories of failure. (i) Rankine's theory of failure, (ii) Maximum shear stress theory, (iii) Shear energy theory, and (iv) Saint Venant's theory. Take Poisson's ratio as 0.298.	**14**	**CO5**	**L3**
20	A mild steel shaft is subjected to a torque of 3kN-m and a bending moment of 2kN-m. Determine the diameter of the shaft required if the yield stress of the material is 200MPa & factor of safety is 2. Use Principal stress theory.	**14**	**CO5**	**L3**
21	Find Euler's critical load for a hollow cylindrical cast iron column 200 mm external diameter and 25 mm thick. The column is 6 m long and hinged at both ends. Take E= 8 X 104 N/mm2. Find Euler's critical load and Rankine's critical load taking σ= 550 N/mm2, α= 1/1600. For what length of the column would the critical loads by Euler's and Rankine's formula be equal?	**14**	**CO5**	**L3**
22	A machine element is subjected to the following stresses σx = 60MPa, σy = 45MPa, τxy = 30MPa. Find the factor of safety if it is made of C$% steel having yield stress as 353 MPa, using the following theories of failure. (i) Maximum principal stress theory, (ii) Maximum shear stress theory, (iii) Shear energy theory, and (iv) Maximum strain theory taking Poisson's ratio as 0.3.	**14**	**CO5**	**L3**
23	A mild steel shaft of 100 mm diameter is to sustain a maximum torque of 20 kNm and maximum bending moment of 10 kNm at a point in the material. Determine the factor of safety based on any three theories of failure. Assume Poisson's ratio as 0.3 and elastic limit in tension as 220MPa.	**14**	**CO5**	**L3**
24	An M.S. shaft having yield stress as 232 MPa is subjected to the following stresses. σx = 120MPa, σy = -60MPa, τxy = 36MPa. Find the factor of safety using: (v) Rankine's theory of failure, (vi) Guest's theory of failure and (vii) Von-Mises theory of failure.	**14**	**CO5**	**L3**
25	Find the diameter of a rod subjected to a bending moment of 3kNm and a twisting moment of 1.8 kNm according to the following theories of failure, taking normal yield stress as 430 MPa and factor of safety as 3. (i) Normal stress theory (ii) Shear stress theory	**14**	**CO5**	**L3**
26	If the principal stresses at a point are: {σ1, σ2, σ3} = {10, 0, -4} MPa and if the yield strength of the material under consideration is 40 MPa, find the factor of safety in design as per (a) Max. Normal Stress Theory (b) Max. Shear Stress Theory and (c) Max. Distortion Energy Theory	**14**	**CO5**	**L3**

27	Using the expression for Euler's critical buckling load, formulate an expression for Rankine's Crippling load in terms of Rankine's constant(α) A column has a square cross-section of 40 mm side. If it has to carry a load of 89,600 N, what should be its limiting length if both ends are assumed to be pinned. Rankine constant α = 1/1600, and compressive strength is 560 N/mm^2.	**14**	**CO5**	**L3**

Prepared By : Prof. Avinesh Pyarilal (Subject Faculty)

Checked By : Prof. JVC Maliackal (Subject Group Coordinator)

Approved By : Dr. Ramadas T (HOD - ME)

Course Code & Name: MET203 Mechanics of Fluids

1. Prescribed Syllabus

Module	Topic	Hours
1	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.	**9**
2	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.	**8**
3	Control volume analysis of mass, momentum and energy, Equations of fluid dynamics: Differential equations of mass, energy and momentum (Euler's equation), Navier-Stokes equations (without proof) in cartesian co-ordinates. Dynamics of Fluid flow: Bernoulli's equation, Energies in flowing fluid, head, pressure, dynamic, static and total head, Venturi and Orifice meters, Notches and Weirs (description only for notches and weirs). Hydraulic coefficients, Velocity measurements: Pitot tube and Pitot-static tube.	**8**
4	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, hydraulic gradient and total energy line, flow through long pipes, pipes in series, pipes in parallel, equivalent pipe, siphon, transmission of power through pipes, efficiency of transmission, Water hammer, Cavitation.	**12**
5	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, Von- Karman momentum integral equations for the boundary layers, calculation of drag, separation of boundary and methods of control. Dimensional Analysis: Dimensional analysis, Buckingham's theorem, important non dimensional numbers and their significance, geometric, Kinematic and dynamic similarity, model studies. Froude, Reynolds, Weber, Cauchy and Mach laws- Applications and limitations of model testing, simple problems only	**10**

2. Text Books (T)

T1. Balachandran.P, Engineering Fluid Mechanics, PHI,2012
T2. A S Saleem, Arun V, S Jose, Fluid Mechanics, Fathima Books,2020
T3. John. M. Cimbala and Yunus A. Cengel, Fluid Mechanics: Fundamentals and Applications (4th edition, SIE), 2019
T4. Robert W. Fox, Alan T. McDonald, Philip J. Pritchard and John W. Mitchell, Fluid Mechanics, Wiley India, 2018

3. Reference Books (R)

R1. Cengel, Fluid Mechanics, McGraw Hill Education India 2014
R2. Bansal R. K., A Textbook of Fluid Mechanics and Hydraulic Machines, Laxmi Publications, 2005
R3. Modi P. N. and S. M. Seth, Hydraulics & Fluid Mechanics, S.B.H Publishers, New Delhi, 2002
R4. Streeter V. L., E. B. Wylie and K. W. Bedford, Fluid Mechanics, Tata McGraw Hill, Delhi, 2010.
R5. Joseph Karz, Introductory Fluid Mechanics, Cambridge University press, 2010
R6. Fox R. W. and A. T. McDonald, Introduction to Fluid dynamics, 5/e, John Wiley and Sons, 2009
R7. Shames I. H, Mechanics of Fluids, McGraw Hill, 1992.
R8. White F.M., Fluid Mechanics, 6/e, Tata McGraw Hill, 2008
R9. White, F. M., Fluid Mechanics, McGraw Hill Education India Private Limited, 8th Edition, 2017
R10. Rathakrishnan, E. Fluid Mechanics: An Introduction, Prentice Hall India, 3rd Edition 2012

4. Course Objectives

a) To study the mechanics of fluid motion and behaviour of fluids.

b) To establish fundamental knowledge of basic fluid mechanics and address specific topics relevant to simple applications involving fluids

c) To familiarize students with the relevance of fluid dynamics, concepts of boundary layers, dimensional analysis and model testing to many engineering systems

5. Course Pre / Co-requisite

MA101 Calculus

6. Course Outcomes

The students will be able to
CO1: Define Properties of Fluids and Solve hydrostatic problems.
CO2: Explain fluid kinematics and Classify fluid flows.
CO3: Interpret Euler and Navier-Stokes equations and Solve problems using Bernoulli's equation.
CO4: Evaluate energy loses in pipes and sketch energy gradient lines.
CO5: Explain the concept of boundary layer and its applications.
CO6: Use dimensional Analysis for model studies

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	H	M													H
CO2	H	M	L												H
CO3	H	M	L												H
CO4	H	H	M												H
CO5	H	M	L												H
CO6	H	M	L												H

8. Justification for CO-PO-PSO Correlation

CO1	PO1	Properties of Fluids are used to solve hydrostatic engineering problems. High correlation is due to the fact that this involves the deep knowledge of science, engineering fundamentals, and an engineering specialization to solve the complex engineering problems.
	PO2	The properties of fluids and hydrostatic equations are used to identify, formulate and analyse the complex engineering problems. Medium correlation is due to the fact that this involves the basic knowledge using first principles of mathematics, science and engineering.
	PSO3	The properties of fluids and hydrostatic equations are used to design solutions for complex engineering problems design and analyse multi-disciplinary systems. High correlation is due to the fact that this involves the deep knowledge of engineering principles to design and analyse multi-disciplinary hydraulic systems.
CO2	PO1	The fluid kinematics and classification of fluid flows are used to solve the engineering problems. High correlation is due to the fact that this involves the deep knowledge of science, engineering fundamentals, and an engineering specialization to solve the complex engineering problems.
	PO2	Analytical knowledge on the fluid kinematics are used to identify, formulate and analyse the complex engineering problems. Medium correlation is due to the fact that this involves the basic knowledge using first principles of mathematics, science and engineering.
	PO3	Analytical knowledge on fluid flow problems and to design the stream function and the velocity potential function for different flows are used to design solutions for complex engineering problems. Low correlation is due to the fact that this involves the only basic knowledge that meet the specified needs with appropriate consideration for the public health and safety and environmental considerations.
	PSO3	Design, analysis and implementation of fluid kinematics are used for design solutions of complex engineering problems. High correlation is due to the

		fact that this involves the deep knowledge of engineering principles to design and analyse multi-disciplinary hydraulic systems.
CO3	**PO1**	Interpreting the momentum and energy equations are used to solve the complex engineering problems. High correlation is due to the fact that this involves the deep knowledge of science, engineering fundamentals, and an engineering specialization to solve the complex engineering problems.
	PO2	Interpret Euler and Navier-Stokes equations and Bernoulli's equation are used to identify, formulate and analyse the complex engineering problems related to flow through bend pipes, fluid machinery etc. Medium correlation is due to the fact that this involves the basic knowledge using first principles of mathematics, science and engineering.
	PO3	Interpreting the momentum and energy equations are used to design/development of solutions for complex engineering problems like fluid flow problems on lifting surfaces/aerodynamic bodies in wind tunnels. Low correlation is due to the fact that this involves the only basic knowledge that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
	PSO3	Interpreting the momentum and energy equations are used to design solutions for complex engineering problems of multi-disciplinary systems. High correlation is due to the fact that this involves the deep knowledge of engineering principles to design and analyse multi-disciplinary hydraulic systems.
CO4	**PO1**	The knowledge of loses in pipes and energy gradient lines are used to solve the engineering problems. High correlation is due to the fact that this involves the deep knowledge of science, engineering fundamentals and engineering specialization to solve the complex engineering problems.
	PO2	To evaluate energy loses in pipes and sketch energy gradient lines are used to identify, formulate and analyse the complex engineering problems. High correlation is due to the fact that this involves the deep knowledge using first principles of mathematics, science and engineering.
	PO3	Evaluate energy loses in pipes and sketch energy gradient lines are used to design solutions for complex pipe flow and fluid transmission problems and design system components. Medium correlation is due to the fact that this involves the basic knowledge that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
	PSO3	Analytical knowledge design, analysis and implementation of mechanical systems/ manufacturing processes for pipe lines, its selections, and energy gradient lines are used for design solutions of complex engineering problems. High correlation is due to the fact that this involves the deep knowledge of engineering principles to design and analyse multi-disciplinary hydraulic systems.
CO5	**PO1**	The concept of boundary layer and its applications are used to solve the complex engineering problems. High correlation is due to the fact that this involves the deep knowledge of science, engineering fundamentals, and an engineering specialization to solve the complex engineering problems.
	PO2	The concept of boundary layer and its applications are used to identify, formulate and analyse the complex engineering problems related to fluid flows. Medium correlation is due to the fact that this involves the basic knowledge using first principles of mathematics, science and engineering.

	PO3	The concept of boundary layer and its applications are used to design/development of solutions for complex engineering problems like fluid flow problems. Low correlation is due to the fact that this involves the only basic knowledge that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
	PSO3	The concept of boundary layer and its applications are used to design solutions for complex engineering problems of multi-disciplinary systems. High correlation is due to the fact that this involves the deep knowledge of engineering principles to design and analyse multi-disciplinary hydraulic systems.
CO6	**PO1**	basic/fundamental knowledge in (engineering) dimensional analysis, wind tunnel application, and knowledge will be limited to recognizing application of the principle of dimensional similarity in wind tunnels are used to solve the complex engineering problems. High correlation is due to the fact that this involves the deep knowledge of science, engineering fundamentals, and an engineering specialization to solve the complex engineering problems.
	PO2	The concept of dimensional analysis and its applications are used to identify, formulate and analyse the complex engineering problems related to fluid flows. Medium correlation is due to the fact that this involves the basic knowledge using first principles of mathematics, science and engineering.
	PO3	The concept of dimensional analysis and its applications are used to design/development of solutions for complex engineering problems like fluid flow problems. Low correlation is due to the fact that this involves the only basic knowledge that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
	PSO3	The concept of dimensional analysis and its applications are used to design solutions for complex engineering problems of multi-disciplinary systems. High correlation is due to the fact that this involves the deep knowledge of engineering principles to design and analyse multi-disciplinary hydraulic systems.

9. Curricular gaps (if any)

- Syllabus declared in the year 2019 is very lengthy.
- The time allotted to cover the basic knowledge in the first & fifth module is very less.
- The syllabus focuses on theoretical concepts, but lacks exposure to real-world applications and case studies. Incorporating examples from industries like aerospace, automotive, can help students see how fluid mechanics principles are applied in practice.

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	Basic knowledge of Bernoulli's principle, venturimeter, orifice meter, manometer, pressure gauges, raynolds experiment.	Visit to Fluid Mechanics lab	PO1

2	To improve the problem solving skills and the concepts of fluid mechanics.	competitions or challenges related to fluid mechanics	PO1, PO2, PO3

11. Internal Assessment mark allocation (as per university curriculum)

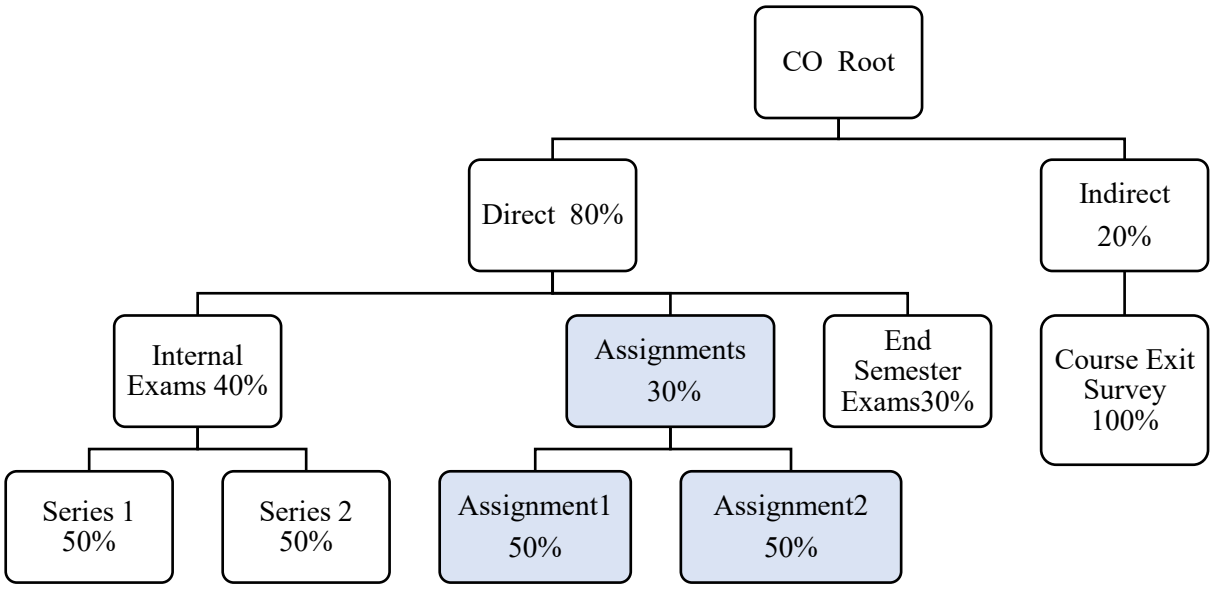
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put' x' if mapping is present)

	Tools		Weightage#	CO1	CO2	CO3	CO4	CO5	CO6
Direct Assessment Tools**	Internal Exam(s) 40%	Series 1	50%	X	X	X			
		Series 2	50%			X	X	X	
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	50%	X	X				
		Assignment 2	50%				X	X	X
	End Semester Exam - 30%		100%	X	X	X	X	X	X
Indirect Assessment Tool	Course Exit Survey		100%	X	X	X	X	X	X

13. Assessment Configuration



14. Course Plan

Sl. no	Topic Name	Module	Reference	Teaching Pedagogy
1	Introduction: Fluids and continuum	1	R2, R3	Lecture
2	Surface tension, compressibility, Newtonâ€™s law of viscosity, Ideal and real fluids, Newtonian and non-Newtonian fluid	1	R2, R3	Lecture
3	Fluid Statics- Pressure-density-height relationship, Pascalâ€™s law, Hydrostatic law	1	R2, R3	Lecture
4	Measurement of pressure, Manometers â€“ types, advantages, limitations, liquids	1	R2, R3	Lecture
5	Manometers- problems,	1	R2, R3	Lecture
6	Mechanical gauges- types, measurement of pressure.	1	R2, R3	Tutorial
7	Pressure on plane surfaces, centroid and area moment of inertia of a surface Centre of pressure, total pressure on a horizontal submerged plane surface	1	R2, R3	Lecture
8	Centre of pressure, total pressure on a horizontal submerged Vertical & inclined surface	1	R2, R3	Lecture
9	Centre of pressure, total pressure on a horizontal submerged plane surface	1	R2, R3	Lecture
10	Centre of pressure, total pressure on a horizontal submerged on curved surfaces	1	R2, R3	Tutorial
11	Buoyancy and floatation, principle of buoyancy, centre of buoyancy, Archimedes principle	1	R2, R3	Lecture
12	Stability of immersed and floating bodies, metacentre and metacentric height, fluid masses subjected to uniform accelerations	1	R2, R3	Tutorial
13	Kinematics of fluid flow: Eulerian and Lagrangian approaches	2	R2, R3	Lecture
14	classification of fluid flow, steady, unsteady, uniform, non-uniform, laminar, turbulent, rotational, irrotational flows	2	R2, R3	Lecture
15	1-D, 2-D and 3-D flow, stream lines, path lines, streak lines, stream tubes	2	R2, R3	Lecture
16	Continuity equation in 3D	2	R2, R3	Lecture
17	velocity and acceleration in fluid,	2	R2, R3	Lecture
18	stream function	2	R2, R3	Tutorial
19	Potential function and Laplace equation	2	R2, R3	Lecture
20	Equipotential lines, Potential lines Circulation and vorticity, flow nets, uses and limitations	2	R2, R3	Tutorial
21	Control volume analysis of mass, momentum and energy, Equations of fluid dynamics: Differential equations of mass, energy and momentum (Eulerâ€™s equation)	3	R2, R3	Lecture
22	Navier-Stokes equations (without proof) in rectangular and cylindrical co-ordinates	3	R2, R3	Lecture

23	Dynamics of Fluid flow: Fluid Dynamics:Bernoulliâ€™s equation	3	R2, R3	Lecture
24	Energies in flowing fluid, head, pressure, dynamic, static and total head	3	R2, R3	Lecture
25	Application of Bernoulliâ€™s equation: Venturi meters	3	R2, R3	Lecture
26	Application of Bernoulliâ€™s equation: Orifice meters	3	R2, R3	Tutorial
27	Notches and Weirs (description only for notches and weirs)	3	R2, R3	Lecture
28	Hydraulic coefficients, Velocity measurements: Pitot tube and Pitot-static tube	3	R2, R3	Tutorial
29	Pipe Flow: Viscous flow: Reynolds experiment to classify laminar and turbulent flows	4	R2, R3	Lecture
30	Significance of Reynolds number, critical Reynolds number	4	R2, R3	Lecture
31	shear stress and velocity distribution in a pipe, law of fluid friction	4	R2, R3	Lecture
32	head loss due to friction, Hagen Poiseuille equation	4	R2, R3	Lecture
33	Turbulent flow	4	R2, R3	Tutorial
34	Darcy- Weisbach equation	4	R2, R3	Lecture
35	Chezyâ€™s equation Moodyâ€™s chart	4	R2, R3	Lecture
36	Major and minor energy losses	4	R2, R3	Tutorial
37	hydraulic gradient and total energy line	4	R2, R3	Lecture
38	flow through long pipes, pipes in series, pipes in parallel, equivalent pipe, siphon	4	R2, R3	Lecture
39	Transmission of power through pipes	4	R2, R3	Tutorial
40	Efficiency of transmission, Water hammer, Cavitation.	4	R2, R3	Lecture
41	Concept of Boundary Layer : Growth of boundary layer over a flat plate and definition of boundary layer thickness	5	R2	Lecture
42	displacement thickness, momentum thickness and energy thickness	5	R2	Lecture
43	displacement thickness, momentum thickness and energy thickness	5	R2	Lecture
44	laminar layers	5	R2	Lecture
45	laminar sub layer, velocity profile	5	R2	Lecture
46	Von- Karman momentum integral equations for the boundary layers	5	R2	Lecture
47	calculation of drag	5	R2	Tutorial
48	Methods of preventing the separation of boundary layer, Magnus effect	5	R2	Lecture
49	Buckinghamâ€™s pai theorem, problems	5	R2	Lecture
50	Dimensional Analysis and Hydraulic similitude, Dimensional Analysis, Dimensions and units, Dimensional homogeneity, Reyleighâ€™s Method	5	R2	Tutorial

51	Important dimensional numbers and their Significance	5	R2	Lecture
52	Buckinghamâ€™s pai theorem, problems	5	R2	Lecture
53	Geometric, Kinematic and dynamic similarity, model studies. Froude, Reynold, Weber, Cauchy and Mach laws	5	R2	Lecture
54	Geometric, Kinematic and dynamic similarity, model studies. Froude, Reynold, Weber, Cauchy and Mach laws	5	R2	Lecture
55	Applications and limitations of model testing, simple problems only	5	R2	Tutorial

15. Question Bank

Module 1				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	Deduce Pascal's Law.	03	CO1	L1
2	Differentiate between Newtonian fluids and Non-Newtonian fluids.	03	CO1	L2
3	Differentiate between gauge pressure and absolute pressure.	03	CO1	L2
4	Explain the "Continuum" concept of fluid. Is the continuum model valid in upper atmosphere?	03	CO1	L1
5	What is meant by vapour pressure? Explain its importance in liquid flow system	03	CO1	L1
6	Briefly explain the principle employed in the manometers for the measurement of pressure	03	CO1	L1
7	State and explain Newton's Law of viscosity. What is the effect of temperature on viscosity of fluids?	03	CO1	L1
8	Define the terms "buoyancy" and "Centre of buoyancy"	03	CO1	L1
9	Differentiate between gauge pressure and absolute pressure with diagrams.	03	CO1	L2
10	What is the difference between Cohesion and Adhesion?	03	CO1	L2
11	Define surface tension. What are the factors that affect surface tension?	03	CO1	L2
12	How the rise of liquid level in a capillary tube gets affected when (i) the tube is of insufficient length (ii) the top of the tube is closed	03	CO1	L2
13	Consider a soap bubble. Is the pressure inside the bubble higher or lower than the pressure outside? Explain.	03	CO1	L2
14	Define the resultant hydrostatic force acting on a submerged surface, and the centre of pressure.	03	CO1	L2
15	What is viscosity? What is the cause of it in liquids and in gases?	03	CO1	L2
16	Consider a 4 kg copper cube and a 4 kg copper ball submerged in a liquid. Will the buoyant forces acting on these two bodies be the same or different? Explain.	03	CO1	L2
17	Explain the phenomenon of capillarity. Derive an expression for capillary depression of mercury.	07	CO1	L2
18	State and prove the hydrostatic law	07	CO1	L2

19	Differentiate between ideal fluids and real fluids. Mark those on rheological diagram.	07	CO1	L2
20	Differentiate between i. Absolute and gauge pressure ii. Piezometer and pressure gauges	07	CO1	L2
21	An open tank contains water up to a depth of 2m and above it an oil of specific gravity 0.9 for a depth of 1m. Find the pressure intensity i. At the interface of the two liquids ii. At the bottom of the tank	07	CO1	L2
22	Dynamic viscosity of oil used for lubrication between a shaft (journal) and bearing is 6 poise. The shaft is of diameter 400 mm and rotates at 190 rpm. Calculate the power lost in the bearing for 90 mm long Journal bearing arrangement. Thickness of oil is 1.5 mm.	07	CO1	L2
23	A rectangular pontoon 10m long 7 m broad & 2.5m deep weights 686.7KN. It carries on its upper deck an empty boiler of 5 m diameter weighing 588.6 KN. The centre of gravity of the boiler and the pontoon are at their respective centers along a vertical line. Find the metacentric height and check the stability of the body. Weight density of sea water is 10.104 KN/m3.	07	CO1	L3
24	In a stream of glycerine in motion at a certain point the velocity gradient is 0.25 s-1. If for the fluid, the density is 1268 kg/m3 and kinematic viscosity is 6.3x10-4 m2/s. Calculate the shear stress at the point.	07	CO1	L2
25	A differential manometer is connected to two pipes whose centres are at 2.5 m difference in height. Higher level pipe is carrying carbon tetra chloride of specific gravity 1.594 under a pressure of 1.05 bar and another pipe is carrying oil of specific gravity 0.8 under a pressure of 1.71 bar. The centre of pipe carrying low pressure liquid is 4 metres above the higher level of mercury in the manometer. The manometric fluid is mercury. Find out the difference of mercury (h) in the manometer.	07	CO1	L2
26	Derive an expression for total pressure and centre of pressure on an inclined plane surface submerged in a liquid.	07	CO1	L2
27	A rectangular plane surface 2m wide and 3m deep lies in water in such a way that its plane makes an angle of 300 with the free surface of water. Determine the total pressure and position of centre of pressure when the upper edge is 1.5m below the free water surface.	07	CO1	L3
28	A triangular plate of base width 2m and height 3m is immersed in water with its plane making an angle of 60^0 with the free surface of water. Determine the hydrostatic pressure force and the centre of pressure when the apex of the triangle lies 5m below the free water surface.	07	CO1	L3
29	A triangular plate of base width 2m and height 3m is immersed in water with its plane making an angle of 60o with the free surface of water. Determine the hydrostatic pressure force and the centre of pressure when the apex of the triangle lies 5m below the free water surface.	07	CO1	L3
30	What is metacentre and metacentric height? Explain the equilibrium conditions of floating bodies.	07	CO1	L1
31	Explain the conditions of equilibrium of floating and submerged bodies.	07	CO1	L1

32	A U-tube differential mercury manometer is connected between two pipes X and Y. Pipe X contains a fluid (Sp.gr. = 1.59) under a pressure of 103 kN/m2 and pipe Y contains oil (Sp.gr. = 0.8) under a pressure of 172 kN/m2. Pipe X is 2.5 m above pipe Y. The mercury level in the limb connected to pipe X is 1.5 m below the centreline of pipe Y. The level of mercury in the limb connected to pipe Y is below the level of mercury (Sp.gr. = 13.6) in the other limb. Find the manometer reading in centimetres of mercury and show the same as a schematic diagram.	07	CO1	L2
33	State and explain the Newton's law of viscosity. Explain with examples the classification of fluids on the basis of this law.	07	CO1	L1
34	A hollow wooden cylinder of specific gravity 0.6 has an outer diameter of 600 mm and an inner diameter of 300 mm. It is required to float in an oil of specific gravity 0.9. Calculate (a) Maximum length (l) of the cylinder so that it shall be stable when floating with its axis vertical. (b) The depth to which it will sink (h).	07	CO1	L3
35	Explain the working principle and use of the following devices. i) Manometer ii) Piezometer iii) Bourden tube pressure gauge	07	CO1	L2
36	Illustrate the characteristics fluid properties to which the following phenomenon are attributable: a. Rise of sap in tree b. Spherical shape of a drop of a liquid c. Cavitation d. Flow of a jet of oil in an unbroken stream e. Water hammer f. Certain insects are able to walk on surface of water.	07	CO1	L3
37	A vertical rectangular gate of 4m width and 2m depth is hinged at a point 0.25 m below the centre of gravity of the gate. If the top edge of gate is 5 m below free surface of water and total depth of water is 7 m, what horizontal force must be applied at the bottom to keep the gate closed?	07	CO1	L3
38	A plate weighing 150N and measuring 0.8mx0.8m slides down an inclined plane over an oil film of 1.2mm thickness for an inclination of 30o and a velocity of 0.2m/s. Compute the dynamic viscosity of the fluid.	07	CO1	L2
39	Determine the total pressure and position of centre of pressure on an isosceles triangular plate of base 5m and altitude 5m when the plate is immersed vertically in an oil of specific gravity 0.8. The base of the plate is 1m below the free surface of oil.	07	CO1	L3
40	A solid cylinder of diameter 5m has a height of 4m. Find the metacentric height of the cylinder when it is floating in water with its axis vertical. The specific gravity of the cylinder = 0.6.	07	CO1	L3
41	A U - Tube manometer is used to measure the pressure of water in a pipe line, which is in excess of atmospheric pressure. The right limb of the manometer contains mercury and the contact between water and mercury is in the left limb. Determine the pressure of water in the main line, if the difference in level of mercury in the limbs of U tube is 10 cm and the free	07	CO1	L3

	surface of mercury is in level with over the centre of the pipe. If the pressure of water in pipe line is reduced to 9810 N/m^2, calculate the new difference in the level of mercury. Sketch the arrangement in both cases.			
42	Derive an expression for the capillary rise of a fluid having surface tension, 'σ'; and contact angle 'θ' between two vertical parallel plates placed a distance, 't' apart.	07	CO1	L2
43				
44	Consider two identical fans, one at sea level and the other on top of a high mountain running at identical speeds. How would you compare (a) the volume flow rates and (b) the mass flow rates of these two fans?	07	CO1	L2
45	You may have noticed that dams are much thicker at the bottom. Explain why dams are built that way?	07	CO1	L2
46	Differentiate between (i) Specific weight and Specific volume (ii) Dynamic viscosity and Kinematic viscosity (iii) Real fluid and Ideal fluid	07	CO1	L2
47	A manometer is used to measure the pressure in a tank. The fluid used has a specific gravity of 0.80 and the manometer column height is 50 cm. If the local atmospheric pressure is 98 kPa, determine the absolute pressure within the tank.	07	CO1	L2
48	An infinite plate is moved over a second plate on a layer of liquid. For small gap width, d = 0.3 mm, we assume a linear velocity distribution in the liquid. The liquid viscosity is 0.065 Ns/m2 and its specific gravity is 0.90. Lower plate is fixed and the upper plate is moving with a velocity of 0.3 m/s. Determine : The kinematic viscosity of the liquid, in m2/s. The shear stress on the upper plate, in N/m2 The shear stress on the lower plate, in Pa. The direction of each shear stress calculated in parts (b) and (c)	14	CO1	L2
49	(a) What is the difference between gage pressure and absolute pressure? (b) Express Pascal's law and give example of it. (c) A vacuum gage connected to a tank reads 30 kPa at a location where the barometric reading is 755 mm Hg. Determine the absolute pressure in the tank. Take density of mercury as 13,590 kg/m3.	14	CO1	L2
Module 2				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	What do you mean by equipotential line, and a line of constant stream function?	03	CO2	L1
2	What are flow nets? Mention its uses and limitations?	03	CO2	L1
3	Define the following terms Streamlines, Stream tube, Streaklines and Pathlines.	03	CO2	L1
4	Differentiate between the Eulerian and Lagrangian method of representing Fluid motion.	03	CO2	L2

5	An oil flows through a 100 mm diameter pipe at a mean velocity of 180 m/min. Find (i) Volume flow rate in m^3/s and litres/min (ii) Weight of oil flow rate in kN/s and mass of oil flow rate in kg/s.	03	CO2	L2
6	For a given flow, two velocity components are given. Find the third component such that they satisfy the continuity equation. $u = x^3+y^2+2z^2$; $v = -x^2y-yz-xy$	03	CO2	L2
7	A stationary probe is placed in a fluid flow and measures pressure and temperature as functions of time at one location in the flow. Is this a Lagrangian or an Eulerian measurement? Explain.	03	CO2	L2
8	What is the definition of a streamline? What do streamlines indicate?	03	CO2	L1
9	What flow property determines whether a region of flow is rotational or irrotational? Discuss.	03	CO2	L2
10	Differentiate the following. (a) Lagrangian method and Eulerian method (b) Steady and unsteady flow (c) Laminar and turbulent flow (d) Stream line and streak line flow. (e) Uniform flow and non-uniform flow (f) Rotational and irrotational flow	07	CO1	L2
11	An idealized flow is given by $V = 2x^3i - 3x^2yj$. Is the flow steady or unsteady? Is it 2D or 3D? Make calculations for the velocity, local acceleration and convective acceleration of a fluid particle in the flow field at the point (2,1,3).	07	CO1	L2
12	The velocity vector in a fluid flow is given by $V = 4x^3i-10x^2yj+2tk$. Find the acceleration of fluid particle at (2,1,3) at time t=1	07	CO2	L2
13	The velocity vector in a fluid flow is given by $V = 4x^3i - 10x^2yj + 2tk$. Find the velocity and acceleration of a fluid particle at (2,1,3) at time t=1.	07	CO2	L2
14	If for a two dimensional potential flow, the velocity potential is $\Phi = x(2y-1)$, determine the velocity at the point P (2, 3). Determine also the value of stream function ψ at the point P.	07	CO2	L2
15	How can you classify fluid flow?	07	CO2	L2
16	The velocity components in a three dimensional flow field for an incompressible fluid are given u = 2x, v = -y and w = -z. Determine the equation of the streamline passing the point (1, 1, 1).	07	CO2	L3
17	In a two dimensional incompressible flow, the fluid velocity components are given by u = x - 4y and v = -y - 4x. Show that the velocity potential exists and Determine its form as well as stream function.	07	CO2	L3
18	The velocity vector for 2D incompressible, fluid flow is given by $V = \left(\frac{y^3}{3} + 2x - x^2y\right)i + (xy^2 - 2y - \frac{x^3}{3})j.$ Find a) whether the flow is possible or impossible. b) Whether the flow is rotational or irrotational.	07	CO2	L2
19	A velocity field is defined by $= 2y^2i + 3xj + 0k$. Compute the velocity, local acceleration and convective acceleration at point (1, 2, 0).	07	CO2	L2

20	The stream function for a flow field is given by $\Psi=2xy$. Check whether the flow is continuous or irrotational.	07	CO2	L2
21	Derive the equation of continuity for one dimensional steady flow based on stream tube concept.	07	CO2	L2
22	Define the stream function and clearly bring out its physical significance. Enumerate some of the salient features of the stream function.	07	CO2	L2
23	The stream function is given $\psi = 3xy$, determine the corresponding potential functions. Also estimate the discharge per unit depth in the Z-direction passing between the stream lines through the points (1, 3) and (3, 3).	07	CO2	L3
24	Given the velocity field; V= (6 + 2xy + t2) i − (xy2 + 10t) j + 25k What is the acceleration of a particle at (3, 0, 2) at time t = 1?	07	CO2	L1
25	Clearly bring out the difference between one, two, and three dimensional flows. Classify the following flows into these categories : (i) Flow in a river (ii) Flow of water over a spillway (iii) Flow through the test section of a water tunnel (iv) Flow in turbo machine	07	CO2	L3
26	The velocity potential function is given by $\varphi= 10(x^2-y^2)$. Calculate the velocity components at the point (4,5).	14	CO2	L3
27	The velocity components in a steady two-dimensional incompressible flow are given by u = 6x and v = -6y. Prove that the flow satisfies law of conservation of mass.	14	CO2	L3
28	A steady, incompressible, two dimensional velocity field is given by the following components in the xy plane : u = 1.1+ 2.8x + 0.65y and v = 0.98 - 2.1x - 2.8y Calculate the acceleration field (find expressions for acceleration components a_x and a_y.), and calculate the acceleration at the point (x, y) = (-2, 3).	14	CO2	L3
29	Consider the flow field given by $\psi = ax^2 - ay^2$ where a = 5 s^{-1}. Show that the flow is irrotational. Determine the velocity potential for this flow.	14	CO2	L3

Module 3

Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	What are the applications and limitations of Bernouli's equation?	3	CO3	L1
2	What are the limitations of Bernoulli's equation?	3	CO3	L1
3	Name the different forces present in a fluid flow. For the Euler's equation of motion which forces are taken into consideration?	3	CO3	L1
4	Define crest and nappe of a weir. What are free, depressed and clinging nappes.	3	CO3	L2
5	What are the advantages of triangular notch over rectangular notch?	3	CO3	L2

6	Does the amount of mass entering a control volume have to be equal to the amount of mass leaving during an unsteady-flow process? Explain.	3	CO3	L3
7	What are the three major assumptions used in the derivation of the Bernoulli equation?	3	CO3	L2
8	Write the modified form of Bernoulli's equation for the following cases: (i)Fluid is real. (ii) A pump is connected between two sections. (iii) A turbine is connected between two sections. (iv) For compressible flow.	4	CO3	L2
9	Sketch and describe a pitot-static probe and explain how it is used to measure the fluid flow through a pipeline.	4	CO3	L2
10	Air enters a nozzle steadily at 2.21 kg/m^3 and 30 m/s and leaves at 0.762 kg/m^3 and 180 m/s. If the inlet area of the nozzle is 80 cm^2, determine (a) the mass flow rate through the nozzle (b) exit area of the nozzle.	4	CO3	L2
11	Consider a device with one inlet and one outlet. If the volume flow rates at the inlet and at the outlet are the same, is the flow through this device necessarily steady? Why?	4	CO3	L2
12	Compare rectangular notch and triangular notch with respect to construction and advantages.	5	CO3	L2
13	Explain the working principle of Pitot tube and Pitot-static tube with neat sketches.	5	CO3	L1
14	Mention the advantages and limitations of an orifice meter as a flow metering device.	5	CO3	L2
15	What is a notch? How is it different from a large orifice?	5	CO3	L1
16	What is Cipolletti weir? Show that its side slopes of 1 horizontal to 4 vertical are provided for a definite purpose.	5	CO3	L2
17	Derive Euler's equation of motion. How will you obtain Bernoulli's equation from Euler's Equation? State the assumptions made for such derivation.	7	CO3	L2
18	State and prove Bernoulli's equation, mentioning clearly the assumptions underlying it.	7	CO3	L2
19	A pipe 300 m long has a slope of 1 in 100 and tapers from 1.2 m diameter at the higher end to 0.6 m diameter at the lower end. Quantity of water	7	CO3	L2

	flowing is 5400 litres per minute. If the pressure at the higher end is 68.67 kPa. Find the pressure at the lower end.			
20	What is a Venturimeter? Derive an expression for the discharge through a venturimeter.	7	CO3	L2
21	A submarine moves horizontally in sea and has its axis below the water surface. A pitot tube is placed in front of the submarine along its axis is connected to the two limbs of a U- tube containing mercury. The difference in mercury level is found to be 170 mm. Find the speed of submarine in km/hr, knowing that specific gravity of sea water is 1.025.	7	CO3	L3
22	Compare Venturimeter and orifice meter with respect to construction, principle, merits and demerits.	7	CO3	L2
23	A Venturimeter whose throat diameter is 1/3rd of pipe diameter is fitted in a horizontal pipe of 300 mm diameter carrying water. The pressure in pipe line is 13.8 N/cm2 (gauge) and vacuum in throat is 37.5 cm of mercury. Determine the rate of flow through the pipeline. Take Cd=0.98.	7	CO3	L3
24	What is Venturimeter? Derive an expression for discharge through a venturimeter.	7	CO3	L2
25	Water flows at the rate of 15litre/s through a pipe 100mm diameter orifice used in a 200 mm diameter pipe. What is the difference of pressure head between upstream section and vena contracta section? Take coefficient of contraction as 0.6 and coefficient of velocity as 1.	7	CO3	L3
26	An oil of specific gravity 0.8 is flowing through a venturimeter having inlet diameter 20cm and throat diameter 10cm. The oil-mercury differential manometer shows a reading of 15cm. Calculate the discharge of oil through the horizontal venturimeter. Take Cd = 0.98	7	CO3	L3
27	A venturimeter is installed in a pipe line carrying water and is 30 cm in diameter. The throat diameter is 12.5 cm. The pressure in pipeline is 140 KN/m2 and the vacuum in the throat is 37.5 cm of mercury. 4% of the differential head is lost between the gauges. Working from first principles, find the flow rate in the pipeline in litre/s assuming the venturimeter to be horizontal.	7	CO3	L3
28	Water flows through a 90 cm diameter pipe at the end of which there is a reducer connecting to a 60 cm diameter pipe. If the gauge pressure at the entrance to the reducer is 412.02 KN/m2 and the velocity is 2 m/s, determine the resultant thrust on the reducer, assuming that the frictional loss of head in the reducer is 1.5 m.	7	CO3	L3

29	Establish a relationship between head loss in the convergent part of the venturimeter and piezometric head difference between inlet and throat of the venturimeter.	7	CO3	L2
30	An orificemeter consisting of 100 mm diameter orifice in a 250 mm diameter pipe has co-efficient of discharge 0.65. The pipe delivers oil of specific gravity of 0.8. The pressure difference between on the two sides of the orifice plate is measured by a mercury-oil differential manometer. If the differential gauge reading is 800 mm of mercury, find the rate of flow in litre/s.	7	CO3	L3
31	A pitot-static tube of co-efficient of velocity 0.97 is connected to an inverted U-tube manometer containing an oil of specific gravity 0.82. If the pitot tube is to measure the velocity of water upto 0.6 m/s; what would be the largest manometer reading?	7	CO3	L3
32	A pitot tube is inserted in a pipe of 30 cm diameter. The static pressure of the tube is 10 cm of mercury vacuum. The stagnation pressure at the centre of the pipe recorded by the pitot-tube is 1 N/cm2. Calculate the rate of flow of water through the pipe, if the mean velocity of flow is 0.85 times the central velocity. Assume co-efficient of the pitot-tube is 0.98.	7	CO3	L3
33	What is a notch? How are the notches classified?	7	CO3	L2
34	What is a weir? How are the weirs classified?	7	CO3	L2
35	215 litres/sec of gasoline of specific gravity 0.82 flows upwards in an inclined venturimeter fitted to a 300 mm diameter pipe. The venturimeter is inclined at 60° to the vertical and its 150 mm diameter throat is 1.2 m from the entrance along its length. Pressure gauges inserted at entrance and throat show pressures 0.141 N/mm2 and 0.077 N/mm2 respectively. Calculate the discharge co-efficient of venturimeter. If instead of pressure gauges the entrance and throat of the venturimeter are connected to the two limbs of a U-tube mercury manometer, determine its reading in mm of differential mercury column.	10	CO3	L3
36	A 1 m3 rigid tank initially contains air whose density is 1.18 kg/m3. The tank is connected to a high pressure supply line through a valve. The valve is opened and air is allowed to enter the tank until the density in the tank rises to 7.20 kg/m3. Determine the mass of air that has entered the tank.	10	CO3	L2
37	A pressurized tank of water has a 10 cm diameter orifice at the bottom where water discharges to the atmosphere. The water level is 3 m above the outlet. The tank air pressure above the water level is 300 kPa (absolute) while the atmospheric pressure is 100 kPa. Neglecting	10	CO3	L2

	frictional effects, determine the initial discharge rate of water from the tank.			
38	A pitot tube is inserted in an air flow to measure the flow speed. The tube is inserted so that it points upstream into the flow and the pressure sensed by the tube is the stagnation pressure. The static pressure is measured at the same location in the flow using a wall pressure tap. If the pressure difference is 42 mm of mercury, determine the flow speed.	14	CO3	L3
39	Air enters a nozzle steadily at 2.5 kg/m^3 and 28 m/s and leaves at 0.81 kg/m^3 and 178 m/s. If the inlet area of the nozzle is 80 cm2, determine (a) the mass flow rate through the nozzle and (b) the exit area of the nozzle.	14	CO3	L2
Module 4				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	Explain "Moody's Chart". What is its use in pipe flow?	3	CO4	L1
2	How is the friction co-efficient, (f) dependent on Reynold's number?	3	CO4	L2
3	Someone claims that the shear stress at the centre of a circular pipe during fully developed laminar flow is zero. Do you agree with this claim? Explain.	3	CO4	L3
4	Explain why the friction factor is independent of the Reynolds number at very large Reynolds numbers.	3	CO4	L3
5	Consider the flow of air and water in pipes of same diameter at the same temperature and at the same mean velocity. Which flow is more likely to be turbulent? Why?	4	CO4	L2
6	Obtain the condition for maximum power transmission through pipes and corresponding efficiency of transmission.	5	CO4	L3
7	An oil of specific gravity 0.9 and viscosity 10 poise is flowing through a pipe of diameter 110 mm. The velocity at the centre is 2 m/s, find : (i) the pressure gradient in the direction of flow (ii) shear stress at the pipe wall; (iii) Reynold's number; and (iv) velocity at a distance 30 mm from the wall.	5	CO4	L2
8	Find the head loss due to friction in a pipe of diameter 250mm and length 60m, through which water is flowing at a velocity of 3m/s, using (i) Darcy's formula and (ii) Chezy's formula for which C = 55 and kinematic viscosity = 0.1 stoke.	5	CO4	L2

9	Explain the principle of venturi meter with a neat sketch and establish an expression for the rate of flow through it.	5	CO4	L2
10	Explain briefly major and minor losses in pipe lines.	5	CO4	L1
11	Define hydraulic gradient and total energy line. Explain its significance in fluid mechanics.	5	CO4	L2
12	Glycerine flows at a velocity of 5m/s in a 10cm diameter pipe. Dynamic viscosity and density of glycerine is assumed as 1.50Pa.s and 1260kg/m3 respectively. Estimate: i) The boundary shear stress in the pipe due to the flow. ii) Head loss in a length of 10m of pipe. iii) Power developed by the flow in a distance of 10m.	5	CO4	L3
13	Derive Darcy- Weisbach equation.	5	CO4	L2
14	Differentiate between laminar and turbulent flows.	5	CO4	L2
15	A crude oil of viscosity 0.97 poise and relative density 0.9 is flowing through a horizontal circular pipe of diameter 100mm and of length 15m. Calculate the difference of pressure at the two ends of the pipe, if 100kg of oil is collected in a tank in 25 seconds.	5	CO4	L2
16	Explain the phenomenon of water hammer. Obtain an expression for the rise of pressure, when the flowing water in a rigid pipe is brought to rest by closing the valve gradually.	5	CO4	L2
17	What is a Syphon? On what principle it works?	5	CO4	L1
18	What do you mean by equivalent pipe? Obtain an expression for equivalent pipe.	5	CO4	L2
19	Find an expression for the power transmission through pipes and efficiency of transmission.	5	CO4	L2
20	How is the friction co-efficient, (f) dependent on Reynold's number?	5	CO4	L2
21	What are minor energy losses in pipe? What are they due to? Can they be eliminated or reduced?	5	CO4	L2
22	Establish a relationship between Darcy's friction co-efficient and Reynolds number for a laminar flow through a circular pipe.	5	CO4	L2
23	An existing compound piping system to transport water from one station to another station consists of 1800 m of 50 cm, 1200 m of 40 cm and 600 m of 30 cm diameter pipes of same material connected in series. It is decided to change these existing pipes with new pipes of uniform	7	CO4	L2

	diameter. Calculate diameter of new pipes to be used so as maintain same discharge and loss of head as in previous situation.			
24	Derive Chezy's formula for loss of head due to friction in a circular pipe.	7	CO4	L2
25	Two pipes each of length L and diameters D1 and D2 are arranged in parallel. The loss of head when a total quantity of Q flows through them being h1. If the pipes are arranged in series and the same quantity of water, Q flows through them, the loss of head is h2. If D1 = 2D2, find the ratio of h1 and h2. Neglect minor losses and friction co-efficient, f to be constant.	7	CO4	L2
26	A fire engine supplies water to a hosepipe, 75 m long and 75 mm in diameter at a pressure of 294.3 kN/m2 (Gauge). The discharge end of the hosepipe has a nozzle of diameter, d, fixed to it. Taking friction factor, 4f = 0.032, determine the diameter of the nozzle, so that the momentum of the issuing jet may be maximum.	7	CO4	L2
27	Two reservoirs with a difference in water surface elevation of 10 m are connected by a pipeline ABC which consists of two pipes of AB and BC joined in series. Pipe AB is 10 cm in diameter, 20 m long and has a value of friction co-efficient, f=0.005, pipe BC is 16 cm diameter, 25 m long and has f = 0.0045. The junctions with the reservoirs and between the pipes are abrupt. (a) Calculate the discharge. (b) What difference in reservoir elevations is necessary to have a discharge of 15 litre/s. Consider all minor losses.	7	CO4	L3
28	A pipe ABC connecting two reservoirs is 80 mm in diameter. From A to B the pipe is horizontal and from B to C it falls by 3.5 metres. The length AB and BC are 25 m and 15m respectively. If the water surface in the reservoir A is 4 m above the centre line of the pipe and at C 1 m above the centre line of the pipe. Calculate the quantity of flow and also the pressure head in the pipe at B. Neglect the loss at the bend, but consider all other minor losses. Take friction co-efficient, f = 0.024 and $K_{entrance}$ = 0.5. Draw the total energy and hydraulic gradient lines.	7	CO4	L2
29	Give a proof of Hagen-Poiseuillie equation for fully developed laminar flow in a circular pipe.	7	CO4	L2
30	Prove that for a steady laminar flow between two horizontal fixed parallel plates, the velocity distribution is parabolic.	7	CO4	L2
31	Derive an expression for head loss due to viscous resistance in a laminar flow between two horizontal fixed parallel plates.	7	CO4	L2

32	The rate of flow of water through a horizontal pipe is 300 litre/s. The diameter of the pipe is suddenly enlarged from 250 mm to 500 mm. The pressure intensity in the smaller pipe is 13.734 N/cm2. Determine (i) Loss of head due to sudden enlargement (ii) Pressure intensity in the large pipe (iii) Power lost due to enlargement.	7	CO4	L3
33	In a pipe of diameter 200 mm and length 500 m an oil of specific gravity 0.9 and viscosity 0.06 poise is flowing at the rate of 0.06 m3/s. Find (i) Head lost due to friction. (ii) Power required to maintain the flow.	7	CO4	L2
34	A straight 25 cm diameter pipeline 5 km long is laid between two reservoirs having a difference in level of 40 m. To increase the capacity of the system an additional 2.5 km long 25 cm diameter pipe is laid parallel from the first reservoir to the midpoint of the original pipe. Assuming friction factor, 4f = 0.025 for both the pipes, find the increase in discharge due to installation of the new pipe.	7	CO4	L3
35	Consider fully developed laminar flow in a circular pipe. If the diameter of the pipe is reduced by half while the flow rate and the pipe length are held constant, the head loss will (a) double (b) triple (c) quadruple (d) increase by a factor of 8 or (e) increase by a factor of 16. Explain.	10	CO4	L2
36	Water at 10°C (Density= 999.7 kg/m^3 and dynamic viscosity=1.307x10-3 Ns/m2) is flowing steadily in a 0.20 cm diameter, 15 m long pipe at an average velocity of 1.2 m/s. Determine (a) the pressure drop, (b) head loss and (c) the pumping power requirement to overcome this pressure drop	10	CO4	L3
37	Water at 30°C (Density = 990 kg/m^3 and dynamic viscosity = 8.9 x10^{-4} Pas) is flowing through a 6 mm diameter 1 m long horizontal pipe steadily at an average velocity of 1 m/s. Determine (a) the head loss (b) the pressure drop, and (c) the pumping power requirement to overcome this pressure drop.	14	CO4	L3
38	(a) Explain why the friction factor is independent of the Reynolds number at very large Reynolds numbers. (b) Consider laminar flow in a circular pipe. Will the wall shear stress be higher near the inlet of the pipe or near the exit? Why?	14	CO4	L3

Module 5

Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	How will you determine whether a boundary layer flow is attached flow, detached flow or on the verge of separation.	3	CO5	L2
2	What do you mean by repeating variables? How repeating variables are selected for dimensional analysis.	3	CO6	L1

3	Explain: i) Geometric similarity ii) Kinematic similarity iii) Dynamic similarity.	3	CO6	L1
4	Consider laminar flow over a flat plate. How does the local friction coefficient change with position?	3	CO5	L2
5	What is the primary reason for nondimensionalizing an equation?	3	CO6	L2
6	Define boundary layer thickness, momentum thickness and displacement thickness.	3	CO5	L1
7	What do you understand by boundary layer? Illustrate with reference to flow over flat plate.	7	CO5	L2
8	Define the following i. Laminar Boundary Layer ii. Turbulent boundary Layer iii. Laminar Sub Layer iv. Boundary Layer Thickness	7	CO5	L2
9	Air flows over a flat plate of 1 m x 1m at a velocity of 6 m/s. Determine (a) Boundary layer thickness at the end of the plate (b) Shear stress at the middle of the plate (c) Total drag per unit length on the sides of the plate.	7	CO5	L2
10	A thin plate is moving in still atmospheric air at a velocity of 5m/s. The length of the plate is 0.6m and width 0.5m. Calculate (i) Thickness of the boundary layer at the end of the plate and (ii) drag force on one side of the plate. Take density of air as 1.25kg/m^3 and kinematic viscosity 0.15 stokes.	7	CO5	L2
11	Find the ratio of displacement thickness to momentum thickness and momentum thickness to energy thickness for the velocity distribution in the boundary layer is given by $\frac{u}{U} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$	7	CO5	L3
12	Define momentum thickness. Derive an expression for momentum thickness.	7	CO5	L2
13	Explain the following: Displacement thickness, Momentum thickness, Energy thickness, Separation of boundary layer with figure.	7	CO5	L2
14	Draw a neat diagram and explain the concept of boundary layer development along a long thin plate. Describe the details of various regions in the boundary layer.	7	CO5	L2
15	For the velocity profile for laminar boundary layer $\frac{u}{U} = 2\left(\frac{y}{\delta}\right) - 2\left(\frac{y}{\delta}\right)^3 + \left(\frac{y}{\delta}\right)^4$ obtain an expression for boundary layer thickness, shear stress, drag force on one side of the plate and coefficient of drag in terms of Reynolds number.	7	CO5	L3
16	Describe the methods of preventing the separation of boundary layer.	7	CO5	L3
17	Derive an expression for i) displacement thickness and ii) momentum thickness.	7	CO5	L2
18	Obtain Von – Karman momentum integral equation from conservation principles.	7	CO5	L3
19	Determine the displacement thickness, momentum thickness and energy thickness in terms of normal boundary layer thickness δ in respect of the following velocity profile in the boundary layer on a flat plate $\frac{u}{U} =$	7	CO5	L3

	$2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$ where u is the velocity at height y above plate surface and U is the free stream velocity.			
20	For the velocity profile in laminar boundary layer is given as $\frac{u}{U} = \frac{3}{2}\left(\frac{y}{\delta}\right) - \frac{1}{2}\left(\frac{y}{\delta}\right)^3$ where u = velocity in boundary layer at a distance y, U = Free stream velocity and δ = Boundary layer thickness. Find the thickness of the boundary layer and shear stress 1.8m from the leading edge of a plate. The plate is 2.5m long and 1.5m wide and is placed in water and which is moving with a velocity of 12cm/s. Find the drag on one side of the plate. Viscosity of water = 0.01 poise.	7	CO5	L3
21	For the velocity profile in a laminar flow $\frac{u}{U} = \sin(\frac{\pi}{2}\frac{y}{\delta})$. Obtain the expression for boundary layer thickness, shear stress, drag force on one side of the plate and coefficient of drag in terms of Reynolds number.	7	CO5	L3
22	Write a short note on boundary layer separation and discuss any two methods to control the same.	7	CO5	L2
23				
24	Find the displacement thickness, momentum thickness and energy thickness for velocity distribution in boundary layer given by $\frac{u}{U} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$	7	CO5	L3
25	A thin plate is moving in still atmospheric air at a velocity of 4m/s. The length of the plate is 0.5 m and width 0.4 m. Calculate the (a) Thickness of the boundary layer at the end of the plate and (b) Drag force on one side of the plate. Take density of air as 1.25 kg/m^3 and kinematic viscosity 0.15 stokes.	7	CO5	L3
26	A 2.5m ship model was tested in fresh water (ρ=1000kg/m3) and measurements indicated that there was a resistance of 45N when the model was moved at 2m/s. Work out the velocity of 40m prototype. Also calculate the force required to drive the prototype at this speed through sea water (ρ =1025kg/m3).	7	CO5	L3
27	A 2.5m ship model was tested in fresh water (ρ =1000 kg/m^3) and measurements indicated that there was a resistance of 45 N when the model was moved at 2 m/s. Workout the velocity of 40m prototype. Also calculate the force required to drive the prototype at this speed through sea water (ρ =1025 kg/m^3).	7	CO6	L3
28	A 1:10 scale model of a passenger car is tested in a wind tunnel. The prototype velocity is 40Kmph. If the model drag is 350N, what is the drag and the power required to overcome the drag in the prototype. Assuming the air in the model and prototype has same properties.	7	CO6	L3
29	The pressure difference ΔP in a pipe of diameter D and length L due to turbulent flow depends on the velocity v, viscosity μ, density ρ and roughness k. Using Buckingham's π theorem, obtain an expression for ΔP	7	CO6	L3
30	Define the following dimensionless numbers: Reynold's number, Froude's number and Mach's number. Mention its applications in fluid flow problems.	7	CO6	L1

31	State Buckingham's π theorem and mention the conditions for selecting repeating variables.	7	CO6	L2
32	A model test is to be conducted in a water tunnel using a 1:20 model of a submarine which is used to travel at a speed of 12 km=h deep under the sea. The water temperature in the tunnel is so maintained that its kinematic viscosity is half as that of the sea water. At what speed the model test is to be conducted.	7	CO6	L3
33	The resistance R to the motion of completely submerged body depends upon the length of the body L, velocity of flow V, mass density of fluid ρ and kinematic viscosity of fluid υ. By dimensional analysis prove that $R = \rho V^2 L^2 \Phi(\frac{VL}{\upsilon})$.	7	CO6	L3
34	Explain the different types of hydraulic similarities that must exist between a prototype and its model.	7	CO6	L1
35	The pressure drop ΔP in a pipe of diameter D, length L, due to turbulent flow depends on mass density ρ and viscosity μ of the flowing fluid, mean velocity of flow V and average height K of roughness projections on the pipe surface. Obtain a dimensionless expression for ΔP by Buckingham's π theorem. Hence show that hf = $4fLV^2/2dg$.	7	CO6	L3
36	An underwater device is 1.5m long and is to move at 3.5 m/s speed. A geometrically similar model 30 cm long is tested in a variable pressure wind tunnel at a speed of 35m/s. Calculate the pressure of air in the model if the model experience a drag force of 40 N, calculate the prototype drag force. [Assume density of water = 998 kg/m^3, density of air at standard atmospheric pressure = 1.17 kg/m^3, dynamic viscosity of air at local atmospheric pressure = $1.95*10^{-5}$ Pas and dynamic viscosity of water = $1 * 10^{-3}$ Pas]	7	CO6	L3
37	State Buckingham's - π theorem. Explain dimensional homogeneity with the help of an example	7	CO6	L2
38	Define and explain the following dimensionless numbers with their applications. Froude number, Euler's Number, Reynold's number, Weber's number and Mach number	7	CO6	L1
39	The variables controlling the motion of a floating vessel (ship) through water are the drag force F, the speed V, the length L, dynamic viscosity μ, the density ρ and acceleration due to gravity g. Derive an expression for drag force F by dimensional analysis. Hence show that the drag force is a function of Reynold's number and Froude number.	7	CO6	L3
40	Explain different laws on which models are designed for dynamic similarity.	7	CO6	L1
41	The velocity distribution in a laminar boundary layer is given by $\frac{u}{U} = \frac{3}{2}\left(\frac{y}{\delta}\right) - \frac{1}{2}\left(\frac{y}{\delta}\right)^2$. Calculate the displacement thickness and momentum thickness.	7	CO6	L3
42	Water tunnel operates with a velocity of 3m/s at the test section and power required was 3.75kW. If the tunnel is to operate with air, determine for similitude the flow velocity and power required.	7	CO6	L3

43	For each statement, choose whether it is true or false and discuss your answer briefly. These statements concern a laminar boundary layer on a flat plate. 1. At a given x location, if the Reynolds number were to increase, the boundary layer thickness would also increase. 2. As outer flow velocity increases, so does the boundary layer thickness. 3. As the fluid viscosity increases, so does the boundary layer thickness? 4. As the fluid density increases, so does the boundary layer thickness?	7	CO5	L2
44	Write the primary dimensions of the universal ideal gas constant Ru. (Use the ideal gas law, $PV = nR_uT$, where P is pressure, V is volume, T is absolute temperature, and n is the number of moles of the gas.)	7	CO6	L3
45	The pressure drop Δp, for steady, incompressible viscous flow through a straight horizontal pipe depends on the pipe length l, the average velocity V, the fluid viscosity μ, the pipe diameter D, the fluid density ρ, and the average "roughness" height e. Determine a set of dimensionless groups that can be used to correlate data.	7	CO6	L3
46	The drag force F, on a smooth sphere depends on the relative speed V, the sphere diameter D, the fluid density ρ, and the fluid viscosity μ. Obtain a set of dimensionless groups that can be used to correlate experimental data.	14	CO6	L3
47	Consider two-dimensional laminar boundary-layer flow along a flat plate. Assume the velocity profile in the boundary layer is sinusoidal, Find expressions for : (a) The rate of growth δ, as a function of x. (b) The displacement thickness δ^*, as a function of x.	14	CO5	L3

Prepared By : Arun V, Course Faculty

Checked By : Asha K R, Subject Group Coordinator

Approved by : Dr. Ramadas T, HoD (ME)

Course Code & Name:	MET205 - Metallurgy & Material Science

1. Prescribed Syllabus

Module	Topic	Hours
1	Earlier and present development of atomic structure - Primary bonds: - characteristics of covalent, ionic and metallic bond - properties based on atomic bonding: - Secondary bonds: - classification, application. *(Brief review only)*. Crystallography: - SC, BCC, FCC, HCP structures, APF - theoretical density simple problems – Miller Indices: - crystal plane and direction - Modes of plastic deformation: - Slip and twinning - Schmid's law - Crystallization: Effects of grain size, Hall - Petch theory, simple problems.	9
2	Classification of crystal imperfections - forest of dislocation, role of surface defects on crack initiation- Burgers vector –Frank Read source - Correlation of dislocation density with strength and nano concept - high and low angle grain boundaries– driving force for grain growth and applications - Polishing and etching - X – ray diffraction, simple problems –SEM and TEM - Diffusion in solids, fick's laws, mechanisms, applications of diffusion in mechanical engineering, simple problems.	8
3	Phase diagrams: - need of alloying - classification of alloys - Hume Rothery`s rule – equilibrium diagram of common types of binary systems: five types - Coring - lever rule and Gibb`s phase rule - Reactions- Detailed discussion on Iron-Carbon equilibrium diagram with microstructure and properties -Heat treatment: - TTT, CCT diagram, applications - Tempering- Hardenability, Jominy end quench test, applications- Surface hardening methods.	9
4	Strengthening mechanisms - cold and hot working - alloy steels: how alloying elements affecting properties of steel - nickel steels - chromium steels - high speed steels -cast irons - principal non ferrous alloys	9

5	Fatigue: - creep -DBTT - super plasticity - need, properties and applications of composites, super alloy, intermetallics, maraging steel, Titanium - Ceramics:- structures, applications.	10

2. Text Books (T)

T1. Callister William. D., Material Science and Engineering, John Wiley, 2014

T2. Higgins R.A. - Engineering Metallurgy part - I – ELBS,1998

T3. Metallurgy and Material Science, Dr. S. Jose & Dr. E. V. Mathew, Pentagon Educational Services

3. Reference Books (R)

R1. Avner H Sidney, Introduction to Physical Metallurgy, Tata McGraw Hill,2009

R2. Anderson J.C. *et.al*., Material Science for Engineers, Chapman and Hall,1990

R3. Clark and Varney, Physical metallurgy for Engineers, Van Nostrand,1964

R4. Dieter George E, Mechanical Metallurgy, Tata McGraw Hill, 1976

R5. Raghavan V, Material Science and Engineering, Prentice Hall,2004

R6. Reed Hill E. Robert, Physical metallurgy principles, 4th edition, Cengage Learning,2009

R7. Myers Marc and Krishna Kumar Chawla, Mechanical behavior of materials, Cambridge University press,2008

R8. Van Vlack -Elements of Material Science - Addison Wesley,1989

R9. https://nptel.ac.in/courses/113/106/113106032

4. Course Objectives

- Understanding of the correlation between the chemical bonds and crystal structure of metallic materials to their mechanical properties.
- Recognize the importance of crystal imperfections including dislocations in plastic deformation.Fe-C alloys.
- Examine the mechanisms of materials failure through fatigue and creep.
- To determine properties of unknown materials and develop an awareness to apply this knowledge in material design

5. Course Pre / Co-requisite

PHT110 Engineering Physics

CYT100 Engineering Chemistry

6. Course Outcomes

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

CO1: Understand the basic chemical bonds, crystal structures (BCC, FCC, and HCP), and their relationship with the properties.

CO2: Analyze the microstructure of metallic materials using phase diagrams and modify the microstructure and properties using different heat treatments.

CO3: Quantify mechanical integrity and failure in materials.

CO4: Apply the basic principles of ferrous and non-ferrous metallurgy for selecting materials for specific applications.

CO5: Define and differentiate engineering materials on the basis of structure and properties for engineering applications.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO1	H												L		
CO2		H											H		M
CO3				M											H
CO4					H								H		H
CO5												M	H		H

8. Justification for CO-PO-PSO Correlation

CO1	**PO1**:	Knowledge of different chemical bonds, crystal structure and their relationship with the properties makes the student capable of selecting a material for a particular application. High correlation is due to the fact that the in-depth knowledge of atomic structure and their relationship with the properties enables students to find solution to complex engineering problems.
	PSO1:	The student will get a basic idea of manipulating the chemical bond or the crystal structure of a material to make it eligible for using in a particular application in a sustainable way. Low correlation is due to the fact this involves basic knowledge of concurrent technologies to solve practical problems in a sustainable way.
CO2	**PO2**:	Analytical knowledge of various microstructure modification will empower the student to improve the properties of the material which thus solve various complex engineering practical problems. High correlation is due to the fact that this involves deep knowledge of engineering sciences.
	PSO1:	The student will be able to use material which do not affect the environment adversely, by improving its properties. High correlation is

		due to the fact that sustainable development can be achieved by using concurrent technologies.
	PSO3:	By gaining knowledge students will be able to design and analyse multi-disciplinary systems by modification of the microstructure and properties using different heat treatments. Medium correlation is due to the fact that this involves standard knowledge of different heat treatment processes to analyse multi-disciplinary systems.
CO3	**PO4**:	Students will be able to quantify mechanical integrity and failure in materials, and analyse, interpret and systematize the information to provide valid conclusions. High Correlation is due to the fact that this involves in-depth knowledge of experiments, analysis and interpretation of data of mechanical integrity and failure in materials and synthesis of the information to provide valid conclusions.
	PSO3:	By quantifying mechanical integrity and failure, students will be able to design and analyse multi-disciplinary systems by analysis and interpretation of data of various materials. High correlation is due to the fact that this involves deep knowledge of experiments, analysis and interpretation of data of mechanical integrity and failure in materials to design and analyse multi-disciplinary systems.
CO4	**PO5**:	By the knowledge of the basic principles of ferrous and non-ferrous metallurgy, the student will be able to predict and model complex engineering activities, like predicting the conditions were the material may fail. High correlation is due to the fact that this involves in depth knowledge of the principles of metallurgy to select materials for different applications with an understanding of the limitations.
	PSO1:	By applying the principles of ferrous and non-ferrous metallurgy the student will be able to solve the practical problems by selecting materials for a particular application in with an eye on sustainable development. High correlation is due to the fact that this involves in depth knowledge of the principles of metallurgy to select materials for different applications with an eye on sustainable development.
	PSO3:	By gaining knowledge of principles of metallurgy, students will be able to design and analyse multi-disciplinary systems. High correlation is due to the fact that this involves in depth knowledge of the principles of metallurgy for design and analysis of multi-disciplinary systems.
CO5	**PO12:**	By defining and differentiating engineering materials on the basis of structure and properties the student will realize and recognize the need for lifelong learning as new materials are made by manipulating the microstructures of already existing materials. Medium correlation is due to the fact that this involves standard knowledge of engineering materials to engage in independent and life-long learning in the broadest context of technological change.

	PSO1:	Using the knowledge of structure and properties of engineering materials, the student will be able to choose the right materials for a particular practical problem with an eye on sustainable development. High correlation is due to the fact that this involves in-depth knowledge of engineering materials to solve the practical problems using the principles of sustainable development.
	PSO3:	By gaining knowledge of engineering materials students will be able to design and analyse multi-disciplinary systems by determining the efficiency and characteristics curve of pumps and turbines. High correlation is due to the fact that this involves in-depth knowledge of engineering materials to to design and analyze multi-disciplinary systems.

9. Curricular gaps

Introduction into Nano-materials and Nano Technology.

10. Course Enrichment Activities

Sl No	Description	Proposed Activities	Relevance to POs and PSOs
1	Composite Manufacturing	Seminars and Notes	PO1
2	Introduction to Nano Technology	NPTEL Videos: https://nptel.ac.in/courses/118102003	PO1, PO5

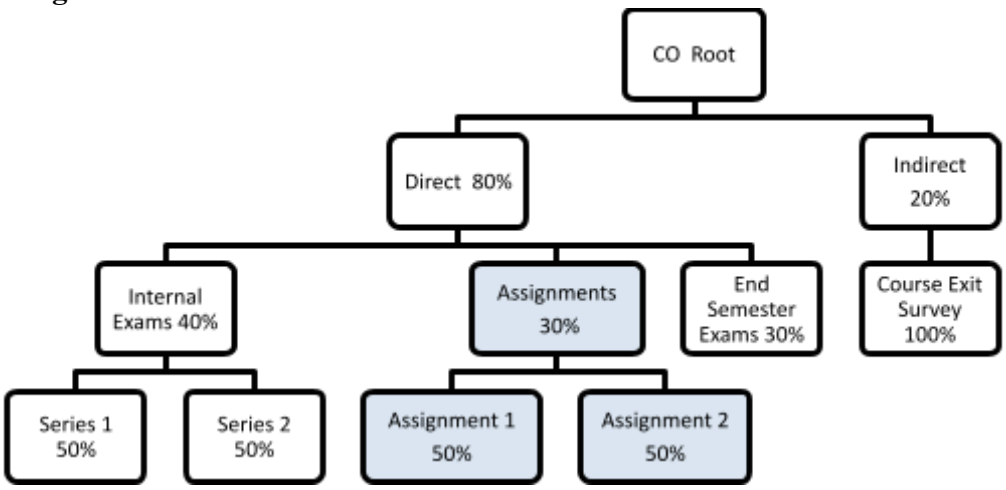
11. Internal Assessment mark allocation (as per university curriculum)

Attendance	- 10 marks
Continuous assessment test	- 25 marks
Assignments	- 15 marks
Total	- 50 marks

12. Assessment – CO Mapping

	Tools		Weightage	CO 1	CO 2	CO 3	CO 4	CO 5
Direct Assessment Tools	Internal Exam(s) 40%	Series 1	50%	x	x			
		Series 2	50%			x	x	x
	Assignment(s) 30%	Assignment 1	50%	x				
		Assignment 2	50%			x	x	
	End Semester Exam 30%		100%	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hour	Topic Name	Module	Reference	Teaching Pedagogy
1	Earlier and present development of atomic structure; attributes of ionization energy and conductivity, electronegativity; correlation of atomic radius to strength; electron configurations; - Primary bonds: - characteristics of covalent, ionic and metallic bond: attributes of bond energy, cohesive fo	1	T1, T2, T3	Lecture
2	properties based on atomic bonding:- attributes of deeper energy well and shallow energy well to melting temperature, coefficient of thermal expansion - attributes of modulus of elasticity in metal cutting process -Secondary bonds:- classification- hydrogen bond and anomalous behavior of ice float	1	T1, T2, T3	Lecture
3	Crystallography:- Crystal, space lattice, unit cell- SC, BCC- atomic packing factor - short and long range order - effects of crystalline and amorphous structure on mechanical properties.	1	T1, T2, T3	Tutorial
4	Crystallography:- Crystal, space lattice, unit cell- FCC, atomic packing factor and HCP structures	1	T1, T2, T3	Tutorial
5	Coordination number and radius ratio; theoretical density; simple problems - Polymorphism and allotropy.	1	T1, T2, T3	Lecture

6	Miller Indices: - crystal plane and direction - Attributes of miller indices for slip system, brittleness of BCC, HCP and ductility of FCC - Modes of plastic deformation: - Slip and twinning	1	T1, T2, T3	Tutorial
7	Schmid's law, equation, critical resolved shear stress, correlation of slip system with plastic deformation in metals and applications.	1	T1, T2, T3	Lecture
8	Mechanism of crystallization: Homogeneous and heterogeneous nuclei formation, under cooling, dendritic growth, grain boundary irregularity - Effects of grain size, grain size distribution, grain shape, grain orientation on dislocation/strength and creep resistance	1	T1, T2, T3	Lecture
9	Hall - Petch theory, simple problems.	1	T1, T2, T3	Tutorial
10	Classification of crystal imperfections: - types of point and dislocations	2	T1, T2, T3	Tutorial
11	Effect of point defects on mechanical properties - forest of dislocation, role of surface defects on crack initiation - Burgers vector.	2	T1, T2, T3	Tutorial
12	Dislocation source, significance of Frank-Read source in metals deformation	2	T1, T2, T3	Tutorial
13	Correlation of dislocation density with strength and nano concept,	2	T1, T2, T3	Lecture
14	Significance high and low angle grain boundaries on dislocation â€“ driving force for grain growth and applications during heat treatment.	2	T1, T2, T3	Lecture
15	Polishing and etching to determine the microstructure and grain size- Fundamentals and crystal structure determination by X - ray diffraction,	2	T1, T2, T3	Lecture
16	simple problems - SEM and TEM.	2	T1, T2, T3	Tutorial
17	Diffusion in solids, fick’s laws, mechanisms, applications of diffusion in mechanical engineering, simple problems.	2	T1, T2, T3	Lecture
18	Phase diagrams: - Limitations of pure metals and need of alloying - classification of alloys, solid solutions	3	T1, T2, T3	Tutorial

19	Hume Rothery`s rule - equilibrium diagram of common types of binary systems: five types.	3	T1, T2, T3	Lecture
20	Coring - lever rule and Gibb`s phase rule - Reactions: - monotectic, eutectic, eutectoid, peritectic, peritectoid.	3	T1, T2, T3	Lecture
21	Detailed discussion on Iron-Carbon equilibrium diagram with microstructure and properties changes in austenite, ledeburite, ferrite, cementite, special features of martensite transformation, bainite, spheroidite etc.	3	T1, T2, T3	Lecture
22	Heat treatment: - Definition and necessity of TTT for a eutectoid iron carbon alloy, CCT diagram	3	T1, T2, T3	Lecture
23	applications - annealing, normalizing, hardening, spheroidizing.	3	T1, T2, T3	Lecture
24	Tempering:- austermpering, martempering and ausforming - Comparative study on ductility and strength with structure of pearlite, bainite, spherodite, martensite, tempered martensite and ausforming.	3	T1, T2, T3	Lecture
25	Hardenability, Jominy end quench test, applications- Surface hardening methods:- no change in surface composition methods :- Flame, induction, laser and electron beam hardening processes-	3	T1, T2, T3	Lecture
26	change in surface composition methods :carburizing and Nitriding; applications.	3	T1, T2, T3	Lecture
27	Cold working: Detailed discussion on strain hardening; recovery; recrystallization, effect of stored energy; re-crystallization temperature - hot working, Bauschinger effect and attributes in metal forming.	4	T1, T2, T3	Lecture
28	Alloy steels:- Effects of alloying elements on steel: dislocation movement, polymorphic transformation temperature, alpha and beta stabilizers, formation and stability of carbides, grain growth, displacement of the eutectoid point, retardation of the transformation rates, improvement in corrosion re	4	T1, T2, T3	Lecture
29	Nickel steels, Chromium steels etc. â€“ change of steel properties by adding alloying elements: - Molybdenum, Nickel, Chromium, Vanadium, Tungsten, Cobalt, Silicon, Copper and Lead - High speed steels	4	T1, T2, T3	Lecture

30	Cast irons: Classifications; grey, white, malleable and spheroidal graphite cast iron etc, composition, microstructure, properties and applications	4	T1, T2, T3	Lecture
31	Principal Non ferrous Alloys: - Aluminum, Copper, Magnesium, Nickel	4	T1, T2, T3	Lecture
32	study of composition, properties, applications, reference shall be made to the phase diagrams whenever necessary.	4	T1, T2, T3	Lecture
33	Fatigue: - Stress cycles â€“ Primary and secondary stress raisers - Characteristics of fatigue failure, fatigue tests, S-N curve.	4	T1, T2, T3	Tutorial
34	Factors affecting fatigue strength: stress concentration, size effect, surface roughness, change in surface properties, surface residual stress	4	T1, T2, T3	Lecture
35	Ways to improve fatigue life â€“ effect of temperature on fatigue, thermal fatigue and its applications in metal cutting.	4	T1, T2, T3	Lecture
36	Fracture: â€“ Brittle and ductile fracture â€“ Griffith theory of brittle fracture & Stress concentration, stress raiser â€“ Effect of plastic deformation on crack propagation - transgranular, intergranular fracture	5	T1, T2, T3	Lecture
37	Effect of impact loading on ductile material and its application in forging, applications - Mechanism of fatigue failure.	5	T1, T2, T3	Lecture
38	Structural features of fatigue: - crack initiation, growth, propagation - Fracture toughness (definition only), applications - Ductile to brittle transition temperature (DBTT) in steels and structural changes during DBTT, applications	5	T1, T2, T3	Lecture
39	Creep: - Creep curves & creep tests - Structural change:- deformation by slip, sub-grain formation, grain boundary sliding - Mechanism of creep deformation - threshold for creep, prevention against creep	5	T1, T2, T3	Lecture
40	Super plasticity: need and applications	5	T1, T2, T3	Lecture
41	Composites: - Need of development of composites; fiber phase; matrix phase	5	T1, T2, T3	Lecture
42	only need and characteristics of PMC, MMC, and CMC.	5	T1, T2, T3	Lecture

43	Modern engineering materials: - only fundamentals, need, properties and applications of, intermetallics, maraging steel, super alloys	5	T1, T2, T3	Lecture
44	Titanium- Ceramics:-coordination number and radius ratios	5	T1, T2, T3	Lecture
45	AX, AmXp, AmBmXp type structures & applications.	5	T1, T2, T3	Lecture

15. Course Bank

Module 1				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	Classify materials based on the type of bonding. List their properties.	**3**	**CO1**	**1**
2	Define allotropy and give two examples	**3**	**CO1**	**1**
3	Define elasticity	**3**	**CO1**	**1**
4	Define interstitialcy	**3**	**CO1**	**1**
5	Define plastic deformation	**3**	**CO1**	**1**
6	Define space lattice	**3**	**CO1**	**1**
7	Define the lattice parameters of a unit cell	**3**	**CO1**	**1**
8	Define the terms lattice, unit cell and crystal structure	**3**	**CO1**	**1**
9	Define the terms space lattice and unit cell.	**3**	**CO1**	**1**
10	Define visco elasticity and anelastic behaviour.	**3**	**CO1**	**1**
11	Differentiate between the HCP structure and FCC structure	**3**	**CO1**	**1**
12	Explain with sketch “grain boundaries”	**3**	**CO1**	**1**
13	Give a suitable classification of engineering materials.	**3**	**CO1**	**1**
14	Give the Hall-Petch equation	**3**	**CO1**	**1**
15	List out the common properties of metallic materials	**3**	**CO1**	**1**
16	List out the general considerations for selection of materials	**3**	**CO1**	**1**
17	Differentiate between microstructure and electronic structure of a material?	**3**	**CO1**	**1**
18	Draw the following: SC, BCC and FCC structures. Find out the effective number of atoms and the co-ordination number for the above	**3**	**CO1**	**2**
19	Copper having FCC Crystal structure. Determine its density if the atomic weight is 63.54 and atomic radius is 1.278 A	**3**	**CO1**	**2**
20	Explain Schmidt’s law. Derive an expression for critical resolved shear stress.	**3**	**CO1**	**2**
21	Define polymorphism and allotropy. Briefly discuss with examples.	**5**	**CO1**	**1**

22	Compare the differences between elastic deformation and plastic deformation. Explain.	**5**	**CO1**	**1**
23	Obtain an expression for atomic radius in terms of lattice parameters for a BCC, FCC and SC Crystals	**5**	**CO1**	**2**
24	Calculate the atomic packing factor for BCC and FCC Crystals.	**5**	**CO1**	**2**
25	What is critical shear? Explain.			
26	What is meant by miller indices? Discuss the method of obtaining miller indices of a plane.	**6**	**CO1**	**1**
27	Define unit cell, space lattice, crystal system and bravaise lattice.	**6**	**CO1**	**1**
28	Name seven crystal systems and define them with reference to axial relationships and inter axial angles	**10**	**CO1**	**1**
29	What is meant by Miller indices? Discuss the method of obtaining Miller indices in a cubic crystal.	**10**	**CO1**	**3**
30	What are co-ordination number and atomic packing factor? Determine these for the simple cubic, B.C.C. and F.C.C crystals.	**10**	**CO1**	**3**
31	Strength of Titanium is found to be 448MPa when the grain size is 0.45x10-6m. Determine (a) the constants of the Hall-Petch equation and (b) the strength of Titanium when grain size is reduced to 0.2x10-6m.	**10**	**CO1**	**3**
32	Mark the following planes in a cubic crystal: (100), (110), (111), (121), (120).	**10**	**CO1**	**3**

Module 2

Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	Write a note on frank read source of dislocations and dislocation movement.	**3**	**CO2**	**1**
2	Define magnification. List the maximum magnification of optical and electron microscopes	**3**	**CO2**	**1**
3	List any three applications of diffusion	**3**	**CO2**	**1**
4	List the different types of line defects and briefly explain.	**3**	**CO2**	**1**
5	List the etchants used in optical microscope (at least two etchants) for (i) Steel, (ii) Aluminium,(iii) Copper, (iv) Stainless steels	**3**	**CO2**	**1**
6	List the need for specimen preparation for microscopic examination	**3**	**CO2**	**1**
7	List the types of surface defects observed in crystalline materials	**3**	**CO2**	**1**
8	With the help of a neat sketches explain edge dislocation and screw dislocations.	**5**	**CO2**	**2**
9	Distinguish between homogeneous and heterogeneous nucleation	**5**	**CO2**	**1**
10	Write a short note on grains, Grain boundary, Grain size and shape.	**5**	**CO2**	**1**
11	Define the following terms. Kirkendal effect, Diffusion flux, concentration gradient, Activation energy.	**5**	**CO2**	**1**

12	Write a note on various microscopes used in Metallography.	**5**	**CO2**	**1**
13	What are the various types of crystalline imperfections? Briefly explain each one of them.	**6**	**CO2**	**1**
14	What is diffusion? Give a detailed description of various mechanisms of diffusion with diagram.	**6**	**CO2**	**1**
15	Differentiate between Slip and Twinning	**6**	**CO2**	**1**
16	Write short notes on crystal defects.	**6**	**CO2**	**1**
17	Discuss importance of etching in metallography	**6**	**CO2**	**1**
16	Derive the expression for first and second law of diffusion	**6**	**CO2**	**2**
18	Define dislocation. Compare edge dislocation and screw dislocation	**8**	**CO2**	**1**
16	Explain the various steps for determining the microstructure of materials.	**8**	**CO2**	**1**

Module 3

Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	With a neat sketch explain the iron carbon equilibrium diagram and also give the equations for binary reactions depicted in it.	**5**	**CO3**	**2**
2	Explain Hume – Rothery's rule. What do you mean by Substitutional solid solution and interstitial solid solutions?	**5**	**CO3**	**2**
3	What is hardenability explain the Jominy end quench test.	**8**	**CO3**	**1**
4	Explain any two strengthening mechanisms.	**3**	**CO3**	**1**
5	With the help of a neat sketch explain copper – nickel phase diagram.	**3**	**CO3**	**1**
6	Write equations for the following invariant reactions with sketches eutectic, eutectoid, peritectic and peritectoid.	**5**	**CO3**	**1**
7	Draw a binary phase diagram between two components which are partially soluble in each other in solid state. Label all the phase fields.	**6**	**CO3**	**1**
8	Describe a TTT diagram and its uses.	**8**	**CO3**	**1**
9	Draw the continuous cooling transformation diagram for eutectoid steel and explain about its uses.	**7**	**CO3**	**1**
10	What are the surface treatments done on steels? Explain any two processes.	**4**	**CO3**	**1**

Module 4

Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	Discuss the composition, properties and applications of copper alloys.	**4**	**CO4**	**1**

2	Discuss recovery, Recrystallization and grain growth.	**5**	**CO4**	**1**
3	What is cast iron? Classify it briefly. Explain the microstructure and its uses.	**6**	**CO4**	**1**
4	Write briefly about properties and applications of any two aluminium alloys.	**5**	**CO4**	**1**
5	Discuss the effects of alloying elements on the microstructure and properties of steels.	**6**	**CO4**	**1**
6	Write a note on free cutting steel, HSLA steels, TMT steels and tool steels.	**5**	**CO4**	**2**
7	Give four major alloying element used in iron and their specific advantage and applications of alloy.	**5**	**CO4**	**2**
8	What are stainless steels? Name different types and discuss with reference to properties and applications.	**6**	**CO4**	**1**
9	With a neat sketch explain the procedure for fatigue testing and draw the S-N Curve. What is the significance of S-N Curve?	**6**	**CO4**	**1**
10	What are the various factors affecting fatigue and how we can protect against fatigue.	**5**	**CO4**	**1**

Module 5

Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	Explain the differences between ductile and brittle fracture with neat sketch.	**8**	**CO5**	**1**
2	Explain Griffith theory of fracture	**5**	**CO5**	**1**
3	What do you mean by super plasticity and its applications	**4**	**CO5**	**1**
4	Write a note on trans granular and inter granular fracture , DBTT.	**5**	**CO5**	**1**
5	What are the various stages of ductile fracture explain with neat sketch	**5**	**CO5**	**1**
6	Write a note on various methods of protection against fracture and modes of fracture	**5**	**CO5**	**1**
7	Draw the creep curve and explain the phenomenon occurring at each stage.	**5**	**CO5**	**2**
8	What are the different types of composites? Explain each type.	**5**	**CO5**	**1**
9	What is a ceramic? Give examples of ceramic used as engineering material.	**3**	**CO5**	**1**
10	Write a note on various smart materials used in industry.	**6**	**CO5**	**1**

11	Write a note on super alloys, intermetallic, maraging steels and nuclear materials	**6**	**CO5**	**1**
12	With neat sketch explain the methods of conducting a typical creep test	**6**	**CO5**	**1**
13	What are the various applications of composite material?	**6**	**CO5**	**1**

Prepared By : Prof. Kuriakose V Thundiyil

Checked By : Prof. Dr. Manoj Jose Kalathil, Subject Committee Coordinator

Approved By : Prof. Asha K R, HOD ME

Course Code & Name: EST 200 Design and Engineering

1. Prescribed Syllabus

Module	Topic	Hours
1	Design Process - Introduction to Design and Engineering Design, defining a design process - Detailing Customer Requirements, Setting Design Objectives, Identifying Constraints, Establishing Functions, Generating Design Alternatives and Choosing a Design.	5
2	Design Thinking Approach - Introduction to Design Thinking, Iterative Design Thinking Process Stages: Empathize, Define, Ideate, Prototype and Test. Design Thinking as Divergent-Convergent Questioning. Design Thinking in a Team Environment.	6
3	Design Communication (Languages of Engineering Design) - Communicating Designs Graphically, Communicating Designs Orally and in Writing. Mathematical Modeling in Design, Prototyping and Proofing the Design.	6
4	Design Engineering Concepts - Project-based Learning and Problem-based Learning in Design. Modular Design and Life Cycle Design Approaches. Application of Biomimicry, Aesthetics and Ergonomics in Design. Value Engineering, Concurrent Engineering, and Reverse Engineering in Design.	4
5	Expediency, Economics and Environment in Design Engineering - Design for Production, Use, and Sustainability. Engineering Economics in Design. Design Rights. Ethics in Design	4

2. Text Books (T)

T1. YousefHaik, Sangarappillai Sivaloganathan, Tamer M. Shahin, Engineering Design Process, Cengage Learning 2003, Third Edition, ISBN-10: 9781305253285,T2. Voland, G., Engineering by Design, Pearson India 2014, Second Edition, ISBN 9332535051

3. Reference Books (R)

R1. Philip Kosky, Robert Balmer, William Keat, George Wise, Exploring Engineering, Fourth Edition:
An Introduction to Engineering and Design, Academic Press 2015, 4th Edition.
R4. Pahl, G., Beitz, W., Feldhusen, J., Grote, K.-H., Engineering Design: A Systematic Approach, Springer 2007, Third Edition, ISBN 978-1-84628-319

4. Course Objectives

The purpose of this course is to

i) introduce the undergraduate engineering students the fundamental principles of design engineering,

ii) make them understand the steps involved in the design process and

iii) familiarize them with the basic tools used and approaches in design.

5. Course Pre / Co-requisite

Nil

6. Course Outcomes

On the successful completion of course, Students will be able to
CO1: Explain the different concepts and principals involved in design engineering.
CO2: Apply design thinking while learning and practicing engineering.
CO3: Develop innovative, reliable, sustainable and economically viable designs incorporating knowledge in engineering.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO 1	M	L					L			L					
CO 2		M				L		L				M			
CO 3			M			L	L		M	M		L			

9. Justification for CO-PO-PSO Correlation

CO	PO/PS	Justification
CO1	PO1	**Knowledge of the different concepts and principles involved in design engineering will help to solve complex engineering problems moderately.**
	PO2	**Understanding the different concepts and principles involved in design engineering will help to identify fairly engineering problems and develop appropriate solution.**
	PO7	**Knowledge of the different concepts and principles involved in design engineering will help to develop sustainable engineering solutions in minor level.**

	PO10	**Understanding the different concepts and principles involved in design**

		engineering will help to communicate fairly on complex engineering activities with the engineering community.
CO2	**PO2**	**Understanding the various aspects of design thinking will help to identify engineering problems and develop appropriate solution moderately.**
	PO6	**The various aspects of design thinking will help to assess societal, health, safety, legal, and cultural issues relevant to the professional engineering practice slighter level.**
	PO8	**The various aspects of design thinking will help to apply fair moral & ethical principles in professional engineering practice.**
	PO12	**Fundamental aspects of design thinking will help to engage in independent and life-long learning in the broadest context of technological change moderately.**
	PO3	**The basic idea of developing innovative, reliable, sustainable and economically viable designs will help to develop moderate suitable design solution giving appropriate consideration for public health, safety, and environment.**
	PO6	**Knowledge of developing innovative, reliable, sustainable and economically viable designs will help to assess fairly the societal, health, safety, legal, and cultural issues relevant to the professional engineering practice.**
	PO7	**Knowledge of developing innovative, reliable, sustainable and economically viable designs will help to develop minor sustainable engineering solutions.**
	PO9	**Basic understanding of developing innovative, reliable, sustainable and economically viable designs will help to function moderately as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.**

CO3	**PO10**	**Knowledge of developing innovative, reliable, sustainable and economically viable designs will help to communicate moderately on complex engineering activities with the engineering community.**
	PO12	**Basic understanding of developing innovative, reliable, sustainable and economically viable designs will help to slightly engage in independent and life- long learning in the broadest context of technological change.**

10. Curricular gaps (if any)

Nil

11. Course Enrichment Activities*

	Description	**Proposed Activities ****	**Relevance to POs and PSOs**
	Develop innovative, reliable, sustainable and economically viable designs for a product	**Poster competition – Design a product**	**PO1 PO2 PO3 PO4 PO9 PO7**

Sl No	**Description**	**Proposed Activities ****	**Relevance to POs and PSOs**
1	**Sustainable Engineering Concepts and Life Cycle Analysis**	**NPTEL COURSE By Prof. Brajesh Kumar Dubey | IIT Kharagpur**	**PO6, PO7, PO12**

**** Proposed Actions: Webinar/Industry Visit/Expert talks /NPTEL/project/training Etc**

*** To better attain POs and PSOs and to bridge the gap between industry academia**

12. Internal Assessment mark allocation (as per university curriculum)

(Provide details as mentioned in syllabus)

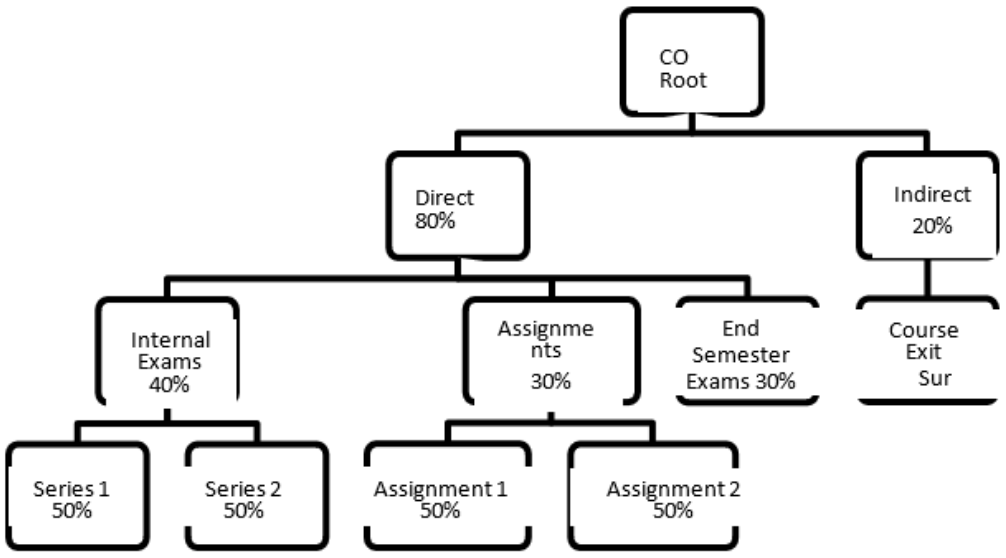
Attendance - 10 marks
Continuous Assessment Test - 25 marks
Assignment (s)/ Course Project - 15 marks
Total - 50 marks

13. **Assessment – CO Mapping (Put' x' if mapping is present)**

	Tools		Weightage#	CO1	CO2	CO3
Direct Assessment Tools**	Internal Exam(s) 40%	Series 1	20%	x	x	
		Series 2	20%		x	x
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x		
		Assignment 2	15%		x	x
	End Semester Exam		30%	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x

****Fill appropriate course specific Direct Assessment tools**
 # Fill appropriate weights such that total weight for direct assessment tools is 100%

14. Assessment Configuration



15. Question Bank

Module 1				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	**Explain briefly about design constraints.**	**3**	**CO1**	**L2**
2	**Explain briefly about design forms.**	**3**	**CO1**	**L2**
3	**List the characteristics and qualities of a good designer.**	**3**	**CO1**	**L1**
4	**Discuss the various steps involved in the basic design process.**	**3**	**CO1**	**L2**
5	**Explain Engineering design?**	**3**	**CO1**	**L2**
6	**Explain the role of divergent-convergent questioning in design thinking.**	**3**	**CO2**	**L2**
7	**How is Engineering design different from other forms of design?**	**3**	**CO2**	**L2**
8	**Explain design process? Illustrate each step with example and diagrams to support.**	**3**	**CO1**	**L2**
9	**How do a designer set objectives, constraints and identify constraints?**	**3**	**CO2**	**L2**
10	**Explain design functions. What is the relation between Science, Engineering and Technology?**	**3**	**CO2**	**L2**

11	State the design objectives, design constraints and design function of . (Any product like hammer, software, ladder, helmet etc.)	14	CO2	L1
12	Explain about design means and design objectives.	14	CO1	L2
13	"Form follows functions" give your comment on th statement from a designer's perspective. Giv examples for the same. Also give two exceptions.	14	CO2	L3
14	Explain the role of client, user and designer in contex of design process of any product.	14	CO1	L2
15	Show the designing of a (any product like TV stand, Remote, cloth hanger, water bottle, software, wrist watch, bookshelf, factory layout etc…) going through the various stages of the design process. (Use hand sketches to illustrate the processes.)	14	CO3	L3

Module 2

Sl. No.	Question	Marks	CO	BL
1	Illustrate with example, different stages iterative design thinking process.	3	CO1	L2
2	Explain the aims of design thinking approach?	3	CO1	L2
3	List the qualities required for a design engineer for design thinking	3	CO1	L1

	approach in a group. Also brief on brainstorming and brain writing techniques.			
4	**Explain the following in context of design thinking:- (consider each stage as separate question of 6 marks each) (a)Empathize (b)Define (c)Ideate (d)Prototype (e)Test**	**3**	**CO1**	**L2**
5	**State the role of divergent-convergent questioning in design thinking.**	**3**	**CO1**	**L1**
6	**Explain briefly the design thinking in team environment.**	**3**	**CO2**	**L2**
7	**Illustrate the design thinking approach for designing (any product like bag, walking stick, skipping rope, chair etc…) for (specific clients like students, old people, sports person, teachers, hospitals etc…) within a limited budget. Describe each stage of the process and the iterative procedure involved. Use hand sketches to support your arguments.**	**14**	**CO2**	**L2**
8	**Construct a number of possible designs and then refine them to narrow down to the best design for (any product like bag, walking stick, skipping rope, chair etc...) for (specific clients like students, old people, sports person, teachers, hospitals etc…). Show how the divergent-convergent thinking helps in the process. Provide your rationale for each step by using hand sketches only**	**14**	**CO3**	**L3**

Module 3				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	**Explain how drawing and sketches help in design communication.**	**3**	**CO1**	**L2**
2	**List three mathematical tools that help in design modeling.**	**3**	**CO1**	**L2**
3	**Compare prototype of a car with its model**	**3**	**CO1**	**L2**
4	**List the factors to be considered in preparing oral presentations to communicate designs effectively to clients.**	**3**	**CO1**	**L2**
5	**How does prototyping help to predict whether the design will function well or not?**	**3**	**CO1**	**L2**
6	**Graphically communicate the design of a kitchen knife. Draw the detailed 2D drawings of the same with design detailing, material selection, scale drawings, dimensions, tolerances, etc. Use only hand sketches.**	**14**	**CO3**	**L3**
7	**Describe the role of mathematical modelling in design engineering. Show how mathematics and physics play a role in designing a lift mechanism to carry 10 passengers up a building of 20 floors high.**	**14**	**CO3**	**L3**
8	**Explain the method of developing a mathematical model for a passenger lift.**	**14**	**CO3**	**L3**
9	**Assume that you have completed the design of a new model ceiling fan and a prototype is needed for testing. Communicate your idea to the production department effectively to manufacture the prototype.**	**14**	**CO3**	**L3**

10	Graphically communicate the design of a foldable ladder for electricians. Draw the detailed 2D drawings of the same with design detailing, material selection scale drawings and dimensions. Use only hand sketches.	3	CO3	L3
11	Describe the role of mathematical modelling in design engineering. Show how mathematics and physics play a role in designing a simple paper cutting scissor.	14	CO3	L3

Module 4				
Sl. No.	Question	Marks	CO	BL
1	Illustrate with an example, what is project based learning	3	CO1	L2
2	Illustrate with an example, what is problem based learning	3	CO1	L2
3	Explain the steps involved in problem based learning ?	3	CO1	L2
4	Explain the steps involved in project based learning ?	3	CO1	L2
5	Differentiate between Project and problem based learning	3	CO1	L2
6	Design a new waste management system in your residence area, especially for plastic waste	3	CO2	L6
7	Explain modularization?List the advantages of modular design?	3	CO1	L2

8	Illustrate with an example, about the modular design process	3	CO2	L2
9	Explain with an example of product life cycle.	3	CO3	L2
10	Explain the ergonomics in design.List out the advantages of ernonomic design.	3	CO1	L2
11	What are the factors considered in ergonomics design	3	CO1	L1
12	Ergonomically design a vegetable knife for your kitchen, consider gripping material, shape, safety and placement of knife	14	CO3	L6
13	Explain the Aesthetics in design.List out the advantages of Aesthetics design.	14	CO3	L2
14	Explain with an example of a Bio-Mimicry in design.	14	CO2	L2
15	What is concurrent engineering?List out the advantages of concurrent engineering	3	CO1	L1

Module 5

Sl. No.	Question	Marks	CO	BL
1.	Illustrate on “Design for production” with an example	3	CO1	L2
2.	Explain “Design for Use” with an example.	3	CO1	L2
3.		3	CO1	L2

	Explain "Design for Sustainability" with an example.			
4.	**Illustrate how concepts like value engineering, concurrent engineering and reverse engineering influence engineering designs?**	**3**	**CO2**	**L2**
5.	**Show how designs are varied based on the aspects of production methods, life span, reliability and environment?**	**3**	**CO2**	**L2**
6	**Explain how economics influence the engineering designs?**	**3**	**CO2**	**L2**
7.	**Explain engineering economics in design.**	**3**	**CO2**	**L2**
8.	**Explain design rights. (How and when to obtain design rights)**	**3**	**CO2**	**L2**
9.	**Explain the aspect of ethics in design.**	**3**	**CO2**	**L2**
10.	**Examine the changes in design of foot ware with constraints of 1)production method, 2)life span requirement, 3)reliability issues and 4)environmental factors. Use hand sketches and give proper rationalization for the changes in design.**	**14**	**CO3**	**L3**
11.	**Design a candle light stand (can be any familiar product) for manufacturing and elaborate on each step of DFM. Also brief on DFA.**	**14**	**CO3**	**L3**

12.	**Describe how to estimate the cost of a particular design using Any of the following: 1)a website, 2)the layout of a plant, 3)elevation of a building, 4)an electrical or electronic system or device, 5)a car. Show how economics will influence the engineering designs. Use hand sketches to support your arguments.**	**14**	**CO3**	**L3**

Prepared By : Dr. Manoj Jose Kalathil, Course Faculty

Checked By : Course Committee Coordinator Ms Renu Mary George
Approved By : Vice Principal , Academics

:

Course Code & Name: MCN201 Sustainable Engineering

1. Prescribed Syllabus

Module	Topic	Hours
1	Sustainability: Introduction, concept, evolution of the concept; Social, environmental and economic sustainability concepts; Sustainable development, Nexus between Technology and Sustainable development; Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs), Clean Development Mechanism (CDM).	**5**
2	Environmental Pollution: Air Pollution and its effects, Water pollution and its sources, Zero waste concept and 3 R concepts in solid waste management; Greenhouse effect, Global warming, Climate change, Ozone layer depletion, Carbon credits, carbon trading and carbon foot print, legal provisions for environmental protection.	6
3	Environmental management standards: ISO 14001:2015 framework and benefits, Scope and goal of Life Cycle Analysis (LCA), Circular economy, Bio-mimicking, Environment Impact Assessment (EIA), Industrial ecology and industrial symbiosis.	6
4	Resources and its utilisation: Basic concepts of Conventional and non-conventional energy, General idea about solar energy, Fuel cells, Wind energy, Small hydro plants, bio-fuels, Energy derived from oceans and Geothermal energy.	4
5	Sustainability practices: Basic concept of sustainable habitat, Methods for increasing energy efficiency in buildings, Green Engineering, Sustainable Urbanisation, Sustainable cities, Sustainable transport.	4

2. Text Books (T)

Nil

3. Reference Books (R)

R1. Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case Studies, Prentice Hall.
R2. Bradley. A.S; Adebayo,A.O., Maria, P. Engineering applications in sustainable design and development, Cengage learning
R3. Environment Impact Assessment Guidelines, Notification of Government of India, 2006
R4. Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publication, London, 1998
R5. ECBC Code 2007, Bureau of Energy Efficiency, New Delhi Bureau of Energy Efficiency Publications-Rating System, TERI Publications - GRIHA Rating System

R6. Ni bin Chang, Systems Analysis for Sustainable Engineering: Theory and Applications, McGraw-Hill Professional.
R7. Twidell, J. W. and Weir, A. D., Renewable Energy Resources, English Language Book Society (ELBS).
R8. Purohit, S. S., Green Technology - An approach for sustainable environment, Agrobios Publication

4. Course Objectives

Objective of this course is to inculcate in students an awareness of environmental issues and the global initiatives towards attaining sustainability. The student should realize the potential of technology in bringing in sustainable practices.

5. Course Pre / Co-requisite

Nil

6. Course Outcomes

After completion of the course, student will be able to
CO1: Understand the relevance and concept of sustainability and the global initiatives in this direction
CO2: Explain the different types of environmental pollution problems and their sustainable solutions.
CO3: Discuss the environmental regulations and standards
CO4: Outline the concepts related to conventional and non-conventional energy
CO5: Demonstrate the broad perspective of sustainable practices by utilizing engineering knowledge and principles

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1						M	H					M			
CO2						M	H					M			
CO3						M	H					M			
CO4						M	H					M			
CO5						M	H					M			

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	PO6	Able to understand the relevance and the concept of social sustainability which is the major part of sustainable development
	PO7	Understand the impact of the professional engineering solutions to

		ensure environmental sustainability
	PO12	Awareness of the concept of social sustainability can be used and applied in the future course of action.
CO2	PO6	Understand environmental pollution issues and need to address while working as an engineer in a society.
	PO7	The environment will be sustainable if all types of pollutions are restricted within the carrying limit of the nature
	PO12	Sustainable solutions for the environmental issues can be used and applied in the future course of action.
CO3	PO6	Able to learn about various environmental management tools which are used to predict the impacts and also helps to take decisions which are under the law.
	PO7	Environmental management tools help for better implementation of developmental activities in a sustainable way.
	PO12	Knowledge of Environmental management tools can be used and applied in the future course of action.
CO4	PO6	Knowledge on several renewable energy sources helps to decide possible solutions which are safer to society while designing a system.
	PO7	Renewable technologies inspire learner to use and design such systems for the welfare of the environmental sustainability
	PO12	The concepts related to conventional and non-conventional energy will be useful to engage in independent and lifelong learning and gaining knowledge in any area of electrical engineering.
CO5	PO6	Helps to become a socially responsible engineer and aware of their duties to the environment while engineering a product
	PO7	Information of several sustainable Green building materials and concepts motivate students to design sustainable products or buildings.
	PO12	Awareness and knowledge of green buildings and sustainable habitat can be used and applied in the future course of action.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs

11. Internal Assessment mark allocation (as per university curriculum)

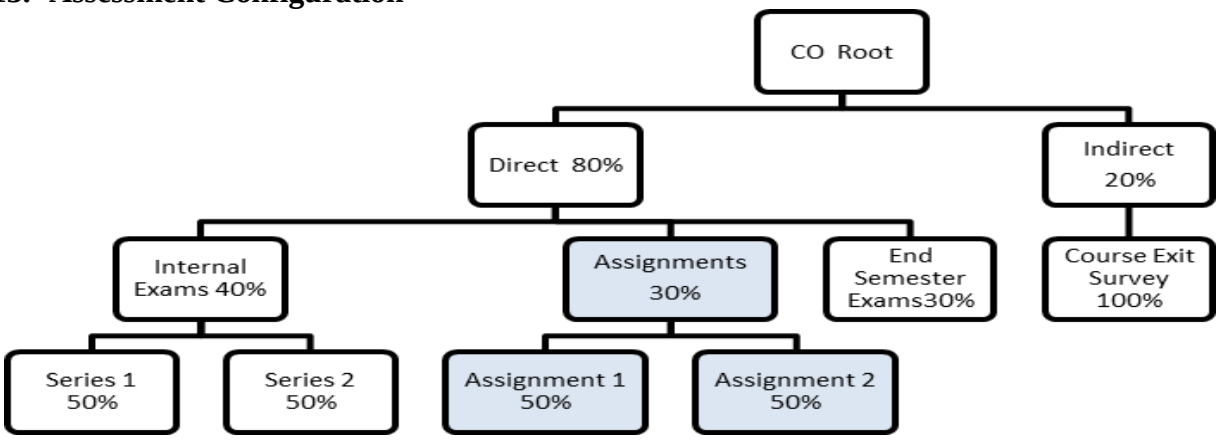
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		Weightage#	CO 1	CO 2	CO 3	CO 4	CO 5
Direct Assessment Tools**	Internal Exam(s) 40%	Series 1	20%	x	x	x		
		Series 2	20%			x	x	x
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x	x	x		
		Assignment 2	15%				x	x
	End Semester Exam		30%	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x

13. **Assessment Configuration**



14. **Course Plan**

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1	Introduction, concept, evolution of the concept	1	R1, R2, R3	Lecture
2	Social, environmental and economic sustainability concepts	1	R1, R2, R3	Lecture

3	Sustainable development, Nexus between Technology and Sustainable development	1	R1, R2, R3	Lecture
4	Millennium Development Goals (MDGs) and Sustainable Development Goals (SDGs)	1	R1, R2, R3	Lecture
5	Clean Development Mechanism (CDM)	1	R1, R2, R3	Lecture
6	Air Pollution and its effects	2	R1, R2, R3	Lecture
7	Water pollution and its sources	2	R1, R2, R3	Lecture
8	Zero waste concept and 3 R concepts in solid waste management	2	R1, R2, R3	Lecture
9	Greenhouse effect, Global warming, Climate change, Ozone layer depletion	2	R1, R2, R3	Lecture
10	Carbon credits, carbon trading and carbon foot print.	2	R1, R2, R3	Lecture
11	Legal provisions for environmental protection.	2	R1, R2, R3	Lecture
12	Environmental management standards	3	R1, R4, R5	Lecture
13	ISO 14001:2015 frame work and benefits	3	R1, R4, R5	Lecture
14	Scope and Goal of Life Cycle Analysis (LCA)	3	R1, R4, R5	Lecture
15	Circular economy, Bio-mimicking	3	R1, R4, R5	Lecture
16	Environment Impact Assessment (EIA)	3	R1, R4, R5	Lecture
17	Industrial Ecology, Industrial Symbiosis	3	R1, R4, R5	Lecture
18	Basic concepts of Conventional and non-conventional energy	4	R1, R3, R6	Lecture
19	General idea about solar energy, Fuel cells	4	R1, R3, R6	Lecture
20	Wind energy, Small hydro plants, bio-fuels	4	R1, R3, R6	Lecture
21	Energy derived from oceans and Geothermal energy	4	R1, R3, R6	Lecture
22	Basic concept of sustainable habitat	5	R1, R2, R8	Lecture
23	Methods for increasing energy efficiency of buildings	5	R1, R2, R8	Lecture
24	Green Engineering	5	R1, R2, R8	Lecture
25	Sustainable Urbanisation, Sustainable cities, Sustainable transport	5	R1, R2, R8	Lecture

15. Question Bank

Module 1				
Sl. No.	**Question**	**Marks**	**CO**	**BL**

1.	Define sustainable development.	**3**	**CO1**	**L1**
2.	List four strategies for achieving Sustainable Development.	**3**	**CO1**	**L1**
3.	What is the relevance of Kyoto Protocol?	**3**	**CO1**	**L1**
4.	Write a short note on Millennium Development Goals.	**5**	**CO1**	**L1**
5.	Explain the Sustainable Development Goals.	**5**	**CO1**	**L1**
6.	Write a short note on Millennium Development Goals.	**5**	**CO1**	**L1**
7.	Explain the Sustainable Development Goals.	**5**	**CO1**	**L2**
8.	Explain the 3 pillars model of sustainability with schematic diagram.	**3**	**CO1**	**L2**
9.	Comment on the challenges for sustainable development in our country and suggest a way to overcome the same.	**3**	**CO1**	**L2**
10.	CDM is a good tool that can be used by developing countries for boosting up their own development. How?	**5**	**CO1**	**L2**
11.	Discuss the evolution of the concept of sustainability. Comment on its relevance in the modern world.	**3**	**CO1**	**L2**
12.	Explain Clean Development Mechanism	**14**	**CO1**	**L2**
13.	Give an example of any activity where sustainability and technology go hand in hand.	**3**	**CO1**	**L3**
14.	Information technology-enabled paperless office is a big step to achieve sustainable development. Come out with three supporting and three opposing points for this statement.	**3**	**CO1**	**L3**
15.	Illustrate the nexus between agricultural technology and sustainability.	**3**	**CO1**	**L3**
16.	Justify, giving one reason, why sustainability is an essential component in any developmental programs and projects.	**3**	**CO1**	**L3**
17.	Comment on any one challenge experienced in the implementation of Sustainable development principles.	**3**	**CO1**	**L3**
18.	Technology may affect sustainability in positive and negative ways. Give one example each for both cases.	**3**	**CO1**	**L3**
19.	Suggest a project under CDM that could be executed in a village in developing nation.	**3**	**CO1**	**L3**
20.	How would you take initiatives in conducting your college fest, so that it remains an environmentally sustainable one?	**5**	**CO1**	**L3**

Module 2				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1.	Explain water use cycle.	**3**	**CO2**	**L1**
2.	What are the various classes of water pollutants and mention some of their effects.	**3**	**CO2**	**L1**
3.	What are the conventional waste water treatment processes? Explain why they are not considered sustainable.	**3**	**CO2**	**L1**
4.	List out and explain the various sustainable waste water treatment methods.	**3**	**CO2**	**L1**
5.	Mention major control measures to reduce air pollution.	**3**	**CO2**	**L1**
6.	What is water pollution? Mention some sources.	**3**	**CO2**	**L1**
7.	Mention the effects of air pollution on humans, plants, animals and environment and property?	**3**	**CO2**	**L1**
8.	Among the major constituents of municipal solid waste, list any three of the most hazardous waste and highlight their impact on the health/human environment.	**3**	**CO2**	**L1**
9.	Illustrate a typical sustainable waste water treatment system with block diagram	**3**	**CO2**	**L1**
10.	List out some methods of solid waste management.	**3**	**CO2**	**L1**
11.	Explain the concept of ozone layer depletion.	**3**	**CO2**	**L1**
12.	Write a note on carbon footprint.	**3**	**CO2**	**L1**
13.	Explain the measures to check climate change.	**3**	**CO2**	**L1**
14.	Explain the causes of climate change.	**3**	**CO2**	**L1**
15.	Explain the effects of climate change.	**3**	**CO2**	**L1**
16.	What are the measures to control global warming?	**3**	**CO2**	**L1**
17.	What are the principles of zero waste concept and explain technologies towards zero waste concept.	**5**	**CO2**	**L1**
18.	Describe carbon credit. Explain in not more than five sentences.	**3**	**CO2**	**L2**
19.	"Clean energy is necessary for sustainable development". Justify this with three arguments.	**3**	**CO2**	**L2**
20.	State whether the statement “Zero waste concept should be a core strategy in sustainable development” is true or false. How does the 3R concept lead to zero waste concept?	**3**	**CO2**	**L2**
21.	Give an account of climate change and its effect on environment	**3**	**CO2**	**L2**
22.	Give any 3 examples of air pollutants and their effect on human health.	**3**	**CO2**	**L2**
23.	Illustrate a typical sustainable waste water treatment	**3**	**CO2**	**L2**

	system with block diagram.			
24.	Suggest any two methods of sustainable waste water treatment.	**3**	**CO2**	**L2**
25.	Explain the phenomenon of ozone layer depletion	**3**	**CO2**	**L2**
26.	Suggest any three sustainable methods each for the solid waste and waste water management system.	**3**	**CO2**	**L2**
27.	Define air pollution and list out major sources of air pollution.	**3**	**CO2**	**L2**
28.	Explain the major types of air pollutants.	**3**	**CO2**	**L2**
29.	What are the factors to be considered to determine the suitability of a waste water treatment method to be sustainable?	**3**	**CO2**	**L2**
30.	Explain any two sustainable waste water treatment methods.	**3**	**CO2**	**L2**
31.	What is waste? Mention some sources of solid waste.	**3**	**CO2**	**L2**
32.	Explain the concepts of carbon trading and carbon credits.	**3**	**CO2**	**L2**
33.	How does an emissions trading scheme work?	**3**	**CO2**	**L2**
34.	Explain the 3R concept of waste management.	**3**	**CO2**	**L2**
35.	What are the impacts of solid waste on land environment?	**3**	**CO2**	**L2**
36.	What are the impacts of solid waste on water environment?	**3**	**CO2**	**L2**
37.	What are the impacts of solid waste on air environment?	**3**	**CO2**	**L2**
38.	What are the impacts of solid waste on health?	**3**	**CO2**	**L2**
39.	Among the major constituents of municipal solid waste, list any three of the most hazardous waste and highlight their impact on the health/human environment.	**3**	**CO2**	**L2**
40.	Differentiate between greenhouse effect and global warming.	**3**	**CO2**	**L2**
41.	Explain the effects of global warming.	**3**	**CO2**	**L2**
42.	What do you mean by e-waste? What are the possible source of e-waste? How can we dispose e-waste without causing harm to environment?	**3**	**CO2**	**L2**
43.	Explain the global warming and mention its causes and effects.	**5**	**CO2**	**L2**
44.	Give an account of solid waste management in cities.	**5**	**CO2**	**L2**
45.	What are the possible effects of ozone layer depletion?	**2**	**CO2**	**L2**
46.	Mention some actions that can be adopted to protect ozone layer.	**2**	**CO2**	**L2**
47.	List out major water pollutants and their effects.	**5**	**CO2**	**L2**

48.	Explain the concept and causes of global warming.	**5**	**CO2**	**L2**
49.	Distinguish between green-house effect, global warming and climate change.	**5**	**CO2**	**L2**
50.	Explain the common sources of water pollution and its harmful effects.	**4**	**CO2**	**L2**
51.	Explain the significance of carbon footprint. Suggest two methods to reduce the carbon footprint in your house.	**5**	**CO2**	**L3**
52.	A comprehensive campaign to address air pollution need to be launched through school children, what programme would you envisage for this. What is the outcome anticipated?	**3**	**CO2**	**L3**
53.	There is a sudden decision to remove all vehicles from the road that fails to meet specified norms of emission level within a specified time period. As part of citizen forum you are requested to give views on the enforced regulation. State your views on this.	**3**	**CO2**	**L3**
54.	A massive campaign on environmental degradation is to be initiated. Bring out a slogan and the key message that need to be addressed.	**3**	**CO2**	**L3**
55.	Suppose you are a Carbon Credit Auditor appointed to assess the greenhouse gas emission reduction strategies. Identify a component of assessment and brief the methodology that could be adopted in connection with this.	**3**	**CO2**	**L3**
56.	Write a short note on any local environmental issues.	**5**	**CO2**	**L3**
57.	What are the activities that can be organized in your college/locality to observe 5th June as the World Environmental Day with theme “Climate Change”?	**5**	**CO2**	**L3**
58.	Densely populated areas are suffering major issues in the field of solid waste and waste water management. Relate this statement with the current situation in our state.	**14**	**CO2**	**L3**
Module 3				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1.	List out the procedures of EIA followed in India	**3**	**CO3**	**L1**
2.	What is Environment Management System (EMS). List out functions of EMS.	**5**	**CO3**	**L1**
3.	Write a short note on EMS. Briefly indicate the steps involved in introducing EMS in an industry.	**5**	**CO3**	**L1**
4.	What is bio mimicry? Give three examples in transportation sector clearly stating the species and invention.	**5**	**CO3**	**L1**
5.	How will you relate industrial ecology principles to	**5**	**CO3**	**L1**

	sustainable engineering?			
6.	Discuss the benefits of doing an EIA study. .List down any six impacts considered in EIA.	**5**	**CO3**	**L1**
7.	What do you mean by Industrial Symbiosis? Explain its concept and benefits.	**9**	**CO3**	**L1**
8.	What is Bio-mimicking?	**3**	**CO3**	**L2**
9.	What is Life Cycle Analysis (LCA)? Justify the need of LCA.	**5**	**CO3**	**L2**
10.	How does industrial ecology help in achieving sustainable development? How does material selection influence industrial processes in achieving sustainability?	**5**	**CO3**	**L2**
11.	List out the advantages and disadvantages of industrial symbiosis.	**5**	**CO3**	**L2**
12.	Write a short note on EMS. Briefly indicate the steps involved in introducing EMS in an industry.	**5**	**CO3**	**L2**
13.	Explain the role played by ISO 14000 towards ensuring sustainability in industrial operations.	**5**	**CO3**	**L2**
14.	What are the benefits gained by an organization in implementing EMS?	**5**	**CO3**	**L2**
15.	List out various procedures of EIA in India.	**5**	**CO3**	**L2**
16.	What steps in EIA involve participation from the public? What are the steps involved after the final public consultation?	**5**	**CO3**	**L2**
17.	List any 5 products developed bases on bio mimics.	**5**	**CO3**	**L2**
18.	What do you mean by Bio-mimicking? Explain any two examples of bio mimicking.	**5**	**CO3**	**L2**
19.	Define circular economy and write its significance in sustainable engineering.	**5**	**CO3**	**L2**
20.	What do you mean by Industrial ecology? Write down the principles and benefits of Industrial ecology.	**6**	**CO3**	**L2**
21.	Can we implement industrial ecology in India? Substantiate your answer. Differentiate industrial ecology and industrial symbiosis with examples. List four set of industries were we can implement industrial symbiosis	**9**	**CO3**	**L2**
22.	Describe the major elements of circular economy.	**9**	**C03**	**L2**
23.	List out some common practices followed in the construction industry, in Kerala promoting energy efficiency.	**3**	**CO3**	**L3**
24.	What is the concept of industrial ecology? Give an example of a recent product.	**3**	**CO3**	**L3**
25.	'Are social and technological changes needed for making a sustainable society'; Justify your answer	**3**	**CO3**	**L3**
26.	What is LCA? Illustrate how LCA can be effectively	**5**	**CO3**	**L3**

	used in the environmental management of industrial production systems.			
27.	Can we use life cycle analysis (LCA) as a tool for profit making? How?	**5**	**CO3**	**L3**
28.	With a suitable example, explain the principles of industrial symbiosis.	**5**	**CO3**	**L3**
29.	Explain Industrial Symbiosis. Give an example.	**5**	**CO3**	**L3**
30.	Can the concept of industrial symbiosis be adopted in Kerala? Explain.	**5**	**CO3**	**L3**
31.	Apply idea of industrial symbiosis to the coconut oil industry.	**5**	**CO3**	**L3**
32.	Explain LCA with an example.	**10**	**CO3**	**L3**
33.	Discuss LCA analysis of polythene carry bags.	**10**	**CO3**	**L3**
34.	Conduct a sample life cycle analysis of any product given below- Plastic pet bottles, lead acid batteries or hollow bricks.	**10**	**CO3**	**L3**
35.	A firm named XYZ Pvt Ltd producing mobile phones wants to get itself ISO14001:2015 certified. What are the steps it should adopt in its organizational level to the product level for the certification?	**14**	**CO3**	**L3**

Module 4

Sl. No.	**Question**	**Marks**	**CO**	**BL**
1.	What are limitations in harnessing the tidal energy?	**3**	**CO4**	**L1**
2.	List out major renewable energy sources available.	**5**	**CO4**	**L1**
3.	List out the advantages of using renewable energy sources.	**3**	**CO4**	**L1**
4.	List the different types of renewable energy sources	**5**	**CO4**	**L1**
5.	List out four non-conventional sources of energy and explain any two in detail.	**6**	**CO4**	**L1**
6.	List 5 ways in which solar energy could be utilized.	**5**	**CO4**	**L1**
7.	What are the steps involved in bio fuel production.	**5**	**CO4**	**L1**
8.	Suggest two renewable energy sources that can be utilized in automobiles.	**5**	**CO4**	**L1**

9.	List out any 5 methods to improve the energy efficiency in buildings.	**5**	**CO4**	**L1**
10.	Discuss the advantages and disadvantages of nuclear energy.	**5**	**CO4**	**L1**
11.	Explain the measure that can be adopted to achieve ZEB through renewable energy and other technologies.	**3**	**CO5**	**L2**
12.	What are social, economical and environmental advantages gained through utilization of solar energy.	**3**	**CO4**	**L2**
13.	"Large hydro-electric power plant is a sustainable power generation model"—state whether this statement is true or false. Justify your answer in two sentences.	**3**	**CO4**	**L2**
14.	Suggest two renewable energy sources for our state and validate your suggestion.	**5**	**CO4**	**L2**
15.	Explain a solar water heating system with the help of a diagram.	**5**	**CO4**	**L2**
16.	List the different renewable energy sources. What are the challenges that we face to develop renewable sources in India?	**5**	**CO4**	**L2**
17.	List out the advantages and disadvantages of non-conventional sources of energy.	**5**	**CO4**	**L2**
18.	Suggest few measures by which usage of energy can be reduced in residential buildings	**5**	**CO4**	**L2**
19.	Suggest few measures that can be adopted for energy efficiency in green buildings.	**5**	**CO4**	**L2**
20.	Differentiate between conventional and non-conventional energy sources. Which will you support? Why?	**5**	**CO4**	**L2**
21.	Write short notes on fuel cells.	**5**	**CO4**	**L2**
22.	Explain a typical wind energy system with a block diagram.	**5**	**CO4**	**L2**
23.	Explain different method using which we can utilize solar energy.	**5**	**CO4**	**L2**
24.	What is bio energy? Explain any 4 methods for converting biomass to energy.	**5**	**CO4**	**L2**
25.	What is bio mass energy? How is it extracted?	**3**	**CO4**	**L2**

26.	Enumerate any 2 impacts of bio mass energy on the environment.	**3**	**CO4**	**L2**
27.	What are the methods for increasing energy efficiency of buildings?	**5**	**CO4**	**L2**
28.	List various ways to conserve energy.	**5**	**CO4**	**L2**
29.	Explain the working of a photo voltaic cell with a neat diagram.	**5**	**CO4**	**L2**
30.	What is the possibility of using solar energy in a state like Kerala? List out the various supporting and opposing factors	**5**	**CO4**	**L2**
31.	Explain in detail, the working of a solar power p l airport in Kerala.	**5**	**CO4**	**L2**
32.	What are the methods to convert biomass to energy without heating it?	**5**	**CO4**	**L2**
33.	List 2 methods of extracting energy from the oceans. Explain the principle of Geothermal energy generation.	**5**	**CO4**	**L2**
34.	How can oceans be utilized for tapping energy. Discuss.	**5**	**CO4**	**L2**
35.	How can energy be derived from oceans?	**5**	**CO4**	**L2**
36.	Explain any one method to geo thermal energy.	**5**	**CO4**	**L2**
37.	Explain in detail, the working of any one type of fuel cell.	**5**	**CO4**	**L2**
38.	With necessary schematics explain the working of : A Geothermal Power Plant. A Tidal Power Plant.	**7**	**CO4**	**L2**
39.	In future, the sources of fossil fuels become rare and extinct. Suggest some methods to overcome this crisis.	**5**	**CO4**	**L3**
40.	The production of renewable as well as non - renewable energy has carbon foot print. Then why we are promoting renewable energy?	**3**	**CO4**	**L3**
41.	Compare the feasibility of different sources of renewable energy, giving suggestions to KSEB.	**3**	**CO4**	**L3**
42.	How can you make use of renewable energy in your home.	**3**	**CO4**	**L3**
43.	Is there a best energy source that will have the minimum environmental impact? Justify your	**3**	**CO4**	**L3**

	answer.			
44.	Discuss the contribution of coal power to Kerala energy production.	**3**	**CO4**	**L3**
45.	Being an agriculture country, what is the scope of using bio-fuels for meeting the energy needs of India?	**3**	**CO4**	**L3**
46.	Compare and contrast conventional and nonconventional energy with reference to sustainability.	**5**	**CO4**	**L3**
47.	We can create a more Sustainable, cleaner and safer world by making wiser energy choices." Evaluate the importance of the quote and discuss on the various Non-Conventional Energy Sources.	**5**	**CO4**	**L3**
48.	What are the energy saving opportunities in a house?	**5**	**CO4**	**L3**
49.	If industrial energy use is the dominant consumer of energy. Give any three suggestions for reducing the energy consumption in industries.	**5**	**CO4**	**L3**
50.	Critically analyse the role of renewable energy Context. Compare the feasibility of various sources of rene w tapped with special reference to India.	**5**	**CO4**	**L3** a
51.	Suggest suitable sustainable systems to generate hot water and electricity for a hostel in Kerala.	**5**	**CO4**	**L3**
52.	There is a remote village on top of a village. Explain any two methods that can be adopted there to generate electricity.	**5**	**CO4**	**L3**
53.	What is the scope of using geothermal energy as a non-renewable energy source? Give suggestions to reduce the power consumption at the place where you are studying, enumerating the unwanted/ wastage of power.	**5**	**CO4**	**L3**
Module 5				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1.	How can sustainable urbanization and poverty reduction be related?	**3**	**CO5**	**L1**
2.	List any three principles of Green Engineering.	**3**	**CO5**	**L1**

3.	List any sustainable materials buildings.	**3**	**CO5**	**L1**
4.	Explain the concept of sustainable Transport.	**3**	**CO5**	**L1**
5.	How can sustainable urbanization and poverty reduction be related.	**3**	**CO5**	**L1**
6.	Which are the three primary green building rating systems in India?	**3**	**CO5**	**L1**
7.	What do you mean by green building design?	**3**	**CO5**	**L1**
8.	What is GRIHA rating?	**3**	**CO5**	**L1**
9.	What are the impacts of non-sustainable transportation system?	**3**	**CO5**	**L1**
10.	How the road transport can be made sustainable?	**3**	**CO5**	**L1**
11.	How can you promote energy efficiency in the domestic sector?	**3**	**CO5**	**L1**
12.	What are the impacts of non-sustainable transportation system?	**4**	**CO5**	**L1**
13.	Enumerate the basic features of a sustainable habitat.	**4**	**CO5**	**L1**
14.	List top four major challenges faced by cities	**5**	**CO5**	**L1**
15.	What are the basic features of a sustainable city?	**5**	**CO5**	**L1**
16.	List 5 practices for making the industrial process move towards the goal of sustainability	**5**	**CO5**	**L1**
17.	For any industry, material selection is very important.	**3**	**CO5**	**L2**
18.	Discuss any three benefits of green engineering.	**3**	**CO5**	**L2**
19.	How can sustainable development be communicated successfully?	**3**	**CO5**	**L2**
20.	List any two materials that can be green substitutes for conventional buildings materials and explain its features.	**3**	**CO5**	**L2**
21.	What are your proposals for a sustainable transport system by integrating road and water transport?	**3**	**CO5**	**L2**

22.	What are the causes of rural-urban migration? How it will affect the urban area?	**5**	**CO5**	**L2**
23.	Suggest few measures by which usage of energy can be reduced in residential buildings.	**5**	**CO5**	**L2**
24.	Explain hybrid power systems with examples.	**5**	**CO5**	**L2**
25.	Write a short note on how appropriate material selection can contribute in achieving sustainability in building construction.	**5**	**CO5**	**L2**
26.	What are the aspects to take care for a green building? Energy efficiency has been given more weightage in the rating systems than all other aspects. Justify this.	**5**	**CO5**	**L2**
27.	What are the impacts of non sustainable transport system. Suggest any method to reduce the impact.	**5**	**CO5**	**L2**
28.	What are the benefits achieved when recycled materials used for construction?	**5**	**CO5**	**L2**
29.	Write a short note on green engineering.	**5**	**CO5**	**L2**
30.	Take an example of green building. How it differs from a conventional building. Compare in any six aspects.	**5**	**CO5**	**L2**
31.	Check whether the "Green Building concept" is related to the "Concept of sustainable habitat". Explain any three key points to justify your answer.	**5**	**CO5**	**L2**
32.	Differentiate between green building and conventional building. Compare any seven aspects.	**14**	**CO5**	**L2**
33.	Discuss on sustainable transport and sustainable cities.	**14**	**CO5**	**L2**
34.	a) Explain different green building rating programs. b) Explain the concept of sustainable cities with suitable examples.	**14**	**CO5**	**L2**
35.	Discuss the elements related to sustainable urbanisation.	**14**	**CO5**	**L2**
36.	Explain different strategies for achieving sustainable transportation.	**14**	**CO5**	**L2**
37.	Discuss methods by which you can increase energy efficiency in buildings.	**14**	**CO5**	**L2**
38.	Studies show that the total urban population is expected to rise to 5 billion by the year 2030. What	**3**	**CO5**	**L2**

	do you think is the reason behind this? How does this affect the sustainability?			
39.	Explain urbanization. Write two push factors and two pull factors for people moving from rural to urban areas.	**3**	**CO5**	**L2**
40.	How does material selection influence industrial processes in achieving sustainability	**3**	**CO5**	**L2**
41.	List any two major characteristics of a sustainable city that address the environmental well being of the inhabitants.	**3**	**CO5**	**L2**
42.	Suggest two water conserving methods that can be adopted in green buildings	**3**	**CO5**	**L2**
43.	Differentiate between green building and conventional building. Compare any seven aspects.	**14**	**CO5**	**L2**
44.	Discuss on sustainable transport and sustainable cities.	**14**	**CO5**	**L2**
45.	a) Explain different green building rating programs. b) Explain the concept of sustainable cities with suitable examples.	**14**	**CO5**	**L2**
46.	Discuss the elements related to sustainable urbanisation.	**14**	**CO5**	**L2**
47.	Explain different strategies for achieving sustainable transportation.	**14**	**CO5**	**L2**
48.	Discuss methods by which you can increase energy efficiency in buildings.	**14**	**CO5**	**L2**
49.	What are the energy saving opportunities in a house?	**3**	**CO5**	**L3**
50.	Your neighbour plants to construct a new home. Suggest some green materials.	**3**	**CO5**	**L3**
51.	Introduction of metro service in Kochi is a major achievement for the transportation system of the city. Do you think this can be related to sustainable engineering? If so, explain.	**3**	**CO5**	**L3**
52.	Electric vehicle (EV) being run on electricity is claimed as emission-free. Still, the fact that significant share of Electrical Energy produced across the globe is of thermal origin put question marks on the emission-free claim. Justify this statement.	**4**	**CO5**	**L3**
53.	As an engineer suggest any 5 points to reduce pollution by an industry in your locality.	**5**	**CO5**	**L3**

Course Code & Name: MEL201 Computer Aided Machine Drawing

1. Prescribed Syllabus

Temporary Joint: Principles of drawing, free hand sketching, Importance of machine Drawing. BIScode of practice for Engineering Drawing, lines, types of lines, dimensioning, scales of drawing, sectional views, Riveted joints.
Fasteners: Sketching of conventional representation of welded joints, Bolts and Nuts or Keys and Foundation Bolts.
Fits and Tolerances: Limits, Fits – Tolerances of individual dimensions – Specification of Fits – basic principles of geometric & dimensional tolerances.

Surface Roughness:

Preparation of production drawings and reading of part and assembly drawings, surface roughness, indication of surface roughness, etc.

Detailed drawing of Cotter joints, Knuckle joint and Pipe joints.
Assembly drawings(2D): Stuffing box and Screw jack

PART –B (CAD drawing)

(Minimum 6 drawings compulsory)

Introduction to drafting software like Auto CAD, basic commands, keyboard shortcuts. Coordinate and unit setting, Drawing, Editing, Measuring, Dimensioning,

Plotting Commands, Layering Concepts, Matching, Detailing, Detailed drawings.

Drawing of Shaft couplings and Oldham's coupling
Assembly drawings(2D) with Bill of materials: Lathe Tailstock and Universal joint
Assembly drawings(2D) with Bill of materials: Connecting rod and Plummer block
Assembly drawings(2D) with Bill of materials: Rams Bottom Safety Valve OR steam stop valve

Sl No	Experiments
1	Introduction to Manual Drawing
2	Manual Drawing of Riveted Joints
3	Manual Drawing of Bolts and Nuts
4	Fits and Tolerances
5	Surface Roughness
6	Manual Drawing of Cotter Joints
7	Manual Assembly Drawings of Stuffing Box
8	Introduction to Drafting Software
9	CAD Drawing of Shaft Couplings
10	CAD Drawings of Lathe tailstock and universal joint
11	CAD Drawings of Connecting Rod and Plummer Block
12	CAD Drawings of Rams Bottoms Safety Valve OR Steam Stop Valve

2. Text Books (T)

T1. N. D. Bhatt and V.M. Panchal, Machine Drawing, Charotar Publishing House.
T2. P I Varghese and K C John, Machine Drawing, VIP Publishers.
T3. K L Narayana and P Kannaiah, Machine Drawing, New Age International Publishers.
T4. Dr. R K Dhawan, Machine Drawing, S Chand Publication.

3. Reference Books (R)

R1. Ajeet Singh, Machine Drawing Includes AutoCAD, Tata McGraw-hill.
R2. P S Gill, Machine Drawing, Kataria& Sons.

4. Course Objectives

To introduce students to the basics and standards of engineering drawing related to machines and components.
To make students familiarize with different types of riveted and welded joints, surface roughness symbols; limits, fits and tolerances.
To convey the principles and requirements of machine and production drawings.
To introduce the preparation of drawings of assembled and disassembled view of important valves and machine components used in mechanical engineering applications.
To introduce standard CAD packages for drafting and modelling of engineering components.

5. Course Pre / Co-requisite

NIL

6. Course Outcomes

After the completion of the course the student will be able to
CO1: Apply the knowledge of engineering drawings and standards to prepare standard dimensioned drawings of machine parts and other engineering components.
CO2: Prepare standard assembly drawings of machine components and valves using part drawings and bill of materials.
CO3: Apply limits and tolerances to components and choose appropriate fits for given Assemblies.
CO4: Interpret the symbols of welded, machining and surface roughness on the component drawings.
CO5: Prepare part and assembly drawings and Bill of Materials of machine components and valves using CAD software.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	H									H					

CO2	**H**		**M**							**H**					
CO3	**H**	**M**													
CO4	**H**														
CO5	**H**				**H**					**H**		**L**	**H**		**H**

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	**PO1**	Knowledge of engineering drawings and standards can be applied to prepare standard dimensioned drawings of machine parts and other engineering components. High correlation is due to the fact that deep knowledge of science, engineering fundamentals, and an engineering specialization could be used to solve the complex engineering problems.
	PO10	Knowledge of engineering drawings and standards can be applied to prepare standard dimensioned drawings of machine parts and other engineering components. High correlation is due to the fact that it uses deep knowledge of engineering drawings and standards could be utilised to communicate effectively on complex engineering activities with engineering community.
CO2	**PO1**	Standard assembly drawings of machine components and valves using part drawings and bill of materials can be made easily to solve complex problems. High correlation is due to the fact that it uses deep knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
	PO3	Standard assembly drawings of machine components and valves using part drawings and bill of materials can be made easily to solve complex problems. Medium correlation is due to the fact that it uses basic principle to design solution for complex engineering problems.
	PO10	Standard assembly drawings of machine components and valves using part drawings and bill of materials can be made easily to solve complex problems. High correlation is due to the fact that deep knowledge of standard assembly drawings could be utilised to communicate effectively on complex engineering activities with engineering community.
CO3	**PO1**	Knowledge of limits, tolerances could be utilised to choose appropriate fits for given components, assemblies. High correlation is due to the fact that it uses deep knowledge of engineering fundamentals, and an engineering specialisation to the solve complex engineering problems.
	PO2	Knowledge of limits, tolerances could be utilised to choose appropriate fits for given components, assemblies. Medium correlation is due to the fact that it uses basic principle to identify, formulate, review research literature and analyse complex engineering problems.
CO4	**PO1**	Symbols of welded, machining and surface roughness on the component drawings can be used to solve complex problems. High correlation is due

		to the fact that it uses deep knowledge of engineering fundamentals to the solution of complex engineering problems.
CO5	**PO1**	CAD software can be used to prepare part, assembly drawings and bill of materials of machine components and valves. This can be used to solve complex engineering problems. High correlation is due to the fact that it uses deep knowledge engineering fundamentals, and an engineering specialisation to the solution of complex engineering problems.
	PO5	CAD software can be used to prepare part, assembly drawings and bill of materials of machine components and valves. High correlation is due to the fact that deep knowledge of CAD is used to create, select and apply appropriate techniques, resources and modern engineering and IT tools including prediction and modelling to complex engineering activities.
	PO10	CAD software can be used to prepare part, assembly drawings and bill of materials of machine components and valves. High correlation is due to the fact that it uses deep knowledge of engineering fundamentals to communicate effectively on complex engineering activities with engineering community.
	PO12	CAD software can be used to prepare part, assembly drawings and bill of materials of machine components and valves. Low correlation is due to the fact that it uses basic principles of engineering science to recognize the need and to have life-long learning in the broadest context of technological change.
	PSO1	CAD software can be used to prepare part, assembly drawings and bill of materials of machine components and valves. High correlation is due to the fact that deep knowledge of concurrent technologies can be used to solve practical problems.
	PSO3	CAD software can be used to prepare part, assembly drawings and bill of materials of machine components and valves. High correlation is due to the fact that it uses deep knowledge of mathematics, engineering science to design and analyse multi- disciplinary system.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs

11. Assessment Pattern (as per university curriculum)

(Provide details as mentioned in syllabus)

Continuous Internal evaluation - 75 marks

End Semester Examination - 75 marks

Total -150 marks

Evaluation criteria (as per syllabus)

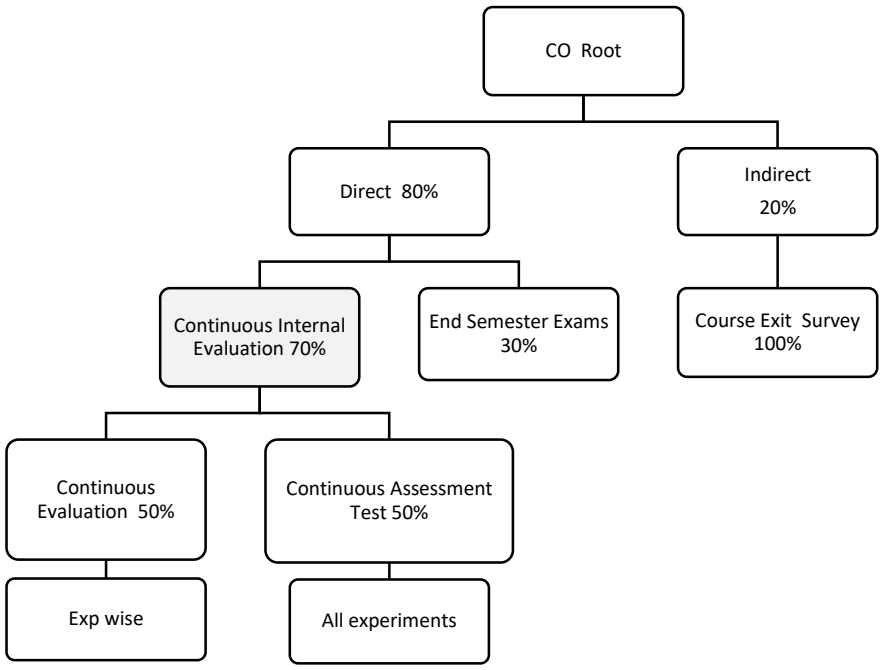
Sl. No.	Nature of Evaluation**	Evaluation Pattern**	Topics of Evaluation **	Duration**	Weightage of marks**
1.	**Continuous Internal evaluation (75 marks)**				
a.	Attendance	90%-100% - 15 marks 85% -90% - 13.5 marks 75% -85 % - 12 marks 70% - 75% - 10.5 marks 65% - 70% - 9 marks 60% - 65% - 7.5 marks	NA	NA	10%
b.	Continuous Evaluation	Accuracy and completeness – 20 marks Record – 10 marks, Total – 30 marks	Each experiment	3 hours	20%
c.	Continuous Assessment Test	Two internal exams Total 30 Marks	All Experiments		20%
2.	**End Semester Examination (75 marks)**				
a.	End semester Examination	Sketching- 15 marks, CAD Drawing –50 marks and viva – 10 marks. Total 75 marks for End Semester Examination	All Experiments	3hrs	50%

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools**	Weightage#	CO1	CO2	CO3	CO4	CO5
Direct Assessment Tools	Continuous Evaluation Experiment wise CO mapping	35%	x	x	x	x	x
	Continuous Assessment Test	35%	x	x	x	x	x

	End Semester Exam – 30%	**30%**	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey	100%	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Weeks(W)	Experiments	Relevance to COs
1	Introduction to Manual Drawing	
2	Manual Drawing of Riveted Joints	CO1
3	Manual Drawing of Bolts and Nuts	CO1
4	Fits and Tolerances	CO2
5	Surface Roughness	CO2
6	Manual Drawing of Cotter Joints	CO2
7	Manual Assembly Drawings of Stuffing Box	CO1, CO3, CO4

8	Introduction to Drafting Software	CO1, CO2, CO3, CO5
9	CAD Drawing of Shaft Couplings	CO1, CO2, CO3, CO5
10	CAD Drawings of Lathe tailstock and universal joint	CO1, CO3, CO5
11	CAD Drawings of Connecting Rod and Plummer Block	CO1, CO3, CO5
12	CAD Drawings of Rams Bottoms Safety Valve OR Steam Stop Valve	CO1, CO3, CO5
Total No. of Hours	33	

Prepared By : Mr. Jibin Jose, (Subject Faculty)

Checked By : Ms. JVC Malieckel (Subject group coordinator)

Approved By : Dr. Ramadas T (HOD - ME)

Course Code & Name: MEL203 MATERIALS TESTING LAB

1. Prescribed Syllabus

Sl No	Experiments
1	To conduct tension test on ductile material (mild steel/ tor-steel/ high strength steel) using Universal tension testing machine and Extensometer.
2	To conduct compression test on ductile material (mild steel/ tor-steel/ high strength steel) using Universal tension testing machine and Extensometer
3	To conduct tension test on Brittle material (cast iron) using Universal tension testing machine and Extensometer
4	To conduct shear test on mild steel rod.
5	To conduct microstructure features of mild steel/copper/ brass/aluminium using optical microscope, double disc polishing machine, emery papers and etchent.
6	To conduct fractography study of ductile or brittle material using optical microscope.
7	To conduct Hardness test of a given material. (Brinell, Vickers and Rockwell)
8	To determine torsional rigidity of mild steel/copper/brass rod.
9	To determine flexural rigidity of mild steel/ copper/brass material using universal testing machine
10	To determine fracture toughness of the given material using Universal tension testing machine.
11	To study the procedure for plotting S-N curve using Fatigue testing machine.
12	To conduct a Toughness test of the given material using Izod and Charpy Machine
13	To determine spring stiffness of close coiled/open coiled/series/parallel arrangements
14	To conduct bending test on wooden beam
15	To conduct stress measurements using Photo elastic methods.
16	To conduct strain measurements using strain gauges.
17	To determine moment of inertia of rotating bodies
18	To conduct an experiment to Verify Clerk Maxwell's law of reciprocal deflection and determine young's Modulus of steel
19	To determine the surface roughness of a polished specimen using surface profilometer

2. Text Books (T)

NIL

3. Reference Books (R)

R1. G E Dieter. Mechanical Metallurgy, McGraw Hill,2013

R2. Dally J W, Railey W P, Experimental Stress analysis , McGarw Hill,1991
R3. Baldev Raj, Jayakumar T, Thavasimuthu M., Practical Non destructive testing, Narosa Book Distributors,2015

4. Course Objectives

To give a broad understanding of common materials related to mechanical engineering with an emphasis on the fundamentals of structure-property-application and its relationships.

5. Course Pre / Co-requisite

EST 100, ENGINEERING MECHANICS

6. Course Outcomes

After the completion of the course the student will be able to

CO1: To understand the basic concepts of analysis of circular shafts subjected to torsion. CO2 To understand the behaviour of engineering component subjected to cyclic loading and failure concepts
CO3 Evaluate the strength of ductile and brittle materials subjected to compressive, Tensile shear and bending forces.
CO4 Evaluate the microstructural morphology of ductile or brittle materials and its fracture modes (ductile /brittle fracture) during tension test.
CO5 To specify suitable material for applications in the field of design and manufacturing.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	H	-	-	-	H	-	-	-	-	-	-	-	-	-	H
CO2	H	H	L	-	H	-	-	-	H	M	M	L	-	H	H
CO3	H	H	H	L	H	-	-	-	H	M	H	M	-	H	H
CO4	H	H	H	H	H	M	M	L	H	M	H	M	M	H	H
CO5	H	H	H	L	H	M	M	L	H	M	H	M	M	H	H

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	PO1	Knowledge of fundamentals in engineering will help students in analysing the concept of circular shafts subjected to torsion.
	PO5	The students will be able to create select and apply appropriate techniques by studying torsion effect in circular shaft.

	PSO3	Understanding the basic concepts of analysis of circular shafts subjected to torsion will enable the students to design and analyze engineering systems.
CO2	**PO1**	By applying the knowledge of engineering fundamentals, the student can understand the behaviour of engineering component subjected to cyclic loading and failure concepts.
	PO2	By studying the failure concept student will able to analysis the problems and arrive at substantiated conclusion.
	PO3	Based on the conceptional knowledge gained by the students, they can develop the solution for the failure concept.
	PO5	Understanding the behaviour of engineering components will helps the students to develop modern engineering tools
	PO9	Students will gain ability to function effectively on multi-disciplinary teams in the area of materials testing.
	PO10	Results obtained from conducting different experiments will help students in better communication of behaviour of engineering components
	PO11	The student can engage themselves to manage the projects and in multidisciplinary environment of the engineering components.
	PO12	Basic knowledge in analysing the mechanical behaviour of engineering materials will aid students to apply in real world problems.
	PSO2	Understanding the behaviour of engineering components in line with standard specifications will help the students to manage engineering projects in a scientific way.
	PSO3	Ability to understand the failure concept of materials will enable students to design and analyze complex problems subjected to cyclic loading.
CO3	**PO1**	The students will develop an understanding on the behaviour of materials subjected to compressive, tension, shear and bending forces.
	PO2	Analysing the mechanical strength properties of engineering materials will enable students to arrive at the conclusion of complex engineering problems.
	PO3	Understanding the concept of bending shear and tensile forces will help the students to develop structural application.
	PO4	Conducting field investigation and understanding problems, students can formulate solutions for problems in strength of materials
	PO5	The students will able to apply the modern tools to determine the ductile and brittle properties of materials
	PO9	Students will gain ability to function effectively on diverse teams in the area of materials testing.

	PO10	Preparing reports of experiments conducted in lab will help students to communicate effectively on complex engineering activities
	PO11	Based on the conceptional knowledge the student can evaluate the strength of materials.
	PO12	Utilising appropriate materials depending upon their properties will help students for applications in real world problems.
	PSO 2	Understanding the mechanical properties of ductile and brittle materials as per standard specifications will enable students to apply them in mechanical engineering projects.
	PSO3	Ability to analyze the mechanical properties of materials will enable students to design and analyze complex mechanical engineering problems.
CO4	**PO1**	Understanding the concepts of microstructural morphology of ductile or brittle materials will help the students to solve the engineering problems
	PO2	Identifying the mechanical properties and practices helps the students to analyse the complex engineering problems
	PO3	Based on the knowledge gained by the students can design solutions that meet the specific needs with appropriate consideration
	PO4	The students can research based on the knowledge including the design of experiments and interpretation of data in mechanical properties.
	PO5	The students can apply appropriate techniques and resources to determine the engineering properties of materials
	PO6	Products can be developed addressing safety, health issues and other problems in society.
	PO7	Students can develop better society by understanding the various sustainable resources and practices in material testing.
	PO8	The ISO standards and specifications in material testing followed in developing design solutions enforce the commitment of professional ethics and responsibilities of an engineer in a student.
	PO9	Students will gain ability to function effectively on diverse teams in the area of materials testing.
	PO10	Students can convey the concept on complex engineering activities with engineering community
	PO11	The students will able to manage principles and apply these to ones own work or in a team in multi-disciplinary environment.
	PO12	Basic knowledge on material testing will help students to engage in real time problems.

	PSO1	Understanding the concepts of microstructural morphology of materials will help the students to solve real time engineering problems
	PSO2	Identifying the ductile and brittle properties of materials as per standard specifications enable the students to analyse engineering problems.
	PSO3	Understanding the microstructural morphology and fracture mode of materials will help the students to design various components in mechanical engineering applications.
CO5	**PO1**	Predicting suitability of material will help students to understand the design and manufacturing of materials.
	PO2	Identifying the suitable material in the field of design can analyse complex engineering problems.
	PO3	Understanding the materials will helps the students to design solutions and design system components in engineering problems
	PO4	Conducting field investigation and research-based knowledge will provide valid conclusions.
	PO5	The students can develop modern engineering tools by understanding the suitable material for the application in the field of design and manufacturing.
	PO6	Students can develop a better society by understanding properties of materials for the design of engineering needs.
	PO7	Students can engage themselves to build up a sustainable world in the field of design.
	PO8	Students will understand the ethical responsibility and norms of the engineering practice in the areas of material testing.
	PO9	Conducting experiments in group will help students to function effectively as a member in diverse teams.
	PO10	Assessing and preparing reports of each experiment will help students to communicate effectively on complex engineering activities
	PO11	Understanding the concept of material will help the student to manage the projects.
	PO12	Application of materials in the field of design and manufacturing help students to apply in real time problems.
	PSO1	Identification of suitable materials will help the students to apply it in real time engineering problems.
	PSO2	Selection of suitable materials as per standard specifications enable the students to manage engineering projects.
	PSO3	Ability to select suitable materials will help students to design and analyze multidisciplinary engineering systems.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs

11. Assessment Pattern (as per university curriculum)

(Provide details as mentioned in syllabus)

Continuous Internal evaluation - 75 marks

End Semester Examination - 75 marks

Total -150 marks

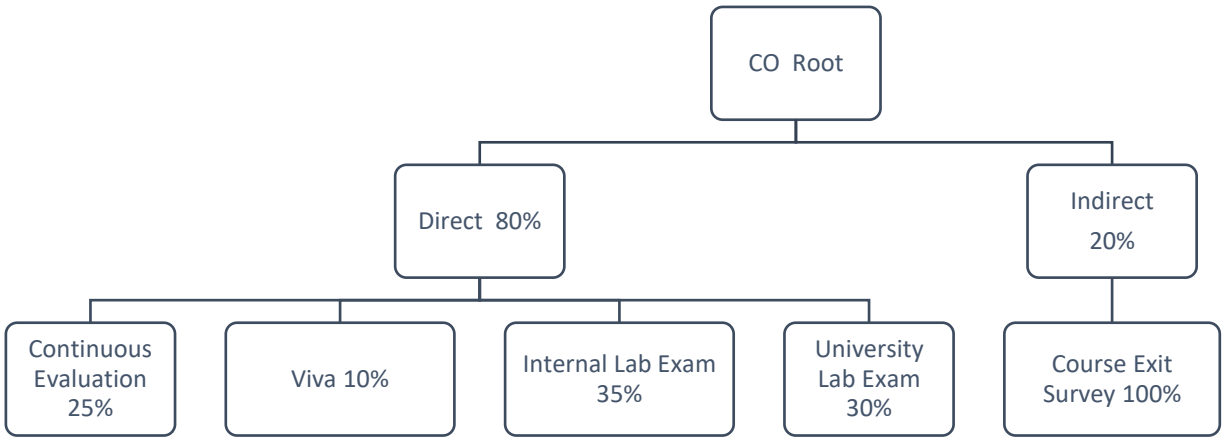
Evaluation criteria (as per syllabus)

Sl. No.	Nature of Evaluation**	Evaluation Pattern**	Topics of Evaluation**	Duration**	Weightage of marks**
1.	**Continuous Internal evaluation (75 marks)**				
a.	Attendance	NA	NA	NA	20%
b.	Continuous Evaluation	Continuous Evaluation-30% Viva-voce-10%	Each experiment	3 hours	40%
c.	Continuous Assessment Test	Procedure-15 marks Conduct – 10 marks, Calculation and Result, Inference – 25 marks, Viva – 25 marks , Total – 75 marks will be converted out of 30 while calculating internal evaluation marks.	All Experiments	2.5 hours	40%
2.	**End Semester Examination (75 marks)**				
a.	End semester Examination	Preliminary work-15 marks Conduct -10 marks Performance, result and inference-25marks and viva – 20 marks Record-5 marks	All Experiments	2.5hrs	100%

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools	Weightage	CO1	CO2	CO3	CO4	CO5
Direct Assessment Tools 80%	Continuous Evaluation Experiment wise CO mapping	25%	x	x	x	x	x
	Viva – Voce Experiment wise CO mapping	10%	x	x	x	x	x
	Internal Lab Exam	35%	x	x	x	x	x
	End Semester Exam – 50%	**50%**	x	x	x	x	x
Indirect Assessment Tool 20%	Course Exit Survey	100%	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Weeks (W)	Experiment	Relevance to COs
1	**B1-1,B2-2,B3-3,B4-4,B5-5**	CO1, CO2, CO3, CO4, CO5
2	**B1-2,B2-3,B3-4,B4-5,B5-1,**	CO1, CO2, CO3, CO4, CO5
3	**B1-3,B2-4,B3-5,B4-1,B5-2,**	CO1, CO2, CO3, CO4, CO5
4	**B1-4,B2-5,B3-1,B4-2,B5-3,**	CO1, CO2, CO3, CO4, CO5
5	**B1-5,B2-1,B3-2,B4-3,B5-4,**	CO1, CO2, CO3, CO4, CO5
6	**B1-6,B2-7,B3-8,B4-9,B5-10**	CO3, CO4, CO5
7	**B1-7,B2-8,B3-9,B4-10,B5-6**	CO3, CO4, CO5
8	**B1-8,B2-9,B3-10,B4-6,B5-7**	CO3, CO4, CO5

9	**B1-9,B2-10,B3-11,B4-7,B5-8**	CO3, CO4, CO5
10	**B1-10,B2-11,B3-12,B4-8,B5-9**	CO3, CO4, CO5
11	**All groups-11,12,13,14,15**	CO2, CO3, CO4, CO5
12	**All groups-11,12,13,14,15**	CO2, CO3, CO4, CO5
Total No. of Hours	38 hours each for batch 1 and batch 2	

Prepared By : Anagha S, Sree Lekshmi G S, Feeba George
Checked By : Bindumol T V, Subject group coordinator

Semester: 4

Curriculum

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MAT202	PROBABILITY, STATISTICS AND NUMERICAL METHODS	3-1-0	4	4
B	MET202	ENGINEERING THERMODYNAMICS	3-1-0	4	4
C	MET204	MANUFACTURING PROCESS	3-1-0	4	4
D	MET206	FLUID MACHINERY	3-1-0	4	4
E	HUT200	PROFESSIONAL ETHICS	2-0-0	2	2
F	MCN202	CONSTITUTION OF INDIA		2	-
S	MEL202	FM & HM LAB	0-0-3	3	2
T	MEL204	MACHINE TOOLS LAB-I	0-0-3	3	2
H	VAC	Remedial/Minor/Honours course	3-1-0	4*	4
TOTAL				25/29	23/27

Course Code & Name: MAT 202 Probability, Statistics and Numerical methods

1. Prescribed Syllabus

Module	Topic	Hours
1	(Text-1: Relevant topics from sections-3.1-3.4, 3.6, 5.1) Discrete random variables and their probability distributions, Expectation, mean and variance, Binomial distribution, Poisson distribution, Poisson approximation to the binomial distribution, Discrete bivariate distributions, marginal distributions, Independent random variables, Expectation -multiple random variables.	9
2	(Text-1: Relevant topics from sections-4.1-4.4, 3.6, 5.1) Continuous random variables and their probability distributions, Expectation, mean and variance, Uniform, exponential and normal distributions, Continuous bivariate distributions, marginal distributions, Independent random variables, Expectation-multiple random variables, i.i.d random variables and Central limit theorem (without proof).	9
3	(Text-1: Relevant topics from sections-5.4, 3.6, 5.1,7.2, 8.1, 8.3, 9.1-9.2,9.4) Population and samples, Sampling distribution of the mean and proportion (for large samples only), Confidence interval for single mean and single proportions (for large samples only). Test of hypotheses: Large sample test for single mean and single proportion, equality of means and equality of proportions of two populations, small sample t-tests for single mean of normal population, equality of means (only pooled t-test, for independent samples from two normal populations with equal variance)	9
4	(Text 2- Relevant topics from sections 19.1, 19.2, 19.3, 19.5) Errors in numerical computation-round-off, truncation and relative error, Solution of equations – Newton-Raphson method and Regula-Falsi method. Interpolation-finite differences, Newton's forward and backward difference method, Newton's divided difference method and Lagrange's method. Numerical integration-Trapezoidal rule and Simpson's 1/3rd rule (Proof or derivation of the formulae not required for any of the methods in this module)	9
5	(Text 2- Relevant topics from sections 20.3, 20.5, 21.1) Solution of linear systems-Gauss-Siedal and Jacobi iteration methods. Curve fitting-method of least squares, fitting staright lines and parabolas. Solution of ordinary differential equations-Euler and Classical Runge-Kutta method of second and fourth order, AdamsMoulton predictor-correction method (Proof or derivation of the formulae not required for any of the methods in this module)	9

2. Text Books (T)

T1. Jay L. Devore, Probability and Statistics for Engineering and the Sciences, 8 th edition, Cengage, 2012.
T2. Erwin Kreyszig, Advanced Engineering Mathematics, 10 th Edition, John Wiley & Sons, 2016.

3. Reference Books (R)

R1. Hossein Pishro-Nik, Introduction to Probability, Statistics and Random Processes, Kappa Research, 2014
R2. Sheldon M. Ross, Introduction to probability and statistics for engineers and scientists, 4th edition, Elsevier, 2009.
R3. T. Veera Rajan, Probability, Statistics and Random processes, Tata McGraw-Hill, 2008
R4. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36 Edition, 2010.

4. Course Objectives

This course introduces students to the modern theory of probability and statistics, covering important models of random variables and techniques of parameter estimation and hypothesis testing. A brief course in numerical methods familiarises students with some basic numerical techniques for finding roots of equations, evaluating definite integrals solving systems of linear equations, and solving ordinary differential equations which are especially useful when analytical solutions are hard to find.

5. Course Pre / Co-requisite

A basic course in one-variable and multi-variable calculus

6. Course Outcomes

At the end of the course students will be able to
CO1: understand the concept, properties and important models of discrete random variables and using them, analyse suitable random phenomena.
CO2: understand the concept, properties and important models of continuous random variables and using them, analyse suitable random phenomena.
CO3: perform statistical inferences concerning characteristics of a population based on attributes of samples drawn from the population
CO4: compute roots of equations, evaluate definite integrals and perform interpolation on given numerical data using standard numerical techniques
CO5: apply standard numerical techniques for solving systems of equations, fitting curves on given numerical data and solving ordinary differential equations.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	H	M	M	M	M					M		L			
CO2	H	M	M	M	M					M		L			
CO3	H	M	M	M	M					M		L			
CO4	H	M	M	M	M					M		L			
CO5	H	M	M	M	M					M		L			

8. Justification for CO-PO-PSO Correlation

CO1-PO1	The knowledge of discrete random variables will help to deal with complex problems related to randomness
CO1-PO2	The concept of discrete random variables will help to analyse random phenomena associated with complex engineering problems
CO1-PO3	The concept of discrete probability density functions and special probability distributions are used to design systems that meet the specific needs with appropriate consideration for public health and environmental issues
CO1-PO4	The concept of discrete probability density functions and special probability distributions can be used to conduct investigations of complex problems involving the synthesis of data to provide valid conclusions
CO1-PO5	The concept of discrete probability density functions and special probability distributions can be used to create, select and apply appropriate techniques, modern engineering and IT tools including prediction and modelling to complex engineering activities
CO1-PO10	The knowledge of discrete random variables and their distributions will help to explain effectively on different types of discrete distributions
CO1-PO12	The knowledge of discrete random variables and their distributions will help to understand its broadest context by lifelong learning process
CO2-PO1	The fundamental knowledge of continuous probability distributions is used to solve complex engineering problems
CO2-PO2	The concept of continuous random variables will help to identify, formulate and analyse random phenomena associated with complex engineering problems and provide economical solutions
CO2-PO3	The concept of continuous probability density functions and special probability distributions are used to design solutions of complex engineering problems
CO2-PO4	The concept of continuous probability density functions and special probability distributions can be used to conduct investigations of complex problems involving design of experiments, analysis and interpretation of the data to provide valid conclusions

CO2-PO5	The concept of continuous probability density functions and special probability distributions can be used to apply appropriate techniques including prediction and modelling to complex engineering activities
CO2-PO10	The knowledge of continuous probability density functions and special probability distributions will help to communicate effectively on various continuous distributions
CO2-PO12	The concept of continuous probability density functions and special probability distributions can be used and applied in the future course of action
CO3-PO1	Basic knowledge of statistical methods will help to solve problems in Engineering.
CO3-PO2	The study of statistical inferences drawn from a population can be used to analyse complex Engineering problems.
CO3-PO3	Statistical inferences concerning characteristics of a population based on attributes of samples drawn from the population can be used to design solutions for complex engineering problems.
CO3-PO4	Study of statistical inferences will help to conduct investigation of complex problems involving analysis and interpretation of data to obtain valid conclusions.
CO3-PO5	Statistical inferences concerning characteristics of a population based on attributes of samples drawn from the population will help to select appropriate techniques in complex engineering activities.
CO3-PO10	Statistical inferences drawn from a population will help to communicate effectively on complex engineering activities.
CO3-PO12	Study of statistical inferences will help to engage in independent and lifelong learning.
CO4-PO1	The knowledge of numerical techniques can be used to solve engineering problems
CO4-PO2	The methods to compute roots of equations, evaluate definite integrals and perform interpolation on given numerical data can be used to formulate and analyse complex engineering problems.
CO4-PO3	Numerical integration, interpolation and numerical techniques to find solution of equations can be used in the development of solutions for various problems in engineering.
CO4-PO4	The knowledge of standard numerical techniques is used to conduct investigations of complex problems involving the synthesis of data to provide valid conclusions.
CO4-PO5	Various methods to compute roots of equations, evaluate definite integrals and interpolation will help to select and apply appropriate numerical techniques in complex engineering activities with an understanding of the limitations.
CO4-PO10	Standard numerical techniques to compute roots of equations, evaluate definite integrals and perform interpolation on given numerical data will help in the effective communication on issues related to engineering community.

CO4-PO12	The knowledge of standard numerical techniques will enhance the ability to engage in independent and lifelong learning.
CO5-PO1	Fundamental knowledge of various numerical techniques will help to solve problems arising in engineering
CO5-PO2	Application of standard numerical techniques for solving systems of equations, fitting curves on given numerical data and solving ordinary differential equations helps to analyse problems with high complexity in Engineering.
CO5-PO3	Various numerical techniques are used to design solutions for complex engineering problems
CO5-PO4	The concept of numerical methods of solution helps to conduct investigation of complex problems
CO5-PO5	Application of standard numerical methods will help to select appropriate techniques in complex engineering activities.
CO5-PO10	Knowledge of various numerical techniques will help to communicate effectively on complex engineering activities.
CO5-PO12	The concept of standard numerical methods can be used and applied in the future course of action.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs

11. Internal Assessment mark allocation (as per university curriculum)

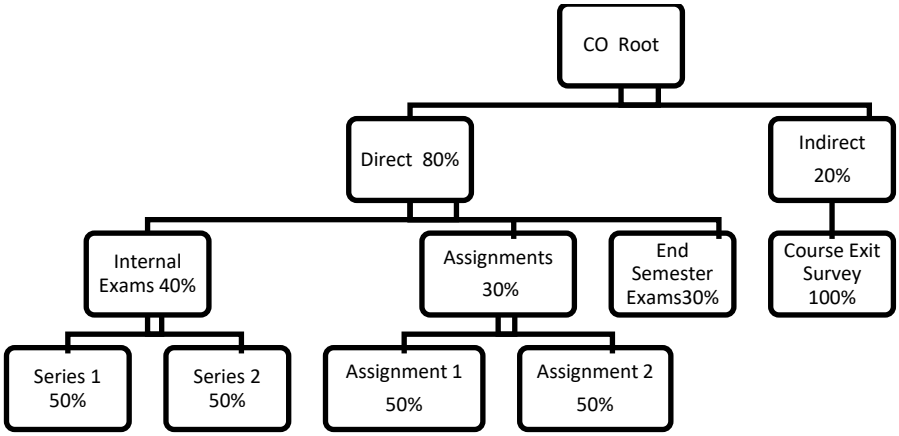
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		Weightage#	CO1	CO2	CO3	CO4	CO5
Direct Assessment Tools	Internal Exam(s) 40%	Series 1	20%	x	x			
		Series 2	20%			x	x	x
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x	x			
		Assignment 2	15%			x	x	x
	End Semester Exam		30%	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x

13. **Assessment Configuration**



14. Course Plan

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1	Discrete random variables and probability distributions	1	T1	Lecture
2	Expected value, mean and variance (discrete)	1	T1	Lecture

3	Expected value, mean and variance (discrete)	1	T1	Lecture
4	Binomial distribution-mean, variance	1	T1	Lecture
5	Poisson distribution-mean,variance	1	T1	Tutorial
6	Poisson approximation to binomial	1	T1	Lecture
7	Discrete bivariate distributions, marginal distributions	1	T1	Lecture
8	Discrete bivariate distributions, marginal distributions, Independence of random variables (discrete), Expected values	1	T1	Lecture
9	Discrete bivariate distributions, marginal distributions, Independence of random variables (discrete), Expected values	1	T1	Tutorial
10	Continuous random variables and probability distributions	2	T1	Lecture
11	Expected value, mean and variance (continuous)	2	T1	Lecture
12	Uniform distribution, mean and variance	2	T1	Lecture
13	Exponential distribution, mean and variance	2	T1	Tutorial
14	Normal distribution, mean and variance	2	T1	Lecture
15	Normal distribution, mean and variance	2	T1	Lecture
16	Continuous bivariate distributions, marginal distributions, Independent random variables, Expected values	2	T1	Lecture
17	Continuous bivariate distributions, marginal distributions, Independent random variables, Expected values, Central Limit Theorem	2	T1	Lecture
18	Central Limit Theorem	2	T1	Tutorial
19	Population and samples, Sampling distribution of the mean and proportion (for large samples only)	3	T1	Lecture
20	Confidence interval for single mean and single proportions (for large samples only)	3	T1	Lecture
21	Test of hypotheses: Large sample test for single mean and single proportion	3	T1	Lecture
22	Test of hypotheses: Large sample test for single mean and single proportion	3	T1	Tutorial
23	Equality of means and equality of proportions of two populations	3	T1	Lecture

24	Equality of means and equality of proportions of two populations	3	T1	Tutorial
25	Small sample t-tests for single mean of normal population	3	T1	Lecture
26	Equality of means (only pooled t-test, for independent samples from two normal populations with equal variance)	3	T1	Lecture
27	Equality of means (only pooled t-test, for independent samples from two normal populations with equal variance)	3	T1	Lecture
28	Roots of equations- Newton-Raphson, Regulafalsi methods	4	T2	Lecture
29	Roots of equations- Newton-Raphson, Regulafalsi methods	4	T2	Lecture
30	Interpolation-finite differences	4	T2	Lecture
31	Newton's forward and backward formula	4	T2	Lecture
32	Newton's forward and backward formula	4	T2	Tutorial
33	Newton's divided difference method, Lagrange's method	4	T2	Lecture
34	Newton's divided difference method, Lagrange's method	4	T2	Lecture
35	Numerical integration-trapezoidal rule and Simpson's 1/3-rd rule	4	T2	Lecture
36	Numerical integration-trapezoidal rule and Simpson's 1/3-rd rule	4	T2	Tutorial
37	Solution of linear systems-Gauss-Siedal method, Jacobi iterationmethod	5	T2	Lecture
38	Solution of linear systems-Gauss-Siedal method, Jacobi iterationmethod	5	T2	Lecture
39	Curve-fitting-fitting straight lines and parabolas to pairs of data points using method of least squares	5	T2	Lecture
40	Curve-fitting-fitting straight lines and parabolas to pairs of data points using method of least squares	5	T2	Tutorial
41	Solution of ODE-Euler	5	T2	Lecture
42	Classical Runge-Kutta method ofsecond order	5	T2	Lecture
43	Classical Runge-Kutta method fourth order	5	T2	Lecture
44	Classical Runge-Kutta method fourth order	5	T2	Tutorial
45	Adams-Moulton predictor-corrector methods	5	T2	Lecture

15. Question Bank

Module 1				
Sl. No	**Question**	**Marks**	**CO**	**BL**
1	In a binomial distribution, if the mean is 6, and the variance is 4, find P[X=1].	3	CO1	L1
2	X follows Poisson distribution with mean 6. Find P[X=1], Variance (x)	3	CO1	L1
3	The probability mass function of a random variable X is given below: x: 0 | 1 | 2 | 3 $f(x)$: c | $2c^2$ | c^2 | $3c^2$ Determine (i) the value of c (ii) $P(X \geq 1)$	3	CO1	L1
4	8 coins are tossed 256 times. In how many tosses do you expect no heads?	3	CO1	L1
5	If a random variable X takes the values 1,2,3,4 such that 2P[X=1]=3P[X=2]=P[X=3]=5P[X=4], find the probability distribution.	3	CO1	L2
6	If a random variable X takes values {-1,0,1} such that P[X=-1]=2P[X=0]=P[X=1]. Find the mean of 3X+7.	3	CO1	L2
7	In a random experiment of throwing a die, let X denote the number turned up. Find its mean.	3	CO1	L2
8	If X and Y are independent with $P_X(0) = 0.5, P_X(1) = 0.3, P_X(2) = 0.2, P_Y(0) = 0.6, P_Y(1) = 0.1, P_Y(2) = P_Y(3) = 0.05, P_Y(4) = 0.2$, display the joint pmf of (X,Y) in a table. Also compute $P[X \leq 1, Y \leq 1]$.	3	CO1	L2
9	The probability distribution function of a random variable X is given below. X: 0 | 1 | 2 | 3 $f(x)$: 0.1 | 0.3 | 0.4 | 0.2 Find $E(Y)$ where $Y = X^2 + X$.	3	CO1	L2

<table>
<tr><td>10</td><td>The probabilities that there will be 0, 1, 2, 3 power failures for a certain machine in the month of June are 0.4, 0.3, 0.2, 0.1 respectively. Find the mean and variance for the number of failures.</td><td>3</td><td>CO1</td><td>L2</td></tr>
<tr><td>11</td><td>The joint distribution of X and Y is as follows:
<table>
<tr><td>X Y</td><td>-1</td><td>0</td><td>1</td></tr>
<tr><td>-1</td><td>3/20</td><td>1/10</td><td>1/10</td></tr>
<tr><td>0</td><td>1/10</td><td>1/10</td><td>1/5</td></tr>
<tr><td>1</td><td>1/20</td><td>3/20</td><td>1/20</td></tr>
</table>
Find E(X+Y)</td><td>3</td><td>CO1</td><td>L2</td></tr>
<tr><td>12</td><td>If X is a Poisson variable such that $P[X = 1] = P[X = 2]$, then find $P[X = 3]$.</td><td>3</td><td>CO1</td><td>L2</td></tr>
<tr><td>13</td><td>A continuous random variable X is uniformly distributed in$(-k, k)$. Find k if $P[X \geq 2] = 0.25$.</td><td>3</td><td>CO1</td><td>L2</td></tr>
<tr><td>14</td><td>Given that f(x) = $\frac{K}{2^x}$ is a probability mass function of a random variable that can take on the values x = 0,1,2,3 and 4, find (i) K and (ii) $P(X \leq 2)$.</td><td>3</td><td>CO1</td><td>L2</td></tr>
<tr><td>15</td><td>Suppose X is a binomial random variable with parameters n=100 and p=0.02. Find P[X<3] using Poisson approximation to X.</td><td>3</td><td>CO1</td><td>L2</td></tr>
<tr><td>16</td><td>A random variable X takes the values -3, -2, -1,0,1,2,3 such that P(X=0) = P(X>0) = P(X<0) and P(X=-3) = P(X=-2) = P(X=-1) = P(X=1) = P(X=2) = P(X=3). Obtain the probability mass function and distribution function of X.</td><td>7</td><td>CO1</td><td>L2</td></tr>
<tr><td>17</td><td>The probability mass function of a discrete random variable is $p(x) = kx, x = 1, 2, 3$ where a positive constant. Find (i)the value of k (ii) $P(X \leq 2)$ (iii) $E[X]$ and (iv) var$(1 - X)$.</td><td>7</td><td>CO1</td><td>L2</td></tr>
<tr><td>18</td><td>A lot of 10 items contain 3 defectives from which a sample of 4 items are drawn without replacement. Let X denote the number of defectives in the sample. Find (i) the probability distribution of X (ii) P[X<1] (iii)P[0<X<2]</td><td>7</td><td>CO1</td><td>L2</td></tr>
<tr><td>19</td><td>A coin is biased so that its head is twice as likely to appear as its tail. If the coin is tossed 6 times, find the probability of getting
(i) exactly 2 heads
(ii) at least 3 heads
(iii) at most 4 heads</td><td>7</td><td>CO1</td><td>L2</td></tr>
</table>

20	Find the mean and variance of a Binomial random variable.	7	CO1	L2
21	Derive mean and variance of Poisson distribution.	7	CO1	L2
22	The joint probability distribution of X and Y is given by $f(x,y) = \frac{2x+3y}{54}$ for $x = 1,2;\ y = 1,2,3$. Find (i) the marginal distributions of X and Y	7	CO1	L2
23	The joint distribution of a two-dimensional random variable (X,Y) is given by p(x,y)=c(2x+3y), x=0,1,2 ; y=1,2,3. Find (i) the value of c (ii) the marginal distributions (iii) Are X and Y independent? (8)	7	CO1	L2
24	The joint probability distribution of X and Y is given by, $f(x,y) = \frac{1}{27}(2x+y)$; x =0,1,2 and y = 0,1,2. (i) Find the marginal distributions of X and Y. (ii) Are X and Y independent random variables.	7	CO1	L2
25	The pdf of a random variable X is given below. Find $k, P(X<4), E(X), Var(X)$. X: 0, 1, 2, 3, 4, 5, 6 $f(x)$: k, $3k$, $5k$, $7k$, $9k$, $11k$, $13k$	7	CO1	L2
26	The joint probability mass function of two random variables X and Y is given by $p(x,y) = \begin{cases} k(x+2y) & for\ x = 1,2,3\ \ y = 1,2 \\ 0 & otherwise \end{cases}$ where k is a constant. (i) Find the value of k (ii) Find $P[X+Y \le 3]$ (iii) Find the marginal density functions of X and Y and (iv) Are X and Y independent?	7	CO1	L2
27	Find a, b if $Y = aX + b$ has mean 4 and variance 16, where X is a random variable with mean 8 and variance 4.	7	CO1	L2
28	a) A random variable X has the following probability distribution: X: -2, -1, 0, 1, 2, 3 $f(x)$: 0.1, $15k^2$, 0.2, $2k$, 0.3, $3k$ (i) Find the value of k, (ii) the mean and variance of X.	7	CO1	L2
29	The joint pdf of X, Y is given by $f(x,y) = k(x+2y), x = 1,2,3; y = 1,2,3$. Find (i) k (ii) marginal pdf of X, Y (iii) $P(X<3, Y \ge 2)$.	7	CO1	L2

30	A random variable X takes values 0,1, 2 and 3 with probabilities $P(X=0)=\frac{8}{15}$, $P(X=1)=\frac{1}{3}$, $P(X=2)=P(X=3)=\frac{1}{15}$ (i) Find the mean and variance of X. If $Y=1000+300X$ find $P(Y\geq 1500)$ and $E[Y]$	7	CO1	L3
31	The probability of an item produced by a certain machine will be defective is 0.05. If the produced items are sent to the market in packets of 20, find the number of packets containing (i) atleast 2 (ii) exactly 2 (ii) atmost 2 defective items in a consignment of 1000 packets using Poisson distribution.	7	CO1	L3
32	The probability that an electric component manufactured by a firm is defective is 0.01. If the produced items are sent to the market in packets of 10, find the number of packets containing exactly two defectives and at most two defectives in a consignment of 1000 packets using (i) binomial distributionand (ii) Poisson approximation to binomial distribution. (8)	7	CO1	L3
33	A complex electronic system is built with a certain number of backup components in itssubsystems. One subsystem has four identical components, each with a probability of 0.2 offailing in less than 1000 hours. The subsystem will operate if any two of the four componentsare operating. Assume that the components operate independently. Find the probability that i)exactly two of the four components last longer than 1000 hours. ii)the subsystem operates longer than 1000 hours.	7	CO1	L3
34	A gambler plays a game of rolling a die with the following rules. He will win Rs. 200 if he throws a 6, but will lose Rs. 40 if he throws 4 or 5 and lose Rs. 20 if he throws 1, 2 or 3. Find the expected value that the gambler may gain.	7	CO1	L3
35	Two fair dice are rolled. Let X denote the number on the first die and $Y = 0$ or 1, according as the first die shows an even number or odd number. Find (i) the joint probability distribution of X and Y, (ii) the marginal distributions. (iii) Are X and Y independent ?	7	CO1	L3
36	The number of gamma rays emitted per second by a certain radioactive substance follows a Poisson distribution with mean 8. Determine the probability that (i) three particles are emitted in one second (ii) at most one particle is emitted in one second (iii) more than one particle is emitted in one second.	7	CO1	L3
37	It is known that 2% of the bolts produced by a company are defective. The bolts are supplied in boxes of 200 bolts. What is the probability that a randomly chosen box contains not more than 5 defective bolts? In a consignment of 1000 such boxes how many can be expected to have more than 5 defective bolts? (Use Poisson distribution)	7	CO1	L3
Module 2				

Sl. No	Question	Marks	CO	BL
1	A random variable X has the probability density function $f(x) = kx(2x-1), 0 < x < 2$. Find the value of k and mean.	3	CO 2	L2
2	Find the mean and variance of the continuous random variable X with probability density function $f(x) = \begin{cases} 2x-4, 2 \le x \le 3 \\ 0, \quad \text{otherwise} \end{cases}$	3	CO 2	L2
3	Find the mean and variance of the probability density $f(x) = \begin{cases} \cos x, 0 < x < \frac{\pi}{2} \\ 0, \quad \text{elsewhere} \end{cases}$	3	CO 2	L2
4	If random variable X has a uniform distribution in (-3,3), find $P(\mid X-2 \mid < 2)$.	3	CO 2	L2
5	A continuous random variable X is uniformly distributed with mean 1 and variance 4/3. Find $P(X < 0)$	3	CO 2	L2
6	A random variable X follows exponential distribution with mean 3. Find $P(X > 3), Variance(X)$	3	CO 2	L2
7	A random variable X follows exponential distribution with mean 6. Find the probability of (i) $P(X \le 10)$ (ii) $P(5 \le X \le 10)$.	3	CO 2	L2
8	The joint density of two random variables is given by $f(x,y) = \begin{cases} ke^{-2x-3y}, x \ge 0, y \ge 0 \\ 0, \quad otherwise \end{cases}$ Find the value of k.	3	CO 2	L2
9	A continuous random variable X is uniformly distributed in $(-k, k)$. Find k if $P[X \ge 2] = 0.25$.	3	CO 2	L2
10	If $X_1, X_2, \ldots, X_n$ are random variables with mean $\mu = 2$ and variance $\sigma^2 = 2$, then use central limit theorem to estimate $P[110 \le S_n \le 150]$, where $S_n = X_1 + X_2 + \cdots + X_n$ and $n = 75$.	3	CO 2	L2
11	The random variable X is exponentially distributed with mean 3. Find $P(X > t+3 \mid X > t)$ where t is any positive real number.	3	CO 2	L3

12	Find the mean and variance for the pdf $f(x) = \begin{cases} kx^2, & 0 < x < 1 \\ 0, & \text{elsewhere} \end{cases}$	7	CO 2	L2
13	If a continuous random variable has pdf $f(x) = \begin{cases} k\,e^{-3x}, & x > 0 \\ 0, & x = 0 \end{cases}$ Find (i) value of k (ii) $P[0 = X = 2]$ (iii)$P[X > 1.5]$	7	CO 2	L2
14	Find the mean and variance of a random variable X which is uniformly distributed in the interval $[a, b]$	7	CO 2	L2
15	Derive mean and variance of exponential distribution.	7	CO 2	L2
16	Suppose that the length of a phone call in minutes is an exponential random variable with parameter $\lambda = \frac{1}{10}$. If someone arrives immediately ahead of you at a public telephone booth, find the probability that you will have to wait: i) More than 10 minutes ii) Between 10 and 20 minutes.	7	CO 2	L2
17	A continuous random variable has the distribution function $F(x) = \begin{cases} 0 & if\ x < 0 \\ k(x-1)^3 & if\ 0 \le x \le 4 \\ 1 & if\ x > 4 \end{cases}$. Find (i) value of k (ii) probability density function $f(x)$ of $F(x)$ and (iii) $P[X \ge 1]$.	7	CO 2	L2
18	If X is a random variable with PDF $f(x) = \begin{cases} \frac{x^2}{3}, & -1 < x < 2 \\ 0, & elsewhere \end{cases}$. Find (i) Mean of X (ii) Variance of X (iii) Cdf of X.	7	CO 2	L2
19	The lifetime of a certain type of electric bulb may be considered as an exponential random variable with mean 50 hours. Using central limit theorem, find the approximate probability that 100 of these electric bulbs will provide a total of more than 6000 hours of burning time.	7	CO 2	L3
20	A bus arrives every 10 minutes at a bus stop. Assuming that the waiting time X for a bus is uniformly distributed, find the probability that the person has to wait (i) For more than 7 minutes **(ii)** Between 2 to 7 minutes	7	CO 2	L3

21	The monthly salary (in Rs.) of 1000 employees in a factory are normally distributed with mean 20,000 and standard deviation 5000. Estimate the number of employees whose monthly salary will be (i) between 18,000 and 22,000 (ii) less than 18,000?	7	CO 2	L3
22	The IQ of an individual randomly selected from a population is a normal distribution with mean 100 and standard deviation 15. Find the probability that an individual has IQ (i) above 140 (ii) between 120 and 130.	7	CO 2	L3
23	The actual amount of instant coffee that a filling machine puts into 4 ounce jars may be looked upon as a random variable having a normal distribution with $s = 0.04$ ounce. If only 2% of the jars are to contain less than 4 ounces, what should be the mean fill of these jars.	7	CO 2	L3
24	In an examination 30% of the candidates obtained marks below 40 and 10% of the candidates got above 75 marks. Assuming that the marks are normally distributed, find the mean and standard deviation of the distribution.	7	CO 2	L3
25	The time to microwave a bag of popcorn using the automatic setting can be treated as a random variable having a Normal distribution with standard deviation 10 seconds.if the probability is 0.8212 that the bag will take less than 282.5 seconds to pop,find the probability that it will take longer than 258.3 seconds to pop.	7	CO 2	L3
26	The joint probability density function of two continuous random variables X and Y is given by $f(x,y) = \begin{cases} kx^2y & if\ 1 \le x \le 4, 0 \le y \le 4 \\ 0 & otherwise \end{cases}$. Find (i) value of k (ii) $P[X \ge 2, Y \le 2]$ and (iii) $P[X + Y < 3]$.	7	CO 2	L3
27	The time (in hours) required to repair a machine is exponentially distributed with mean 2. (i) What is the probability that the repairing time exceeds 2 hours? (ii) What is the conditional probability that a repair takes at least 10 hours given that its duration exceeds 9 hours?	7	CO 2	L3
28	Suppose the diameter at breast height (in.) of trees of a certain type is normally distributed with mean 8.8 and standard deviation 2.8 (i) What is the probability that the diameter of a randomly selected tree will be at least 10 in.? (ii) What is the probability that the diameter of a randomly selected tree will exceed 20 in.? (iii) What is the probability that the diameter of a randomly selected tree will be between 5 in and 10 in.?	7	CO 2	L3
29	Buses arrived at a specified stop at 15 minute intervals starting at 7 am. A passenger arrives at the stop at random time between 7 am and 7.30 am. Find the probability that he waits (i) less than 5 minutes, (ii) at least 12 minutes.	7	CO 2	L3

30	For a normally distributed population, 31% of the items have their values less than 45 and 8% are above 64. Find the mean and standard deviation of the distribution.	7	CO 2	L3
31	The lifetime of a certain type of machine follows an exponential distribution with mean 50 hours. Use Central Limit Theorem to find the probability that 100 of these machines will provide a total life time of more than 6000 hours.	7	CO 2	L3
32	In a Normal distribution 17% of items are below 30 and 17% of the items are above 60. Find mean and variance	7	CO 2	L3
33	The joint density function of two continuous random variables X, Y is given by $f(x,y) = \begin{cases} K(1-x-y), & 0 < x < \frac{1}{2}; 0 < y < \frac{1}{2} \\ 0, & otherwise \end{cases}$. Find (i) the value of K $(ii) P\left(X < \frac{1}{4}, Y > \frac{1}{4}\right)$ (iii) the marginal distributions of X, Y (iv) check whether X, Y are independent.	7	CO 2	L4
34	The joint density function of random variables X and Y is given by $f(x,y) = \begin{cases} e^{-(x+y)}, & x > 0, \quad y > 0 \\ 0 & \text{otherwise.} \end{cases}$ Find $P(X + Y \leq 1)$. Are X and Y independent? Justify.	7	CO 2	L4
35	The joint pdf of (X,Y) is $f(x,y) = \begin{cases} 8xy, & 0 < y < x < 1 \\ 0, & \text{otherwise} \end{cases}$ i) Check whether X and Y are independent ii) Find $P(X + Y < 1)$	7	CO 2	L4
36	The joint density function of 2 continuous random variable X and Y is $f(x,y) = \begin{cases} cxy ; & 0 < x < 4, \quad 1 < y < 5 \\ 0 ; & otherwise \end{cases}$ (i) Find the value of the constant c. (ii) Find P ($X \geq 3, Y \leq 2$) (iii) Find the marginal density of X.	7	CO 2	L4
37	The life time of a certain brand of tube light may be considered as a random variable with mean 1200 hours and standard deviation 250 hours. Using Central limit theorem, find the probability that the average life time of 60 lights exceeds 1250.	7	CO 2	L5

38	If $X_1, X_2, \ldots \ldots X_n$ are Poisson variables with parameter λ=2, use the central limit Theorem to estimate $P(120 < S_n < 160)$ where $S_n = X_1 + X_2 + \cdots \ldots + X_n$ with n=75.	7	CO 2	L5
39	A random sample of size 100 is taken from a population with mean 60 and variance 400.Using Central limit Theorem, with what probability can we assert that the mean of the sample will not differ from μ=60 by more than 4.	7	CO 2	L5

Prepared By : Prof. Neethu Rose T.H

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Approved By : V P Academics

Course Code & Name: MET202 Engineering Thermodynamics

1. Prescribed Syllabus

Module	Topic	Hours
1	Role of Thermodynamics and it's applications in Engineering and Science –Basic Concepts Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic System and Control Volume, Surrounding, Boundaries, Types of Systems, Universe, Thermodynamic properties, Process, Cycle, Thermodynamic Equilibrium, Quasi – static Process, State, Point and Path function. Zeroth Law of Thermodynamics, Measurement of Temperature, reference Points, Temperature Scales.	**5**
2	Energy - Work - Pdv work and other types of work transfer, free expansion work, heat and heat capacity. Joule's Experiment- First law of Thermodynamics - First law applied to Non flow Process- Enthalpy- specific heats- PMM1, First law applied to Flow Process, Mass and Energy balance in simple steady flow process. Applications of SFEE, Transient flow –Filling and Emptying Process, Limitations of the First Law	**11**
3	Second Law of Thermodynamics, Thermal Reservoir, Heat Engine, Heat pump – KelvinPlanck and Clausius Statements, Equivalence of two statements, Reversibility, Irreversible Process, Causes of Irreversibility, PMM2, Carnot's theorem and its corollaries, Absolute Thermodynamic Temperature scale. Clausius Inequality, Entropy- Entropy changes in various thermodynamic processes, principle of increase of entropy and its applications, Entropy generation, Entropy and Disorder, Reversible adiabatic process- isentropic process, Third law of thermodynamics, Available Energy, Availability and Irreversibility- Second law efficiency.	**11**
4	Pure Substances, Phase Transformations, Triple point, properties during change of phase, T-v, p-v and p-T diagram of pure substance, p-v-T surface, Saturation pressure and Temperature, T-h and T-s diagrams, h-s diagrams or Mollier Charts, Dryness Fraction, steam tables. Property calculations using steam tables. The ideal Gas Equation, Characteristic and Universal Gas constants, Deviations from ideal Gas Model: Equation of state of real substances, Vander Waals Equation of State, Virial Expansion, Compressibility factor, Law of corresponding state, Compressibility charts.	**8**
5	Mixtures of ideal Gases – Mole Fraction, Mass fraction, Gravimetric and volumetric Analysis, Dalton's Law of partial pressure, Amagat's Laws of additive volumes, Gibbs-Dalton's law Equivalent Gas constant and Molecular Weight, Properties of gas mixtures: Internal Energy, Enthalpy, specific heats and Entropy, Introduction to real gas mixtures- Kay's rule. General Thermodynamic Relations – Combined First and Second law equations – Helmholtz and Gibb's functions - Maxwell's Relations, Tds Equations. The Clapeyron Equation, equations for internal energy, enthalpy and entropy, specific heats, Throttling process, Joule Thomson Coefficient, inversion curve	**10**

2. Text Books (T)

T1. P. K. Nag, Engineering Thermodynamics, McGraw Hill, 2013
T2. E. Rathakrishnan Fundamentals of Engineering Thermodynamics, PHI, 2005
T3. Y. A. Cengel and M. A. Boles, Thermodynamics an Engineering Approach, McGraw Hill, 2011

3. Reference Books (R)

R1. Moran J., Shapiro N. M., Fundamentals of Engineering Thermodynamics, Wiley, 2006
R2. R. E. Sonntag and C. Borgnakke, Fundamentals of Thermodynamics, Wiley, 2009
R3. Holman J. P. Thermodynamics, McGraw Hill, 2004
R4. M. Achuthan, Engineering Thermodynamics, PHI, 2004 COURSE PLA

4. Course Objectives

Introduction to the basic concepts and laws of thermodynamics.

5. Course Pre / Co-requisite

NIL

6. Course Outcomes

After completing this course, students will be able to:
CO1: Understand basic concepts and laws of thermodynamics
CO2: Conduct first law analysis of open and closed systems
CO3: Determine entropy and availability changes associated with different processes
CO4: Understand the application and limitations of different equations of state
CO5: Determine change in properties of pure substances during phase change processes
CO6: Evaluate properties of ideal gas mixtures

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	M										M			H
CO2	M	M	L	L								L			H
CO3	H	H	M	M								L			
CO4	M	M	M	M								L			
CO5	H	H	M	L								L			

8. Justification for CO-PO-PSO Correlation

CO1	**PO1**	Students will be able to apply basic laws and concepts of thermodynamics to check if a given process is possible or not.
	PO2	Students will be able to apply laws and basic concepts of thermodynamics to formulate, review literature and analyse complex problems reaching substantiated conclusion.
	PO12	Students will be able to use laws and basic concepts of thermodynamics to recognize the need for, and have the preparation and ability to engage in independent and life-long learning.
	PSO3	Students will be able to use laws and basic concepts of thermodynamics to design and analyse multi-disciplinary systems.
CO2	**PO1**	Students will be able to apply first law analysis to solve complex engineering problems.
	PO2	Students will be able to apply first law analysis to analyse complex problems to arrive at a substantiated conclusion.
	PO3	Students will be able to apply first law analysis to develop design solutions for processes that meet the specified needs with appropriate consideration for the public health and safety and environmental considerations.
	PO4	Students will be able to apply first law analysis to conduct investigations of complex engineering problems and synthesis the information to provide valid conclusions.
	PO12	Students will be able to apply first law analysis to recognize the need for, and have the preparation and ability to engage in independent and life-long learning.
	PSO3	Students will be able to apply first law analysis to design and analyse multi-disciplinary systems.
CO3	**PO1**	Students will be able to determine entropy and availability changes associated with different processes to solve complex engineering problems.
	PO2	Students will be able to apply first law analysis to analyse complex problems to arrive at a substantiated conclusion.
	PO3	Students will be able to determine entropy and availability changes associated with different processes to develop design solutions for processes that meet the specified needs with appropriate environmental and safety considerations.
	PO4	Students will be able to determine entropy and availability changes associated with different processes to conduct investigations of complex engineering problems and synthesis the information to provide valid conclusions.
	PO12	Students will be able to determine entropy and availability changes associated with different processes to recognize the need for, and have the preparation and ability to engage in independent and life-long learning.
CO4	**PO1**	Students will be able to use the knowledge of limitations of different equations of state to solve complex engineering problems.
	PO2	Students will be able to use the knowledge of limitations of different equations of state to analyse complex problems to arrive at a substantiated conclusion.
	PO3	Students will be able to use the knowledge of limitations of different equations of state to develop design solutions for processes that meet the specified needs with appropriate consideration for the public health and safety and environmental considerations.

	PO4	Students will be able to use the knowledge of limitations of different equations of state to conduct investigations of complex engineering problems and synthesis the information to provide valid conclusions.
	PO12	Students will be able to use the knowledge of limitations of different equations of state to recognize the need for, and have the preparation and ability to engage in independent and life-long learning.
CO5	**PO1**	Students will be able to use the knowledge of limitations of different equations of state to solve complex engineering problems.
	PO2	Students will be able to use the knowledge of limitations of different equations of state to analyse complex problems to arrive at a substantiated conclusion.
	PO3	Students will be able to determine change in properties of pure substances to develop design solutions for processes and complex engineering problems.
	PO4	Students will be able to determine change in properties of pure substances to conduct investigations of complex engineering problems and synthesis the information to provide valid conclusions.
	PO12	Students will be able to determine change in properties of pure substances to recognize the need for, and have the preparation and ability to engage in independent and life-long learning.
CO6	**PO1**	Students will be able to evaluate properties of ideal gas mixtures to solve complex engineering problems.
	PO2	Students will be able to evaluate properties of ideal gas mixtures to analyse complex problems to arrive at a substantiated conclusion.
	PO3	Students will be able to evaluate properties of ideal gas mixtures to develop design solutions for processes and complex engineering problems.
	PO4	Students will be able to evaluate properties of ideal gas mixtures to conduct investigations of complex engineering problems and synthesis the information to provide valid conclusions.
	PO12	Students will be able to evaluate properties of ideal gas mixtures to recognize the need for, and have the preparation and ability to engage in independent and life-long learning.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	Lab visit	Visiting Thermal Engineering lab	PO5, PO8

11. Internal Assessment mark allocation (as per university curriculum)

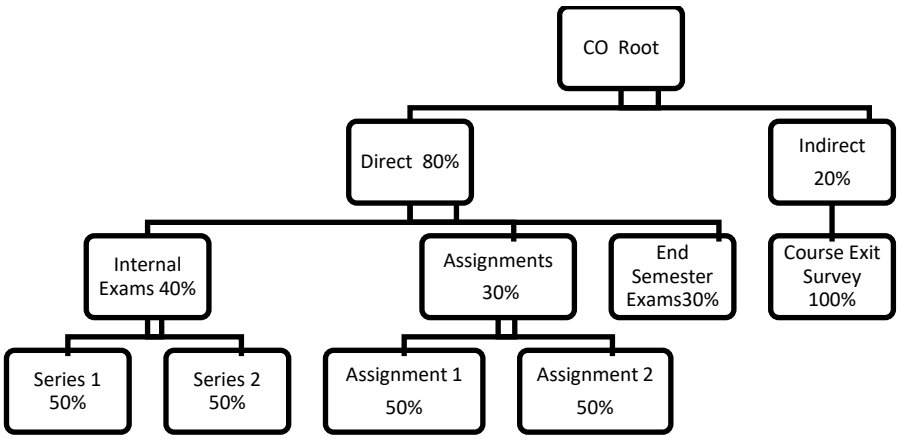
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		Weightage#	CO1	CO2	CO3	CO4	CO5	CO6
Direct Assessment Tools	Internal Exam(s) 40%	Series 1	20%	x	x	x			
		Series 2	20%	x	x	x	x	x	x
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x	x	x			
		Assignment 2	15%				x	x	x
	End Semester Exam		30%	x	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1	Role of Thermodynamics and it's applications in Engineering and Science – Basic Concepts Macroscopic and Microscopic viewpoints	1	T1, T2, T3	Lecture
2	Concept of Continuum, Thermodynamic System and Control Volume, Surrounding, Boundaries, Types of Systems, Universe	1	T1, T2, T3	Lecture
3	Thermodynamic properties, Process, Cycle, Thermodynamic Equilibrium, Quasi – static Process, State, Point and Path function.	1	T1, T2, T3	Lecture
4	Zeroth Law of Thermodynamics, Measurement of Temperature,	1	T1, T2, T3	Lecture
5	Reference Points, Temperature Scales.	1	T1, T2, T3	Lecture
6	Reference Points, Temperature Scales.	1	T1, T2, T3	Tutorial
7	Energy - Work - Pdv work and other types of work transfer,	2	T1, T2, T3	Lecture
8	free expansion work, heat and heat capacity.	2	T1, T2, T3	Lecture
9	free expansion work, heat and heat capacity.	2	T1, T2, T3	Tutorial
10	Joule's Experiment- First law of Thermodynamics - First law applied to Non flow Process	2	T1, T2, T3	Lecture
11	Enthalpy- specific heats- PMM1	2	T1, T2, T3	Lecture
12	Enthalpy- specific heats- PMM1	2	T1, T2, T3	Tutorial
13	First law applied to Flow Process	2	T1, T2, T3	Lecture
14	Mass and Energy balance in simple steady flow process. Applications of SFEE	2	T1, T2, T3	Lecture
15	Transient flow –Filling and Emptying Process, Limitations of the First Law.	2	T1, T2, T3	Lecture
16	Second Law of Thermodynamics, Thermal Reservoir, Heat Engine, Heat pump	3	T1, T2, T3	Lecture
17	Kelvin-Planck and Clausius Statements, Equivalence of two statements	3	T1, T2, T3	Lecture
18	Reversibility, Irreversible Process, Causes of Irreversibility, PMM2, Carnot's theorem and its corollaries	3	T1, T2, T3	Lecture
19	Absolute Thermodynamic Temperature scale.	3	T1, T2, T3	Lecture

20	Clausius Inequality, Entropy- Entropy changes in various thermodynamic processes, principle of increase of entropy and its applications	3	T1, T2, T3	Lecture
21	Entropy generation, Entropy and Disorder, Reversible adiabatic process-isentropic process, Third law of thermodynamics	3	T1, T2, T3	Lecture
22	Available Energy, Availability and Irreversibility Second law efficiency.	3	T1, T2, T3	Lecture
23	Pure Substances, Phase Transformations, Triple point,	4	T1, T2, T3	Lecture
24	properties during change of phase, T-v, p-v and p-T diagram of pure substance, p-v-T surface,	4	T1, T2, T3	Lecture
25	Saturation pressure and Temperature, T-h and T-s diagrams, h-s diagrams or Mollier Charts	4	T1, T2, T3	Lecture
26	Dryness Fraction, steam tables. Property calculations using steam tables	4	T1, T2, T3	Lecture
27	The ideal Gas Equation, Characteristic and Universal Gas constants,	4	T1, T2, T3	Lecture
28	Deviations from ideal Gas Model: Equation of state of real substances,	4	T1, T2, T3	Lecture
29	Vander Waals Equation of State, Virial Expansion	4	T1, T2, T3	Lecture
30	Compressibility factor, Law of corresponding state, Compressibility charts.	4	T1, T2, T3	Tutorial
31	Mixtures of ideal Gases – Mole Fraction, Mass fraction, Gravimetric and volumetric Analysis,	5	T1, T2, T3	Lecture
32	Dalton's Law of partial pressure, Amagat's Laws of additive volumes, Gibbs-Dalton's law.	5	T1, T2, T3	Lecture
33	Equivalent Gas constant and Molecular Weight	5	T1, T2, T3	Lecture
34	Properties of gas mixtures: Internal Energy, Enthalpy, specific heats and Entropy	5	T1, T2, T3	Tutorial
35	Introduction to real gas mixtures- Kay's rule	5	T1, T2, T3	Lecture
36	General Thermodynamic Relations – Combined First and Second law equations	5	T1, T2, T3	Lecture

37	Helmholtz and Gibb's functions - Maxwell's Relations	5	T1, T2, T3	Lecture
38	Tds Equations, The Clapeyron Equation	5	T1, T2, T3	Lecture
39	equations for internal energy, enthalpy and entropy, specific heat	5	T1, T2, T3	Tutorial
40	Throttling process, Joule Thomson Coefficient, inversion curve.	5	T1, T2, T3	Lecture
41	equations for internal energy, enthalpy and entropy, specific heat	5	T1, T2, T3	Tutorial

15. Question Bank

Module 1				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	Distinguish between thermodynamic system and control volume	3	CO1	L2
2	Describe quasi static process undergone by a system with the help of neat sketches including the *pv* diagram.	3	CO1	L2
3	What do you mean by macroscopic and microscopic approaches in thermodynamics?	3	CO1	L1
4	What do you mean by ideal gas temperature scale	3	CO1	L1
5	Differentiate between macroscopic and microscopic analyses in thermodynamics. How does the concept of continuum relate to the above?	3	CO1	L2
6	What is a thermocouple? How does it work? State the thermometric property used in thermocouples.	3	CO1	L1
7	State the three conditions to be satisfied for a system to be in thermodynamic equilibrium.	3	CO1	L1
8	Give the definition and a brief description of the term thermodynamic property of a system. Give the classification of property with exactly one example for each.	3	CO1	L1
9	What is the concept of continuum? How would you use this idea to define density? Describe with neat diagrams.	3	CO1	L2

10	Provide the terminological expressions for the universal and characteristic gas constants. Also explain the difference between them.	3	CO1	L2
11	Explain quasi static process with suitable sketches.	7	CO1	L2
12	Describe about (i) system and control volume (ii) properties, state, path and process with respect to thermodynamics.	7	CO1	L2
13	Explain different types of temperature scales.	7	CO1	L2
14	A new absolute temperature scale is proposed. On this scale the ice point of water is 150oS and the steam point is 300oS. Determine the temperature in oC that corresponds to 100oS and 400oS respectively. What is the ratio of the size of the oS to the Kelvin? At what temperature both the Celsius and the new temperature scale reading would be the same?	7	CO1	L3
15	Define the following terms associated with a thermodynamic system: Properties, State, Path, Process, Cycle, Intensive and Extensive properties	7	CO1	L1
16	What was the temperature measurement method used before 1954? Derive the equation used for temperature measurement in this method.	7	CO1	L2
17	i) What do you mean by thermodynamic equilibrium of a system? What are the conditions required for a system to exist in thermodynamic equilibrium? Explain. ii) Consider a system whose temperature is 18°C. Express this temperature in R, K, and °F.	7	CO1	L3
18	The temperature t on a thermometric scale is defined in terms of a property K by the relation $t = a \ln K + b$ where a and b are constants. The values of K are found to be 1.83 and 6.78 at the ice point and the steam point, the temperatures of which are assigned the numbers 0 and 100 respectively. Determine the temperature corresponding to a reading of K equal to 2.42 on the thermometer. ii) What is the working principle of a constant volume gas thermometer? Explain with neat sketches.	7	CO1	L3
19	Differentiate between thermodynamic system and control volume with the help of at least one example for each. What is meant by thermodynamic equilibrium of a system? Give a brief description on the conditions to be satisfied for a system to be in thermodynamic equilibrium.	7	CO1	L2
20	With the help of an example, describe the concept of a quasi-static process. Illustrate - isobaric, isothermal, and adiabatic processes on p-v plot within the same diagram.	7	CO1	L2

21	State Zeroth law of thermodynamics. What is its significance? Describe Celsius scale and its corresponding absolute scale. Which is the fixed point used in the measurement of temperature in Celsius scale? Show the mathematical relation connecting the absolute temperature and the thermometric property, in terms of the fixed point.	7	CO1	L2
22	The temperature 't' on a thermometric scale is defined in terms of property K by the relation $t=aln K+b$, where a and b are constants. The values of K are found to be 1.52 and 8.79 at the ice point and steam point, the temperatures of which are assigned the numbers 00C and 1000C respectively. Determine the value of K at 250C and 500C?	7	CO1	L3

Module 2

Sl. No.	Question	Marks	CO	BL
1	Explain positive and negative heat and work interactions.	3	CO2	L2
2	Which property of system increases when heat is transferred: (a) at constant volume, (b) at constant pressure? Give the expressions for these properties in terms of specific heats.	3	CO2	L2
3	Derive the equation for pdv work in a polytropic expansion process	3	CO2	L3
4	State and explain the first law of thermodynamics for a closed system undergoing a cyclic process with the help of neat sketches	3	CO2	L2
5	How does flow work differ from displacement work?	3	CO2	L2
6	A gas enclosed in a cylinder piston assembly expands from 2 m3 to 4 m3. The pressure volume correlation is given by $p=V2+6V$, where p is in bar. Determine the work done by the system, considering the process as non-flow and reversible.	3	CO2	L3
7	What is a steady flow process?	3	CO2	L1
8	Describe the limitations of first law of thermodynamics, with the help of an example case.	3	CO2	L2
9	Define enthalpy. Why is temperature the only factor to determine enthalpy of an ideal gas?	3	CO2	L2
10	What is displacement work? Under what circumstances does the work done equal to $\int pdV$?	3	CO2	L1

11	Explain first law of thermodynamics for a closed system undergoing change of state. Show that energy is a property of the system	7	CO2	L2
12	A fluid is confined in a cylinder by spring-loaded, frictionless piston so that the pressure in the fluid is a linear function of the volume (p = a + bV). The internal energy of the fluid is given by the equation (U = 34 + 3.15 pV), where U in kj, p in kPa, and V in cubic metre. If the fluid changes from an initial state of 170 kPa, 0.03 m3 to a final state of 400 kPa, 0.06 m3, with no work other than that done on the piston. Find the direction and magnitude of the work and heat transfer.	7	CO2	L3
13	Discuss the application of steady flow process in following engineering systems: (i) Nozzle and Diffuser (ii) Throttling device (iii) Turbine and Compressor	7	CO2	L2
14	Air at a temperature of 15oC passes through a heat exchanger at a velocity of 30 m/s where its temperature is raised to 800oC. It then enters a turbine with the same velocity of 30 m/s and expands until the temperature falls to 650oC. On leaving the turbine, the air is taken at a velocity of 60 m/s to a nozzle where it expands until the temperature has fallen to 500oC. If the air flow rate is 2kg/s, calculate: (a) The rate of heat transfer to the air in the heat exchanger, (b) The power output from the turbine assuming no heat loss, and (c) The velocity at exit from the nozzle, assuming no heat loss. Take the enthalpy of air as h=cpt ; where cp is the specific heat equal to 1.005 kJ/kg K and t is the temperature	7	CO2	L3
15	Give an account of various forms of energy that may be stored in a system. Write the first law equation for a system undergoing change of state accounting all forms of above energies. Assume that a battery is connected to an external electrical load in a closed circuit for a period of time so that the battery is discharged as a result of the electric current flow. Apply first law of thermodynamics for this case, assuming no dissipation of energy into heat.	7	CO2	L2
16	A turbine operates under steady flow conditions, receiving steam at the following state: Pressure 1.2 MPa, temperature 188°C, enthalpy 2785 kJ/kg, velocity 33.3 m/s and elevation 3 m. The steam leaves the turbine at the following state: Pressure 20 kPa, enthalpy 2512 kJ/kg, velocity 100 m/s and elevation 0 m. Heat is lost to the surroundings at the rate of 0.29 kJ/s. If the rate of steam flow through the turbine is 0.42 kg/s, what is the power output of the turbine in kW?	7	CO2	L3
17	Derive the general energy equation for a variable flow process using control volume technique. What happens to this equation for a steady flow?	7	CO2	L3

18	1.5 kg of liquid having a constant specific heat of 2.5 kJ/kgK is stirred in a well insulated chamber causing the temperature rise by 15oC. Find ΔE and W for the process. If the same liquid is stirred in a conducting chamber, the temperature of the liquid is increased to 15°C, and the heat transfer from the liquid to the surroundings was 1.7 kJ. Find ΔE and W for the process	7	CO2	L3
19	The properties of a certain fluid are related as follows: $\boldsymbol{u = 196 + 0.718\,t}$ $\boldsymbol{pv = 0.287\,(t + 273)}$ where *u* is the specific internal energy (kJ/kg), *t* is in °C, *p* is pressure (kN/m2) and *v* is the specific volume (m3/kg). For this fluid, find cv and cp.		CO2	L3
20	Air at 110 K and 101.32 kPa is passing through a converging nozzle and leaves at 300 K. Determine the velocity of air at nozzle outlet. The nozzle is laid horizontal. The inlet velocity of air is 10 m/s. Write the assumptions made.	7	CO2	L3

Module 3

Sl. No.	Question	Marks	CO	BL
1	What are the causes of irreversibility of a process?	3	CO3	L1
2	Give the Kelvin-Planck and Clausius' statements of second law of Thermodynamics.	3	CO3	L1
3	Distinguish between reversible and irreversible processes with the help of neat sketches.	3	CO3	L2
4	Define a PMM2. Why is it impossible?	3	CO3	L2
5	Describe the limitations of first law of thermodynamics, with the help of suitable example.	3	CO3	L2
6	An inventor claims that he invented a cyclic heat engine that can produce work continuously by receiving heat from a higher temperature reservoir, and without leaving any heat to the lower temperature reservoir. Is his claim correct or not? Justify your answer.	3	CO3	L3
7	A cyclic heat engine operates between a source temperature of 7000C and a sink temperature of 280C. What is the least rate of heat rejection per KW net output of the engine?	3	CO3	L3
8	Why does free expansion have zero work transfer?	3	CO3	L1
9	What is available energy and unavailable energy?	3	CO3	L1

10	Define entropy, and prove that entropy is a property of a system.	3	CO3	L2
11	Derive Clausius inequality and explain the criteria with respect to a cyclic process.	7	CO3	L3
12	A heat pump working on the Carnot cycle takes in heat from a reservoir at 10oC and delivers heat to a reservoir at 80oC. The heat pump is driven by a reversible heat engine which takes in heat from a reservoir at 1000oC and rejects heat to a reservoir at 80oC. The reversible heat engine also drives a machine that absorbs 50 kW. If the heat pump extracts 10 kJ/s from the 10oC reservoir, determine (a) The rate of heat supply from the 1000oC source, and (b) The rate of heat rejection to the 80oC sink.	7	CO3	L3
13	Explain the mixing of two fluids with respect to entropy principle.	7	CO3	L3
14	Calculate decrease in available energy when 25 kg of water at 95oC mix with 35kg of water at 35oC, the pressure being taken as constant and the temperature of the surroundings being 15oC (cp of water = 4.2 kJ/kg K)	7	CO3	L3
15	With the help of neat sketches, prove that Kelvin Planck and Clausius statements of second law are equivalent. (Both the proofs are required)	7	CO3	L3
16	Prove the inequality of Clausius for defining the reversibility condition for a cycle. Write also the criterion for reversible cycle, irreversible cycle and impossible cycle	7	CO3	L3
17	A fluid undergoes a reversible adiabatic compression from 0.5 MPa, 0.2 m3 to 0.05 m3 according to the law, pv1.3=constant. Determine the change in enthalpy, internal energy, entropy, heat transfer and the work transfer during the process.	7	CO3	L3
18	With neat sketches, explain the concept of construction of absolute thermodynamic temperature scale between the ice point and the steam point.	7	CO3	L2
19	With the help of schematic diagrams describe cyclic heat engine, cyclic heat pump and cyclic refrigerator. How they differ purpose wise? Define the performance parameters of the above three machines.	7	CO3	L2
20	Two reversible heat engines operate in series between two end temperatures 600K and 300K via an intermediate thermal reservoir. Both the engines develop the same power. Determine the temperature of the intermediate thermal reservoir.	7	CO3	L3
21	Give the statement of third law of thermodynamics and explain it. Will a reversible and adiabatic process surely be isentropic? Justify your answer. Comment on the reverse statement; that is, Will an isentropic process surely be reversible and adiabatic? Justify your answer .	7	CO3	L2

22	A heat engine is embedded between two temperature reservoirs 500 K and 300 K. In three different cycles which it rejects 210 kW, 180 kW and 150 kW, while receiving heat at the rate of 300 kW in each case. Justify in which case the engine runs reversibility and irreversibility. Also look for the impossible.	7	CO3	L3

Module 4

Sl. No.	Question	Marks	CO	BL
1	What is critical state? Explain the terms critical pressure, critical temperature and critical volume of water.	3	CO4	L1
2	What is the fundamental property of gas with respect to the product pv? Differentiate Universal and characteristic gas constants.	3	CO4	L2
3	What are steam tables and saturation states? What for they are used?	3	CO5	L1
4	Draw the T-s plot of a pure substance, and show various constant property lines on it.	3	CO5	L2
5	What are compressed liquid, superheated vapour, and quality of vapour?	3	CO5	L1
6	Write a short note on Mollier diagram.	3	CO5	L1
7	What is the difference between critical point and triple point?	3	CO5	L2
8	Give a description on the law of corresponding states.	3	CO4	L1
9	What is meant by vapour dome? Provide an illustration on T-s and h-s diagrams.	3	CO5	L2
10	What is the degree of super heat and the degree of sub cooling? Use diagrams to illustrate them.	3	CO5	L1
11	Explain with P-V diagram, the different stages for a substance whose volume decreases on melting	7	CO5	L2
12	Steam at 0.8 MPa, 250oC and flowing at the rate of 1kg/s passes into a pipe carrying wet steam at 0.8 MPa, 0.95 dry. After adiabatic mixing the flow rate is 2.3 kg/s. Determine the condition of steam after mixing and degree of superheat.	7	CO5	L3
13	Explain Compressibility factor with respect to Virial expansions.	7	CO4	L2
16	What are reasons for the deviation of the real gas behaviour from the ideal gas behaviour? With reference to van der Waals correction, explain the deviation of equation of state of a real substance from ideal gas.	7	CO4	L2

14	Explain the *p-v* diagram of a pure substance other than water with the help of neat sketches. Write the critical pressure, critical temperature, and critical volume of water?	7	CO5	L2
15	Steam initially at 0.3 MPa, 250°C is cooled at constant volume. Determine the following: (a) At what temperature will the steam become saturated vapor? (b) What is the quality at 80°C? (c) What is the heat transferred per kg of steam in cooling from 250°C to 80°C?	7	CO5	L3
16	What are Virial equations of state? Define compressibility factor. Also derive the relation between Virial expansion coefficients B' and B, and C' C, and D'and D for a real gas	7	CO4	L3
17	Derive the equation of law of corresponding states from Vander Waals equation of state? What is the significance of this expression? Explain.	7	CO4	L3
18	Explain the terms - critical state, critical pressure, critical temperature, and critical volume. Show the critical state point on any suitable phase change diagram. Differentiate between sensible heat and latent heat.	7	CO4	L2
19	A steam at 2 MPa has a specific volume of 0.09 m3/kg. Determine the dryness fraction of the steam. Also calculate the specific enthalpy and specific entropy. Use steam table for the above calculations.	7	CO5	L3
20	Give descriptions on the following. Virial expansions, Law of corresponding states and generalised compressibility chart.	7	CO4	L2
21	Determine the specific volume of nitrogen at 100 atm and 300 K. For nitrogen Pc=3390 kPa Tc= 126.2 K	7	CO4	L3

Module 5

Sl. No.	Question	Marks	CO	BL
1	What are reduced properties?	3	CO6	L1
2	Why there is no temperature change when ideal gas is throttled?	3	CO6	L1
3	Draw the isenthalpic curve and inversion curve in the *T-p* coordinates. Explain how these curves are obtained?	3	CO6	L2
4	Derive the Clausius-Clapeyron equation from the first *T-ds* equation. What is the significance of this equation?	3	CO6	L3

5	State Dalton's law of partial pressure. How is the partial pressure of a component in a gaseous mixture related to the mole fraction of that component?	3	CO6	L2
6	Show, with the help of appropriate property relation, that the saturation pressure of a liquid increases with temperature, in a phase change process from liquid to vapour.	3	CO6	L2
7	Write the ideal gas equation for *n* moles of a gas. Explain each term used in the equation with proper units in SI. How the characteristic gas equation can be obtained from this equation?	3	CO6	L1
8	Define Joule-Thomson coefficient. Prove that Joule-Thomson coefficient is zero for an ideal gas.	3	CO6	L1
9	Define Joule-Thomson coefficient. Show that Joule-Thomson coefficient is zero for an ideal gas.	3	CO6	L1
10	Show that the internal energy of an ideal gas is a function of temperature.	3	CO6	L2
11	State and explain Dalton's law of partial pressures and Amagat's laws of additive volumes. Derive the expression for partial pressure of component gas in terms of mole fraction	7	CO6	L2
12	A mixture of ideal gases consists of 3kg of nitrogen and 5kg of carbon dioxide at a pressure of 300 kPa and a temperature of 20oC. Find, (a) The mole fraction of each component. (b) The equivalent molecular weight of the mixture. (c) The equivalent gas constant of the mixture. (d) The partial pressure and the partial volumes.	7	CO6	L3
13	Explain Joule-Kelvin effect with respect to significance of inversion curve. Show that for an ideal gas, Joule-Kelvin coefficient is zero	7	CO6	L2
14	Derive Maxwell's equations	7	CO6	L3
15	A vessel is divided into three compartments (a), (b), (c) by two partitions. Part (a) contains oxygen and has a volume of 0.1 m3, Part (b) has a volume of 0.2 m3 and contains nitrogen, while part (c) is 0.05 m3 and holds CO2. All three parts are at a pressure of 2 bar and a temperature of 13°C. When the partitions are removed and the gases mix, determine the change in entropy of each constituent, the final pressure in the vessel and the partial pressure of each gas. The vessel may be taken as being completely isolated from its surroundings.	7	CO6	L3
16	Two vessels, A and B, both containing nitrogen, are connected by a valve which is opened to allow the contents to mix and	7	CO6	L3

<table>
<tr><td></td><td>achieve an equilibrium temperature of 27°C. Before mixing, the details of gases in the two vessels are as given below:
Calculate the final equilibrium pressure and the amount of heat transferred to the surroundings. Take γ =1.4
<table>
<tr><td>Vessel A</td><td>Vessel B</td></tr>
<tr><td>p = 1.5 MPa</td><td>p = 0.6 MPa</td></tr>
<tr><td>t = 50°C</td><td>t = 20°C</td></tr>
<tr><td>Contents = 0.5 kg mol</td><td>Contents = 2.5 kg</td></tr>
</table></td><td></td><td></td><td></td></tr>
<tr><td>17</td><td>Derive the TdS equations for a pure substance undergoing an infinitesimal reversible process.</td><td>7</td><td>CO6</td><td>L3</td></tr>
<tr><td>18</td><td>What is a throttling process? Give a description on Joule Thomson coefficient with its significance. What would be the value of Joule Thompson coefficient for ideal gas and how would it adversely influence the refrigeration effect in a throttling process?</td><td>7</td><td>CO6</td><td>L2</td></tr>
</table>

Prepared By : Prof. Jobin Jose (Subject Faculty)

Checked By : Dr. Manoj Jose Kalathil, (Subject Group Coordinator)

Approved By : Dr. Ramadas T (HOD - ME)

Course Code & Name: MET 204 MANUFACTURING PROCESS

1. Prescribed Syllabus

Module	Topic	Hours
1	Casting:-Characteristics of sand -pattern and allowances -type of patterns-cores-core prints-chaplets-simple problems. Elements of gating system-gating system, pouring time, choke area -risering Caine's method-chills –simple problems. Special casting process:-shell molding, precision investment, die casting, centrifugal casting, continues casting, squeeze casting surface roughness obtainable and application of each casting process. Defects in castings :- Shaping faults arising in pouring, Inclusions and sand defects, Gas defects, Shrinkage defects, Contraction defects, Dimensional errors, Compositional errors and segregation; significance of defects on Mechanical properties . (Kalpakjian, Beeley, Rao). Superalloy Production Methods: Vacuum Induction Melting; Electroslag Remelting; Vacuum Arc Remelting (ASM).	9
2	Welding:-welding metallurgy, diffusion, heat affected zone, driving force for grain growth, grain size and hardness- joint quality: porosity, slag inclusions, cracks, surface damage, residual stress lamellar tears, stress reliving, heat treatment of welded joints - weldability (Kalpakjian, Lindberg) - destructive and non destructive tests of welded joints (may be provided as class assignment - Lindberg). Resistance welding: HAZ, process and correlation of process parameters with welded joints of spot, seam, projection, stud arc, percussion welding- applications of each welding process –simple problems. (Kalpakjian). Arc welding:-HAZ, process and correlation of process parameters with welded joints of shielded metal arc, submerged, gas metal, flux cored, electrogas, electroslag, gas tungsten, plasma arc, electron beam, laser beam –simple problems - Thermit welding, friction welding- applications of each welding process. (Kalpakjian, Lindberg). Oxyacetylene welding:-chemistry, types of flame and its applications - brazing- soldering - adhesive bonding.	9
3	Rolling:- principles - types of rolls and rolling mills - mechanics of flat rolling, roll pressure distribution, neutral point, front and back tension, torque and power, roll forces in hot rolling, friction, deflection and flattening, spreading -– simple problems. rolling defects-vibration and chatter - flat rolling -miscellaneous rolling process: shape, roll forging, ring, thread and gear, rotary tube piercing, tube rolling - applications – simple problems. (Kalpakjian). Plastic deformation of metals - stress-strain relationships- State of stress - yield criteria of Tresca, von Mises, and comparisons - applications. Flow rules -power and energy deformations - Heat generation and heat transfer in metal forming process -temperature in forging. (ASM- Taylan Altan).	8
4	Forging: material characterization; grain flow and strength - Forging:- classification - open die forging, forces and work of deformation - Forging methods analysis:- slab method only, solid cylindrical, rectangular work piece in plane strain, forging under sticking condition	9

	-simple problems -applications. Deformation zone geometry – die forging: - impression, close, coining, skew rolling etc. –simple problems– defects in forging. (Kalpakjian). Metal extrusion: - metal flow - mechanics of extrusion:-deformation and friction, actual forces, die angle, forces in hot extrusion – miscellaneous process- defects - simple problems- applications. (Kalpakjian, Lindberg). Wire, Rod, and tube drawing: - mechanics of rod and wire drawing: deformation, friction, die pressure and angle, temperature, reduction per pass, drawing flat strip and tubes- –simple problems- drawing defects-swaging-applications. (Kalpakjian, Lindberg, Rao). Deep drawing-deep drawability, simple problems - different drawing practices.	
5	Locating and clamping methods: - basic principle of location; locating methods; degrees of freedom; locating from plane, circular, irregular surface –simple problems. Locating methods and devices: - pin and button locators, rest pads and plates, nest or cavity location.. Basic principles of clamping:-strap, cam, screw, latch, wedge, hydraulic and pneumatic clamping –simple problems. (Donaldson, Wilson F.W.). Sheet metal operations: Press tool operations: shearing action, shearing operations: blanking, piercing, simple problems, trimming, shaving, nibbing, notching – simple problems - applications. Tension operations: stretch forming - Compression operations: - coining, sizing, ironing, hobbing - tension and compression operations: drawing, spinning, bending, forming, embossing – simple problems-applications.(Donaldson, Wilson F.W., Rao P.N). Fundamentals of die cutting operations - inverted, progressive and compound die - simple problems. (Donaldson)	**10**

2. Text Books (T)

T1. Donalson cyril, LeCain, Goold, Ghose:- Tool design, McGraw Hill.

T2. Serope Kalpakjian, Steven R. Schmid - Manufacturing Engineering and Technology, Pearson.

3. Reference Books (R)

R1. Joseph R. Davis, S. L. Semiatin, American Society for Metals - ASM Metals Handbook, Vol. 14 Forming and Forging ASM International (1989).
R2. Peter Beeley, Foundry Technology, Butterworth-Heinemann
R3. Rao P.N., Manufacturing Technology, Volume -1, Tata McGraw Hill.
R4. Taylan Altan, Gracious Ngaile, Gangshu Shen - Cold and Hot Forging Fundamentals and Applications - ASM International (2004).
R5. Matthew J. Donachie, Stephen J. Donachie, Super alloys A Technical Guide, Second Edition, 2002 ASM International.

4. Course Objectives

- To gain theoretical and practical knowledge in material casting processes and develops an understanding of the dependent and independent variables which control materials casting in a production processes.

- Provide a detailed discussion on the welding process and the physics of welding. Introduce students to different welding processes weld testing and advanced processes to be able to appreciate the practical applications of welding.
- The course will also provide methods of analysis allowing a mathematical/physical description of forming processes.
- Correlate the material type with the possible fabrication processes
- Generate solutions to problems that may arise in manufacturing engineering

5. Course Pre / Co-requisite

MET 205 Metallurgy and material science

6. Course Outcomes

The students will be able to

CO1: Illustrate the basic principles of foundry practices and special casting processes, their advantages, limitations and applications.

CO2: Categorise welding processes according to welding principle and material.

CO3: Understand requirements to achieve sound welded joint while welding different similar and dissimilar engineering materials.

CO4: Student will estimate the working loads for pressing, forging, wire drawing etc. processes.

CO5: Recommend appropriate part manufacturing processes when provided a set of functional requirements and product development constraints.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO1	**H**														**M**
CO2	**H**											**H**			**M**
CO3	**H**		**H**												**M**
CO4	**H**			**H**											**M**
CO5	**H**	**H**													**M**

8. Justification for CO-PO-PSO Correlation

CO1	**PO1**	Students gain knowledge about the basic principles of foundry practices, special casting processes, their advantages, limitations and applications. They can apply this knowledge in order to select the casting process and parameters according to the requirements.Hence high correlation is mapped.
	PSO3	Students acquire knowledge of the fundamental principles of foundry practices and special casting processes, including their advantages, limitations, and applications, enabling them to apply mathematical, scientific, and engineering principles to design and analyze multidisciplinary systems, thereby achieving a medium level of correlation.

CO2	**PO1**	Students gain knowledge of welding processes by categorizing them based on welding principles and materials. They can apply this understanding, along with their knowledge of mathematics, science, and engineering fundamentals, to analyze and solve complex engineering problems related to welding. Hence, a medium correlation is mapped.
	PO12	Students will be able categorize welding processes according to welding principle and the material to be welded. This skill can be used for recognize and selecting the type of welding and welding parameters depending on the requirements. Hence medium correlation can be obtained.
	PSO3	Students acquire knowledge of the fundamental principles of welding processes, including their classification based on welding principles and materials, along with their advantages, limitations, and applications. This understanding enables them to apply mathematical, scientific, and engineering principles to design and analyze multidisciplinary systems, thereby achieving a medium level of correlation.
CO3	**PO1**	Students gain knowledge about the fundamental requirements for achieving sound welded joints while welding similar and dissimilar engineering materials. They can apply the principles of mathematics, science, engineering fundamentals, and their specialization to solve complex engineering problems related to welding. Hence, a high correlation is mapped.
	PO3	Students will be able to design solutions for obtaining sound and defect free welded joints. High correlation is mapped due to fact that it uses basic principles to meet the specified needs.
	PSO3	Students acquire knowledge of the fundamental requirements for achieving sound welded joints while welding similar and dissimilar engineering materials, including the influencing factors, techniques, and material behaviors. This understanding enables them to apply mathematical, scientific, and engineering principles to design and analyze multidisciplinary systems, thereby achieving a medium level of correlation.

CO4	**PO1**	Students gain knowledge about estimating the working loads for pressing, forging, wire drawing, and other related processes. They can apply the principles of mathematics, science, engineering fundamentals, and their specialization to solve complex engineering problems related to these manufacturing processes. Hence, a high correlation is mapped.
	PO4	By the analysis and interpretation of data students will be able to estimate the working loads for pressing, forging, wire drawing etc. Hence high correlation can be obtained.
	PSO3	Students acquire knowledge of estimating the working loads for pressing, forging, wire drawing, and other related processes, including the influencing factors and material behavior. This understanding enables them to apply mathematical, scientific, and engineering principles to design and analyze multidisciplinary systems, thereby achieving a medium level of correlation.
	PO1	Students gain knowledge about various part manufacturing processes, their capabilities, and constraints. They can apply the principles of mathematics, science, engineering fundamentals, and their specialization to recommend appropriate manufacturing processes based on functional requirements and product development constraints. Hence, a high correlation is mapped.

CO5	**PO2**	PO2: Students will be able to analyse a set of functional requirements and product development constraints and reach substantiated conclusions regarding appropriate part manufacturing processes. High correlation is due to the fact it uses basic principles of engineering to identify and analyse complex problems
	PSO3	Students acquire knowledge of various part manufacturing processes, including their advantages, limitations, and suitability for different functional requirements and product development constraints. This understanding enables them to apply mathematical, scientific, and engineering principles to design and analyze multidisciplinary systems, thereby achieving a medium level of correlation.

9. Curricular gaps (if any)

The concepts explained in this Syllabus is conventional methods only.

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
-	-	-	-

11. Internal Assessment mark allocation (as per university curriculum)

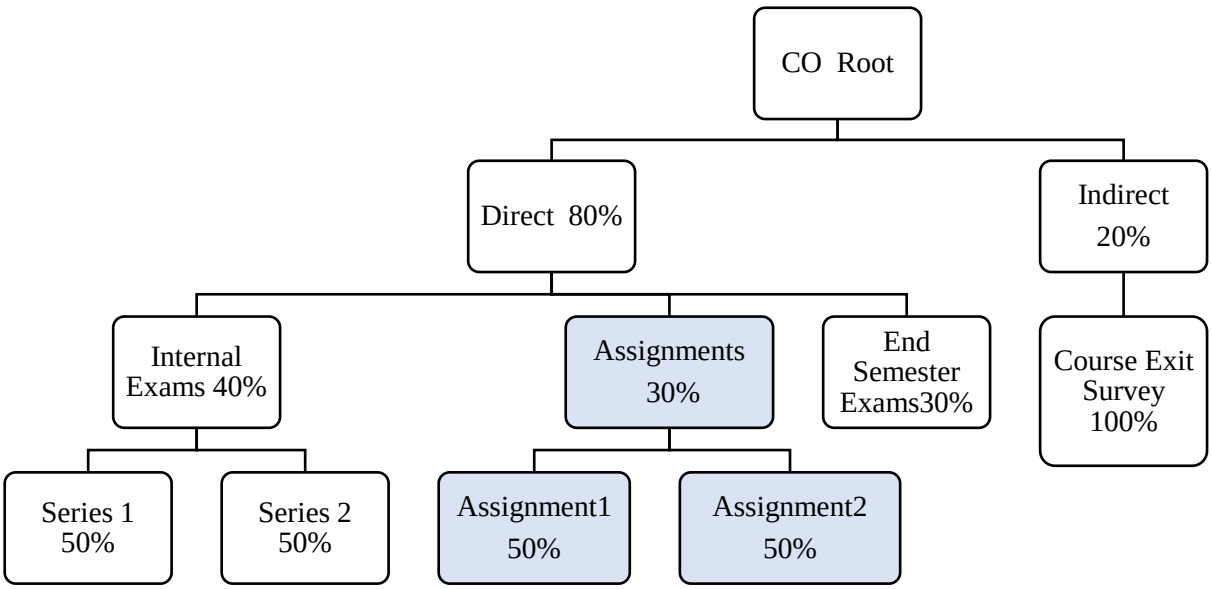
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		**Weightage**	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Direct Assessment Tools 80%	Internal Exam(s) 40%	Series 1	50%	x	x			
		Series 2	50%			x	x	x
	Assignment (s)/ Course Project /Quiz etc. 30%	Assign. 1	50%	x	x			
		Assign. 2	50%			x	x	x
	End Semester Exam 30%		100%	x	x	x	x	x
Indirect Assessment Tool 20%	Course Exit Survey		100%	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Sl. No.	Topic Name	Ref. R1 (Primary)	Ref. R2 (Secondary/Alternative)	Teaching Pedagogy	Hours
	Module 1: Casting Process			**CO1**	**9**
1.1	Characteristics of Sand, Pattern Materials, Types of Patterns, Allowances (Shrinkage, Machining, Draft).	Kalpakjian / Rao	Beeley	Lecture / Discussion	2
1.2	Cores, Core Prints, Chaplets. Elements of Gating System, Pouring Time, Choke Area.	Kalpakjian / Rao	Beeley	Lecture / Problem Solving (Simple)	2
1.3	Risering (Caine's Method), Chills.	Kalpakjian	Beeley	Lecture / Problem Solving (Simple)	1
1.4	Special Casting Processes: Shell Molding, Investment Casting, Die Casting (Hot/Cold Chamber), Centrifugal Casting.	Kalpakjian	Rao	Lecture / Case Study	2
1.5	Continuous Casting, Squeeze Casting. Surface Roughness, Applications. Defects in Castings (Pouring, Inclusions, Gas, Shrinkage, Contraction, Dimensional, Compositional Errors).	Kalpakjian	Beeley	Lecture / Group Activity	1
1.6	Superalloy Production Methods: Vacuum Induction Melting (VIM); Electroslag Remelting (ESR); Vacuum Arc Remelting (VAR).	ASM	Kalpakjian	Lecture / Discussion	1
	Module 2: Joining Processes (Welding)			**CO2**	**9**

2.1	Welding Metallurgy: Diffusion, Heat Affected Zone (HAZ), Driving Force for Grain Growth, Grain Size, and Hardness.	Kalpakjian	Lindberg	Lecture / Discussion	2
2.2	Joint Quality: Porosity, Slag Inclusions, Cracks, Surface Damage, Residual Stress, Lamellar Tears, Stress Relieving, Heat Treatment. Weldability.	Kalpakjian	Lindberg	Lecture / Case Study	2
2.3	**Resistance Welding:** HAZ, Process, Correlation of Process Parameters (Spot, Seam, Projection, Stud Arc, Percussion Welding). Applications.	Kalpakjian	Lindberg	Lecture / Problem Solving (Simple)	1
2.4	**Arc Welding (Part 1):** Shielded Metal Arc (SMAW), Submerged (SAW), Gas Metal (GMAW/MIG), Flux Cored (FCAW). HAZ and Process Parameters.	Kalpakjian	Lindberg	Lecture / Demonstration	1
2.5	**Arc Welding (Part 2):** Electrogas, Electroslag, Gas Tungsten (GTAW/TIG), Plasma Arc, Electron Beam, Laser Beam, Thermit Welding. Applications.	Kalpakjian	Lindberg	Lecture / Problem Solving (Simple)	1
2.6	Friction Welding. Oxyacetylene Welding (Chemistry, Types of Flame and Applications).	Kalpakjian	Lindberg	Lecture / Visualization	1
2.7	Brazing, Soldering, Adhesive Bonding. Destructive and Non-Destructive Tests.	Kalpakjian	Lindberg	Lecture / Discussion	1
	Module 3: Bulk Deformation (Rolling & Theory)			**CO3**	**8**
3.1	Plastic Deformation of Metals: Stress-Strain Relationships, State of Stress, Flow Rules, Power and Energy Deformations.	ASM (Taylan Altan)	Kalpakjian	Lecture / Derivation	2
3.2	Yield Criteria: Tresca, von Mises, and Comparisons. Heat Generation and Heat Transfer, Temperature in Forging.	ASM (Taylan Altan)	Kalpakjian	Lecture / Problem Solving (Simple)	2
3.3	**Rolling Principles:** Types of Rolls and Rolling Mills. Mechanics of Flat Rolling: Roll Pressure Distribution, Neutral Point, Friction.	Kalpakjian	Lindberg	Lecture / Discussion	2
3.4	Roll Forces (Hot Rolling), Torque and Power, Deflection, Flattening, Spreading. Rolling Defects, Vibration and Chatter.	Kalpakjian	Lindberg	Lecture / Problem Solving (Simple)	1
3.5	Miscellaneous Rolling Processes: Shape, Roll Forging, Ring, Thread and Gear, Rotary Tube Piercing, Tube Rolling. Applications.	Kalpakjian	Lindberg	Lecture / Case Study	1
	Module 4: Bulk Deformation (Forging, Extrusion, Drawing)			**CO4**	**9**

4.1	**Forging:** Material Characterization; Grain Flow and Strength. Classification (Open Die, Impression Die, Close Die).	Kalpakjian	Lindberg	Lecture / Discussion	1
4.2	Open Die Forging: Forces and Work of Deformation. Forging Methods Analysis (Slab Method): Solid Cylindrical, Rectangular Workpiece (Plane Strain), Forging under Sticking Condition.	Kalpakjian	Rao	Lecture / Problem Solving (Simple)	2
4.3	Deformation Zone Geometry. Die Forging: Impression, Close, Coining, Sizing, Skew Rolling. Defects in Forging. Applications.	Kalpakjian	Lindberg	Lecture / Case Study	2
4.4	**Metal Extrusion:** Metal Flow. Mechanics of Extrusion: Deformation and Friction, Actual Forces, Die Angle, Forces in Hot Extrusion.	Kalpakjian	Lindberg	Lecture / Problem Solving (Simple)	2
4.5	Miscellaneous Extrusion Processes. Extrusion Defects. Applications.	Kalpakjian	Lindberg	Lecture / Visualization	1
4.6	**Wire, Rod, and Tube Drawing:** Mechanics (Deformation, Friction, Die Pressure and Angle, Reduction per Pass), Drawing Flat Strip and Tubes.	Kalpakjian / Rao	Lindberg	Lecture / Problem Solving (Simple)	1
	Module 5: Sheet Metal & Jigs/Fixtures			**CO5**	**10**
5.1	**Locating and Clamping (Part 1):** Basic Principle of Location, Degrees of Freedom (3-2-1 Principle). Locating from Plane, Circular, Irregular Surfaces.	Donaldson	Wilson F.W.	Lecture / Discussion	2
5.2	Locating Methods and Devices: Pin and Button Locators, Rest Pads and Plates, Nest or Cavity Location. Simple Problems.	Donaldson	Wilson F.W.	Lecture / Problem Solving (Simple)	2
5.3	**Clamping:** Basic Principles of Clamping. Clamping Devices: Strap, Cam, Screw, Latch, Wedge, Hydraulic and Pneumatic Clamping. Simple Problems.	Donaldson	Wilson F.W.	Lecture / Problem Solving (Simple)	2
5.4	**Sheet Metal Operations:** Fundamentals of Shearing Action and Shearing Operations: Blanking, Piercing, Trimming, Shaving, Nibbling, Notching.	Rao P.N.	Kalpakjian	Lecture / Problem Solving (Simple)	2
5.5	Tension Operations (Stretch Forming). Compression Operations (Coining, Sizing, Ironing, Hobbing). Tension and Compression Operations (Deep Drawing, Deep Drawability, Spinning).	Rao P.N.	Kalpakjian	Lecture / Discussion	1
5.6	Bending, Forming, Embossing. Different Drawing Practices. Fundamentals of Die Cutting: Inverted, Progressive and Compound Die. Applications.	Rao P.N.	Donaldson	Lecture / Case Study (Simple)	1

15. Question Bank

	MODULE-1			
1	Differentiate solidification of alloys with solidification of pure metals.	3	CO1	L1
2	List differences and similarities between sand casting, die-casting and permanent mould casting processes.	3	CO1	L1
3	List five typical components produced by the casting process.	3	CO1	L1
4	List important considerations when selecting pattern materials.	3	CO1	L1
5	List the advantage and limitations of die casting.	3	CO1	L1
6	List the general design considerations in casting.	3	CO1	L1
7	Name and describe the characteristics of the types of sand-moulding machines.	3	CO1	L1
8	Name the important factors in selecting sand for moulds.	3	CO1	L1
9	Name the important factors involved in the economics of casting operations.	3	CO1	L1
10	List the two basic mould types that distinguish casting processes.	3	CO1	L1
11	Name the type of materials used for permanent mould casting processes.	3	CO1	L1
12	Name the types of cast irons available and list their major characteristics.	3	CO1	L1
13	Differentiate between a split pattern and a match-plate pattern.	3	CO1	L1
14	Define hot spots.	3	CO1	L1
15	List the major limitations and disadvantages of casting.	3	CO1	L1
16	List the advantages of casting process over other shaping processes.	3	CO1	L1
17	List the advantages of pressure casting.	3	CO1	L1
18	List the differences between a pattern and a casting.	3	CO1	L1
19	List the factors you will consider before selecting the material for a pattern.	3	CO1	L1
20	List the most common metals used in die casting.	3	CO1	L1
21	Define a chaplet.	3	CO1	L1
22	Define a riser.	3	CO1	L1
23	Define directional solidification.	3	CO1	L1
24	Define shrinkage allowance and machining allowance.	3	CO1	L1

25	Differentiate between a pattern and a core in sand moulding.	3	CO1	L1
26	Differentiate between an open mould and a closed mould.	3	CO1	L1
27	Differentiate between sand and shell mould casting.	3	CO1	L1
28	Differentiate between true centrifugal and semi centrifugal casting.	3	CO1	L1
29	Differentiate between vacuum mould casting and vacuum moulding.	3	CO1	L1
30	List the properties which determine the quality of a sand mould for sand casting.	3	CO1	L1
31	Define shrinkage and porosity. How can you tell whether cavities in a casting are due to shrinkage?	5	CO1	L2
32	Describe the advantages and limitations of hot-chamber and cold-chamber die casting processes.	5	CO1	L2
33	Describe the features of a gating system.	5	CO1	L2
34	Describe the function of a blind riser. Explain the importance of it.	5	CO1	L2
35	Explain the importance of permeability in moulding sand.	5	CO1	L2
36	Explain the reasons for hot tearing in castings.	5	CO1	L2
37	Explain why a casting may have a slightly different shape than the pattern used to make it.	5	CO1	L2
38	Explain why the strength to weight ratio of die-cast parts increases with decreasing wall thickness.	5	CO1	L2
39	Explain how dissolved gases are removed from molten metal.	5	CO1	L2
40	Explain how the blowholes are formed in a casting.	5	CO1	L2
41	List and describe any three general defects encountered in casting processes.	5	CO1	L2
42	Explain the differences between hot chamber die-casting and cold chamber die-casting processes.	5	CO1	L2
43	Explain the function of chills.	5	CO1	L2
44	Explain why drafts are necessary in some moulds.	5	CO1	L2
45	Explain why steels are more difficult to cast than cast irons.	5	CO1	L2
46	Explain how to select a suitable casting process to manufacture a product of your choice considering various factors.	8	CO1	L3
47	Identify which piece will solidify first and which one in the last using the following data. Three pieces to be cast have the same volume but different shapes: one is a sphere, one is a cube and the third is a cylinder with height equal to its diameter.	8	CO1	L3
48	Discuss about the consequences of pouring molten metal into the mould cavity at a rapid rate and at a slower rate.	8	CO1	L3
49	Explain different types of casting defects in detail with effects of each defect on quality of the casting.	8	CO1	L3
50	Suggest a suitable casting process for making an engine piston with Aluminum alloy. What type of mould can be used?	10	CO1	L4

	MODULE-2			
50	Explain the circumstances under which adhesive bonding be preferred over soldering	5	CO2	L2
51	Differentiate the heat transfer factor in arc-welding processes that utilize consumable electrodes with those that use non-consumable electrodes	5	CO2	L2
52	Describe the shielded metal arc-welding (SMAW) process.	5	CO2	L2
53	Explain why the shielded metal arc-welding (SMAW) process is difficult to automate	5	CO2	L2
54	Describe submerged arc welding (SAW)	5	CO2	L2
55	Explain why the temperatures are much higher in plasma arc welding than in other arc welding processes	5	CO2	L2
56	Describe the sequence of steps in the cycle of a resistance spot-welding operation.	5	CO2	L2
57	Explain why the oxy-acetylene welding process is favored over the other oxy-fuel welding processes	5	CO2	L2
58	Describe and distinguish the two basic types of friction welding process.	5	CO2	L2
59	Describe the features of a fusion welding and identity the different regions in HAZ	5	CO2	L2
60	Explain the characteristics of the heat-affected zone in welding	5	CO2	L2
61	Discuss the factors that influence weld quality.	5	CO2	L2
62	Describe the common types of discontinuities in welds.	5	CO2	L2
63	Explain fusion as it relates to welding operations.	5	CO2	L2
64	Describe the reactions that take place in an oxyfuel gas torch. What is the level of temperatures generated?	5	CO2	L2
65	Describe the procedure to be followed in an oxyfuel gas welding operation.	5	CO2	L2
66	Explain the basic principles of arc-welding processes.	5	CO2	L2
67	Explain why is shielded metal-arc welding a commonly used process? Why is it also called stick welding?	5	CO2	L2
68	Describe the features of three types of arcs in gas metal-arc welding. Why has it been called MIG welding?	5	CO2	L2
69	Explain what is meant by solid-state welding.	5	CO2	L2
70	Describe the principle of ultrasonic welding.	5	CO2	L2
71	Explain the difference between friction welding and inertia friction welding.	5	CO2	L2
72	Describe the principle behind resistance welding processes.	5	CO2	L2
73	Explain the principle underlying brazing.	5	CO2	L2
74	Describe the types of fluxes used in soldering and their applications.	5	CO2	L2
75	Explain how the filler metal is applied in furnace brazing	5	CO2	L2

76	State the advantages and limitations of (a) arc welding (b) gas welding and (c) resistance welding	5	CO2	L2
77	Distinguish between gas welding, arc welding, and resistance welding with respect to temperature generated, quality of welding obtained, application and cost.	5	CO2	L2
78	Discuss the factors that influence weld quality	8	CO2	L3
79	Explain whether the filler metal be of the same composition as that of the base metal to be welded	8	CO2	L3
80	Discuss weld penetration in DSCP and DCRP welding	8	CO2	L3
81	Explain the features of neutral, reducing and oxidizing flames. Why is reducing flame so called?	8	CO2	L3
82	Explain why an oxidizing flame is desirable in welding copper alloys	8	CO2	L3
83	Explain why so many different welding processes have been developed.	8	CO2	L3
84	Explain why welding is not used for attaching electrical components to circuit boards	8	CO2	L3
85	Select the process of welding you are going to suggest to weld broken leg of a mild steel chair and explain the reasons for selection	8	CO2	L3
86	Explain, with an example, the situation in which joining process becomes essential when compared to the other manufacturing processes.	8	CO2	L3
87	Select and justify the method of welding which will be best for welding high melting point metals.	8	CO2	L3
88	Explain the consequences of (a) high current (b) high speed and (c) high voltage in arc welding processes	8	CO2	L3
89	Justify whether oxy-acetylene flame can be used for cutting.	8	CO2	L3
90	Explain the consequences of substituting methane in place of acetylene in gas welding process.	8	CO2	L3
91	Explain why some joints may have to be preheated prior to welding? If the parts to be welded are preheated, is the likelihood that porosity will form increased or decreased? Explain	8	CO2	L3
92	Discuss why some metals are easier to weld than the others	8	CO2	L3
93	Two plates were welded together and then the strength of the joint was tested. It is found that the weld was stronger than either of the plates. Do you think that the statement is incorrect? Postulate, giving valid reasons with neat sketches	8	CO2	L3
94	What are the methods available for controlling the distortions in welded assembly structure? Describe their relative effects and application	8	CO2	L3
95	Two 1-mm thick, flat Copper sheets are being spot welded using a current of 5000A and a current flow time of t=0.18 seconds the electrodes are 5mm in diameter. Estimate the heat generated in the weld zone	8	CO2	L3
96	What does the strength of a weld nugget in resistance spot welding depends on?	8	CO2	L3
97	Explain how the atmosphere around the work piece affect the weld obtained in electron beam welding	8	CO2	L3
98	Why is the quality of welds produced by submerged arc welding very good?	8	CO2	L3
99	What does the strength of a weld nugget in resistance spot welding depends on?	8	CO2	L3

100	What is the strength of a welded joint is inferior or superior to the parent metal? Why?	8	CO2	L3
101	Why some joints may have to be preheated prior to welding.	8	CO2	L3
102	Assume that you are asked to inspect a weld for a critical application. Describe the procedure you would follow. If you find a flaw during your inspection, how would you go about determining whether or not this flaw is important for the particular application?	10	CO2	L4
103	In the building of large ships, there is a need to weld large sections of steel together to form a hull, for this application, which welding process would you select? Why?	10	CO2	L4
	MODULE-3			
1	Classify the metal forming processes.	3	CO3	L1
2	List the consequences of having rolls made of (a) very smooth surfaces, and (b) rough surfaces?	3	CO3	L1
3	List the various processes of metal working.	3	CO3	L1
4	List the advantages of hot working over cold working of metals	3	CO3	L1
5	Compare the specific merits of cold working over hot working	3	CO3	L1
6	State two parameters which determine the extent of deformation possible in a given material in a metal working process.	3	CO3	L1
7	Define ‘grain flow’ in the case of forged or rolled components	3	CO3	L1
8	Differentiate cold rolling from hot rolling in terms of the process and product	3	CO3	L1
9	List the methods in which the roll-separating force could be reduced in cold rolling.	3	CO3	L1
10	Define the terms ingot, slab, bloom and billet.	3	CO3	L1
11	List the advantages and disadvantages of hot working	3	CO3	L1
12	List the common hot working processes	3	CO3	L1
13	Define the principle involved in hot rolling.	3	CO3	L1
14	Classify the types of rolling mills and sketch them.	3	CO3	L1
15	List the advantages and disadvantages of cold working	3	CO3	L1
16	Define ‘Rolling’. Differentiate cold rolling from hot rolling	3	CO3	L1
17	List the main process variables in a rolling process.	3	CO3	L1
18	Define (a) roll gap (b) neutral point (c) draft.	3	CO3	L1
19	Describe the difference between a bloom, a slab and a billet.	3	CO3	L1
20	List the defects commonly observed after flat rolling.	3	CO3	L1

21	List the advantages of tandem rolling	3	CO3	L1
22	Make a list of some parts that can be made by shape rolling.	3	CO3	L1
23	Name the four basic bulk deformation processes.	3	CO3	L1
24	Define draft in rolling operation	3	CO3	L1
25	Do you think metal forming process is more competitive when compared to machining or casting process? Explain your answer with an example.	5	CO3	L2
26	In a four-high rolling mill, why do we use small diameter rolls as working rolls and larger diameter rolls as back up rolls. Explain	5	CO3	L2
27	Justify whether thread rolling be a hot working process.	5	CO3	L2
28	Specify the temperature to which a given plain-carbon steel be heated for hot working	5	CO3	L2
29	Give a line diagram of the various processes involved in the manufacture of the steel sheet, starting from steel ingots.	5	CO3	L2
30	Explain why the strength of a rolled part considered usually better than a cast piece	5	CO3	L2
31	Explain the principle of rolling with a neat sketch.	5	CO3	L2
32	Explain some defects that can be present in rolled products with their remedies.	5	CO3	L2
33	Describe the arrangement of rolls, specific uses and other details of any two types of rolling mills in commercial use.	5	CO3	L2
34	Explain planetary rolling mill in detail.	5	CO3	L2
35	Describe what happens to metal when it is rolled.	5	CO3	L2
36	Discuss briefly principle and mechanism of rolling.	5	CO3	L2
37	Describe briefly “Cluster rolls’ and “Planetary mill”	5	CO3	L2
38	Explain briefly various defects observed in rolling.	5	CO3	L2
39	Explain the factors contribute to spreading in flat rolling	5	CO3	L2
40	Explain the types of deflection that rolls undergo.	5	CO3	L2
41	Explain how seamless tubes are produced by rolling	5	CO3	L2
42	Describe the process of thread rolling.	5	CO3	L2
43	Identify some of the ways in which force in flat rolling can be reduced.	5	CO3	L2
44	Explain the working of a two-high rolling mill	5	CO3	L2
45	Explain the features of a reversing mill in rolling	5	CO3	L2
46	Besides flat rolling and shape rolling, identify some additional bulk forming processes that use rolls to effect the deformation.	5	CO3	L2
47	An annealed Copper strip 228mm wide and 25mm thick is rolled to a thickness 20mm in one pass. The roll radius is 300mm and the rolls rotate at	5	CO3	L2

	100rpm. Calculate the roll force and the power required in this operation			
48	Explain how do you select the speed of the rolls at different stands in a continuous rolling mill.	8	CO3	L3
49	Suggest a suitable process for the manufacture of rails and justify your answer.	8	CO3	L3
50	Explain the reasons why the bulk deformation processes are important commercially and technologically	8	CO3	L3
51	Explain how to choose the material for making rolls	8	CO3	L3
52	A 100mm square billet is to be rolled into a rod of 12.5mm diameter. Draw the sequence of operations	8	CO3	L3
53	Explain the yield criteria of Tresca, von Mises and compare each other	8	CO3	L3
54	Simply stretching the material can reduce thickness of the material. Explain why do we require rolling process.	8	CO3	L3
55	Explain what happens in rolling process if: rolls are made from different sizes, rolls are made from materials having different properties, and rolls rotate at different speeds.	8	CO3	L3
56	An annealed Copper strip 228mm wide and 25mm thick is rolled to a thickness 20mm in one pass. The roll radius is 300mm and the rolls rotate at 100rpm. Calculate the roll force and the power required in this operation	8	CO3	L3
	MODULE-4			
1	Classify the metal forming processes	3	CO4	L1
2	Name the forming process used to make wire coat hanger	3	CO4	L1
3	List any 5 components manufactured by extrusion process.	3	CO4	L1
4	Compare forged components with cast components, in respect of grain flow	3	CO4	L1
5	Differentiate between drop forging and press forging.	3	CO4	L1
6	List the various types of forging methods available to a manufacturing engineer.	3	CO4	L1
7	List the various processes of metal working.	3	CO4	L1
8	List the advantages of hot working over cold working of metals	3	CO4	L1
9	List the specific merits of cold working over hot working	3	CO4	L1
10	Specify the temperature that should plain-carbon steel be heated for hot working	3	CO4	L1
11	Distinguish between open and closed die-forging processes.	3	CO4	L1
12	Distinguish clearly between drop forging and press-forging processes with reference to the process and products obtained.	3	CO4	L1
13	List the advantages of forging of metals.	3	CO4	L1
14	Differentiate upsetting and fullering in forging	3	CO4	L1
15	Compare forged components with cast components	3	CO4	L1

16	Differentiate between impact extrusion and cold extrusion forging	3	CO4	L1
17	Distinguish between wire drawing and tube drawing, with sketches.	3	CO4	L1
18	List the advantages and disadvantages of hot working	3	CO4	L1
19	List out the various forging defects and explain any two in detail.	3	CO4	L1
20	Differentiate 'hand forging' from 'machine forging'	3	CO4	L1
21	State the advantages and disadvantages of forging.	3	CO4	L1
22	List the advantages, limitations and applications of extrusion process.	3	CO4	L1
23	Classify the extrusion process.	3	CO4	L1
24	List the difference between extrusion and drawing	3	CO4	L1
25	List the types of defects may occur in extrusion and in drawing	3	CO4	L1
26	Name the important process variables in the drawing of rod and wire.	3	CO4	L1
27	Compare extrusion and drawing of tubes.	3	CO4	L1
28	Indicate some of the advantages of cold working relative to warm and hot working.	3	CO4	L1
29	Distinguish between direct and indirect extrusion	3	CO4	L1
30	Name some products that are produced by extrusion.	3	CO4	L1
31	Differentiate between wire drawing and bar drawing	3	CO4	L1
32	Explain why stainless steel is not used in extrusion process	5	CO4	L2
33	Explain (a) forward extrusion (b) backward extrusion, (c) impact extrusion and (d) tube extrusion process.	5	CO4	L2
34	Explain how toothpaste tubes are manufactured by impact extrusion process are filled.	5	CO4	L2
35	Explain with an example, each for (a) hand forging (b) drop forging and (c) press forging, mentioning the type of job performed by the three processes.	5	CO4	L2
36	Explain with the help of neat sketches, how a hexagonal nut can be manufactured from a cylindrical rod.	5	CO4	L2
37	Explain the basic operations that are normally employed in forging.	5	CO4	L2
38	Explain how forging improves the mechanical properties of components.	5	CO4	L2
39	Explain why draft is provided in a drop-forging die	5	CO4	L2
40	Explain the significance of recrystallisation temperature in metal working	5	CO4	L2
41	Differentiate the features of 'grain flow' in the case of forged or rolled components	5	CO4	L2
42	List the different stages in the drop forging process in production of a component such as spanner.	5	CO4	L2

43	Explain the term “flash” in a forging, with the help of a sketch.	5	CO4	L2
44	Draw the cross section of a drawing die, labeling various features of it.	5	CO4	L2
45	Explain with sketches the difference between direct and indirect extrusion.	5	CO4	L2
46	Explain why the whole of the material (billet) put in the container for extrusion is not extruded.	5	CO4	L2
47	List the various materials used for making wire-drawing dies and list the applications of each of them.	5	CO4	L2
48	Explain how collapsible tubes of aluminium (such as those used for tooth paste tubes) are manufactured.	5	CO4	L2
49	Explain the common hot working processes	5	CO4	L2
50	Describe the process of hot extrusion of tubes.	5	CO4	L2
51	Describe the indirect extrusion process for solid and hollow workpiece and hydrostatic extrusion process.	5	CO4	L2
52	Explain briefly the following three basic categories of forging a) Open-die forging; b) Impression die forging; c) Closed-die forging	5	CO4	L2
53	Explain briefly the following extrusion processes a) Hydrostatic extrusion; b) Backward extrusion; c) Impact extrusion	5	CO4	L2
54	Describe briefly the extrusion defects	5	CO4	L2
55	Explain the wire drawing process with a neat sketch.	5	CO4	L2
56	Explain the features of a typical forging die.	5	CO4	L2
57	Explain the function of flash in impression die forging.	5	CO4	L2
58	Explain why there are so many different types of forging machines.	5	CO4	L2
59	Explain why cold extrusion has become an important manufacturing process.	5	CO4	L2
60	Explain why friction is generally undesirable in metal forming operations	5	CO4	L2
61	Explain sticking friction in metal working	5	CO4	L2
62	Classify forging operations by the degree to which the work is constrained in the die. Name the three basic types according to this classification.	5	CO4	L2
63	Explain why flash is desirable in impression die forging	5	CO4	L2
64	Justify with examples, whether metal forming process is more competitive when compared to machining or casting process.	8	CO4	L3
65	Justify with reasoning whether a gear can be manufactured by extrusion process	8	CO4	L3
66	Justify whether backward extrusion process can be substituted for forward extrusion process.	8	CO4	L3
67	Justify whether it is possible to forge all the materials.	8	CO4	L3
68	Explain how the parting line is chosen in the case of drop-forging operations? Give examples	8	CO4	L3
69	Explain why brittle materials can be worked by extrusion more successfully than by some other metal-working methods.	8	CO4	L3

70	Show by schematic sketches the process of forward and backward extrusion, with the help of two examples of components produced by extrusion.	8	CO4	L3
71	Discuss the relative merits and demerits of direct extrusion and indirect extrusion	8	CO4	L3
72	Explain the principles of different forging machines.	8	CO4	L3
73	Explain the concerns in the layout of upsetting dies.	8	CO4	L3
74	Explain why extrusion is a batch or semi-continuous process. Do you think it can be made into a continuous process? Explain.	8	CO4	L3
75	Explain the different ways by which changing the die angle affects the extrusion process.	8	CO4	L3
76	Although the work piece in a wire drawing operation is obviously subjected to tensile stresses, Explain how compressive stresses also play a role in the process	8	CO4	L3
77	Explain why in a wire drawing operation, the drawing stress never exceed the yield strength of the work metal	8	CO4	L3
78	Explain why crankshaft of an automobile is manufactured by forging and not by casting	8	CO4	L3
79	Assume that you are reducing the diameter of two round rods, one by simple tension and the other by indirect extrusion. Which methods would be better? Explain	8	CO4	L3
80	A cylindrical specimen made of annealed 4135 steel has a diameter of 6 inches and is 4 inch high. It is upset by open die forging with flat dies to a height of 2 inch at room temperature. Assuming that the coefficient of friction is 0.2, calculate the force required at the end of the stroke. Use average pressure formula.	8	CO4	L3
81	How can you tell whether a certain part is forged or cast? Describe the features that you would investigate to arrive at a conclusion.	8	CO4	L3
82	Explain why forged parts withstand high loads, compared to cast parts.	8	CO4	L3
83	Explain why the die pressure in drawing process decreases towards the exit of the die	8	CO4	L3
84	Explain what can be expected, if during the wire-drawing operation, the reduction attempted is more than the recommended value	8	CO4	L3
85	Estimate the limiting drawing ratio that you would expect from a sheet metal that, when stretched by 23 percentage in length, decreases in thickness by 10 percentage	10	CO4	L4
86	Explain why crankshaft of an automobile is manufactured by forging and not by casting	10	CO4	L4
87	Assume that you are reducing the diameter of two round rods, one by simple tension and the other by indirect extrusion. Which methods would be better? Explain	10	CO4	L4
88	Two solid cylindrical specimens A and B, made of a perfectly plastic material, are being forged with friction and isothermally at room temperature to a reduction in height of 50%. Specimen A has a height of 2 inch and cross sectional area of 1 square inch, and specimen B has a height of is 1 inch and a cross sectional area of 2 square inch will the work done be the same for the two specimens? Explain.	10	CO4	L4
	MODULE-5			
1	List some important defects, prevalent in sheet metal formed parts.	3	CO5	L1

2	Differentiate between coining and embossing.	3	CO5	L1
3	List various operations generally performed in a sheet-metal shop.	3	CO5	L1
4	Distinguish between bending and drawing in sheet-metal operations.	3	CO5	L1
5	Differentiate blanking and punching.	3	CO5	L1
6	Name the various methods by which sheet-metal blanks can be cut from a large sheet.	3	CO5	L1
7	List the advantages of rubber forming.	3	CO5	L1
8	Differentiate between bulk deformation processes and sheet metal processes.	3	CO5	L1
9	Identify the three basic types of sheet metal working operations.	3	CO5	L1
10	Define drawing in the context of sheet metal working.	3	CO5	L1
11	List some of the possible defects in drawn sheet-metal parts.	3	CO5	L1
12	Define locating.	3	CO5	L1
13	List the major factors that determines how a workpiece will be located.	3	CO5	L1
14	Define complete location.	3	CO5	L1
15	Define concentric location and give an example.	3	CO5	L1
16	List the four essential requirements of clamps and clamping devices.	3	CO5	L1
17	Define the term ‘degrees of freedom’.	3	CO5	L1
18	List the main functions of a locating device.	3	CO5	L1
19	Define a clamp and state the function of a clamping device.	3	CO5	L1
20	Enumerate various types of clamps (e.g., Strap, Side, Hinged).	3	CO5	L1
21	Distinguish between spinning and cup drawing with reference to the process and components produced.	5	CO5	L2
22	Draw a sketch of a punch and a die set used for punching operation. Indicate its various parts.	5	CO5	L2
23	Sketch a deep-drawing set up, labeling the various important parts.	5	CO5	L2
24	Show by a neat sketch, the edge-bending operation with a die punch set in position.	5	CO5	L2
25	Explain why is it necessary to provide proper clearance between the punch and die in a shearing operation.	5	CO5	L2
26	Explain why blank holding is necessary in a sheet-metal drawing operation.	5	CO5	L2
27	Explain sheet metal spinning.	5	CO5	L2
28	Explain bending operation on a metal, including V-bending and edge bending.	5	CO5	L2

29	Explain deep drawing in detail.	5	CO5	L2
30	Explain the principle of hot spinning.	5	CO5	L2
31	Explain springback in sheet-metal bending.	5	CO5	L2
32	Distinguish between redrawing and reverse drawing.	5	CO5	L2
33	Explain the embossing operation.	5	CO5	L2
34	Explain stretch forming.	5	CO5	L2
35	Explain how sheet-metal working process is different from the metal forming process.	5	CO5	L2
36	Explain the different stages involved in the blanking operation.	5	CO5	L2
37	Explain with neat sketches how a soap box can be manufactured from a given sheet of material (Deep Drawing).	5	CO5	L2
38	Explain the consequences, if a blank holder does not hold the blank in a drawing operation.	5	CO5	L2
39	Differentiate between hemming, beading, seaming and flanging operations.	5	CO5	L2
40	Explain why locating points should be placed as far apart as possible.	5	CO5	L2
41	Explain the common methods of locating from circular surfaces.	5	CO5	L2
42	Describe the basic rules for applying clamping forces.	5	CO5	L2
43	Explain what is a spherical washer, and when is it used.	5	CO5	L2
44	Describe briefly ‘principles of location’.	5	CO5	L2
45	Explain the 3-2-1 principle of location.	5	CO5	L2
46	Explain the factors which affect the clearances for proper cutting operation in blanking or piercing.	8	CO5	L3
47	List and explain the properties of materials that influence springback.	8	CO5	L3
48	Outline the difference that you have observed between products made of sheet metals and those made by casting and forging.	8	CO5	L3
49	Explain why springback in bending depends on yield stress, elastic modulus, sheet thickness, and bend radius.	8	CO5	L3
50	Explain why it is necessary to establish complete location of a workpiece whose configuration is formed by flat planes.	8	CO5	L3

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Course Code & Name: MET 206 Fluid Machinery

1. Prescribed Syllabus

Module	Topic	Hours
1	Impact of jets: Introduction to hydrodynamic thrust of jet on a fixed and moving surface (flat and curve), – Series of vanes - work done and efficiency. Hydraulic Turbines: Impulse and Reaction Turbines – Degree of reaction – Pelton Wheel – Constructional features - Velocity triangles – Euler's equation – Speed ratio, jet ratio and work done, losses and efficiencies, design of Pelton wheel – Inward and outward flow reaction turbines- Francis Turbine – Constructional features – Velocity triangles, work done and efficiencies. Axial flow turbine (Kaplan) Constructional features – Velocity triangles- work done and efficiencies	
2	Characteristic curves of turbines – theory of draft tubes – surge tanks – Cavitation in turbines – Governing of turbines – Specific speed of turbine , Type Number– Characteristic curves, scale Laws – Unit speed – Unit discharge and unit power. Rotary motion of liquids – free, forced and spiral vortex flows Rotodynamic pumps- centrifugal pump impeller types,-velocity triangles manometric head- work, efficiency and losses, H-Q characteristic, typical flow system characteristics, operating point of a pump. Cavitation in centrifugal pumps- NPSH required and available- Type number- Pumps in series and parallel operations. Performance characteristics- Specific speed-Shape numbers – Impeller shapes based on shape numbers.	
3	Positive displacement pumps- reciprocating pump – Single acting and double acting- slip, negative slip and work required and efficiency- indicator diagram- acceleration head - effect of acceleration and friction on indicator diagram – speed calculation- Air vessels and their purposes, saving in work done to air vessels multi cylinder pumps. Multistage pumps-selection of pumps pumping devices-hydraulic ram, Accumulator, Intensifier, Jet pumps, gear pumps, vane pump and lobe pump.	
4	Compressors: classification of compressors, reciprocating compressor-single stage compressor, equation for work with and without clearance volume, efficiencies, multistage compressor,	

	intercooler, free air delivered (FAD). Centrifugal compressor-working, velocity diagram, work done, power required, width of blades of impeller and diffuser, isentropic efficiency, slip factor and pressure coefficient, surging and chocking. Axial flow compressors:-working, velocity diagram, degree of reaction, performance. Roots blower, vane compressor, screw compressor.	
5	Gas turbines: classification, Thermodynamic analysis of gas turbine cycles-open, closed and semi closed cycle; ideal working cycle-Brayton cycle-P-v and T-s diagram, thermal efficiency. Effect of compressor and turbine efficiencies. Optimum pressure ratio for maximum specific work output with and without considering machine efficiencies. Comparison of gas turbine and IC engines, Analysis of open cycle gas turbine, Improvements of the basic gas turbine cycles-regeneration, intercooling and reheating-cycle efficiency and work output-Condition for minimum compressor work and maximum turbine work. Combustion chambers for gas turbines. pressure loss in combustion process and stability loop.	

2. Text Books (T)

T1. Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017 T2. Rathore, M., Thermal Engineering, Tata McGraw Hill, 1st edition, 2010

3. Reference Books (R)

R1. Ganesan, V., Gas Turbines, Tata McGraw Hill, 3rd edition, 2017.
R2. Sawhney G.S., Thermal and Hydraulic Machines, Prentice Hall India Learning Private Limited; 2nd edition, 2011

4. Course Objectives

To acquire knowledge on hydraulic machines such as pumps and turbines.

b) To prepare the students to solve complex problems related to fluid forces on a vane.

c) To introduce the concepts of design aspects of hydraulic machines like turbines and pumps and their applications.

d) To understand the working of air compressors and do the analysis

e) Describe the operating characteristics of Fluid machinery (pumps, turbines and compressors), and the factors affecting their operation and specifications, as well as their operation in a system.

5. Course Pre / Co-requisite

MET203 Mechanics of Fluids

6. Course Outcomes

Upon successful completion of the course students will be able to
CO1: Explain the characteristics of centrifugal and reciprocating pumps
CO2: Calculate forces and work done by a jet on fixed or moving plate and curved plates CO3: Explain the working of turbines and Select a turbine for specific application.
CO4: Analyse the working of air compressors and Select the suitable one based on application.
CO5: Analyse gas turbines and identify the improvements in basic gas turbine cycles.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO 1	H	H	M												M
CO 2	H	H	M												H
CO 3	H	H	M												M
CO 4	H	H	M												H
CO 5	H	H	M												H

8. Justification for CO-PO-PSO Correlation

CO1	**PO1**	The characteristics features and constructional features of centrifugal and reciprocating pumps are used to solve the engineering problems. High correlation is due to the fact that this involves the deep knowledge of science, engineering fundamentals, and an engineering specialization to solve the complex engineering problems.
	PO2	The interpretation of characteristics features for centrifugal and reciprocating pumps are used to identify, formulate and analyse the complex engineering problems. High correlation is due to the fact that this involves the deep knowledge using first principles of mathematics, science and engineering.
	PO3	The characteristics of centrifugal and reciprocating pumps are used to design solutions for complex engineering problems and design system components. High correlation is due to the fact that this involves the deep knowledge that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
	PSO3	The characteristics of centrifugal and reciprocating pumps are used to design solutions for complex engineering problems design and analyse multi-

		disciplinary systems. Medium correlation is due to the fact that this involves the basic knowledge of engineering principles to design and analyse multi-disciplinary hydraulic systems.
CO2	**PO1**	Analytical knowledge on forces and work done by a jet on fixed or moving plate and curved plates are used to solve the engineering problems. High correlation is due to the fact that this involves the deep knowledge of science, engineering fundamentals, and an engineering specialization to solve the complex engineering problems.
	PO2	Analytical knowledge on the forces and work done by a jet on fixed or moving plate and curved plates of power producing and power consuming machineries are used to identify, formulate and analyse the complex engineering problems. High correlation is due to the fact that this involves the deep knowledge using first principles of mathematics, science and engineering.
	PO3	Analytical knowledge on the forces and work done by a jet on fixed or moving plate and curved plates are used to design solutions for complex engineering. High correlation is due to the fact that this involves the deep knowledge that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
	PSO3	Analytical knowledge on the forces and work done by a jet on fixed or moving plate and curved plates are used for design solutions of complex engineering problems. High correlation is due to the fact that this involves the deep knowledge of engineering principles to design and analyse multi-disciplinary hydraulic systems.
CO3	**PO1**	The knowledge of hydraulic turbines working and its selection is used to solve the engineering problems. High correlation is due to the fact that this involves the deep knowledge of engineering fundamentals and engineering specialization to solve the complex engineering problems.
	PO2	The knowledge of hydraulic turbines working and its selections are used to identify, formulate and analyse the complex engineering problems. High correlation is due to the fact that this involves the deep knowledge using first principles of mathematics, science and engineering.
	PO3	The knowledge of hydraulic turbines working and its selections are used to design solutions for complex engineering problems and design system

		components. High correlation is due to the fact that this involves the deep knowledge that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
	PSO3	The knowledge of hydraulic turbines working and its selections are used to design solutions for complex engineering problems design and analyse multi-disciplinary systems. Medium correlation is due to the fact that this involves the basic knowledge of engineering principles to design and analyse multi-disciplinary hydraulic systems.
CO4	**PO1**	The knowledge of working of air compressors are used to solve the engineering problems. High correlation is due to the fact that this involves the deep knowledge of science, engineering fundamentals and engineering specialization to solve the complex engineering problems.
	PO2	The working of air compressors, its selections are used to identify, formulate and analyse the complex engineering problems. High correlation is due to the fact that this involves the deep knowledge using first principles of mathematics, science and engineering.
	PO3	The analysis and working of air compressors, its selections are used to design solutions for complex engineering problems and design system components. High correlation is due to the fact that this involves the deep knowledge that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
	PSO3	Analytical knowledge of working of air compressors, its selections are used for design solutions of complex engineering problems. High correlation is due to the fact that this involves the deep knowledge of engineering principles to design and analyse multi-disciplinary hydraulic systems.
CO5	**PO1**	Analyse the gas turbines and identifying the improvements in basic gas turbine cycles are used to solve the engineering problems. High correlation is due to the fact that this involves the deep knowledge of science, engineering fundamentals and engineering specialization to solve the complex engineering problems.
	PO2	The working of gas turbines and identifying the improvements in basic gas turbine cycles are used to identify, formulate and analyse the complex

		engineering problems. High correlation is due to the fact that this involves the deep knowledge using first principles of mathematics, science and engineering.
	PO3	The analysis and working of gas turbines are used to design solutions for complex engineering problems and design system components. High correlation is due to the fact that this involves the deep knowledge that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
	PSO3	Analytical knowledge of working of gas turbines, its selections, the improvements in basic gas turbine cycles are used for design solutions of complex engineering problems. High correlation is due to the fact that this involves the deep knowledge of engineering principles to design and analyse multi-disciplinary hydraulic systems.

9. Curricular gaps (if any)

Syllabus declared in the year 2019 is very lengthy.
The time allotted to cover the basic knowledge in the first module is very less.

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	basic knowledge of turbine/ pumps/ air compressors	Visit to Fluid Mechanics lab and Thermal lab	PO1

11. Internal Assessment mark allocation (as per university curriculum)

(Provide details as mentioned in syllabus)

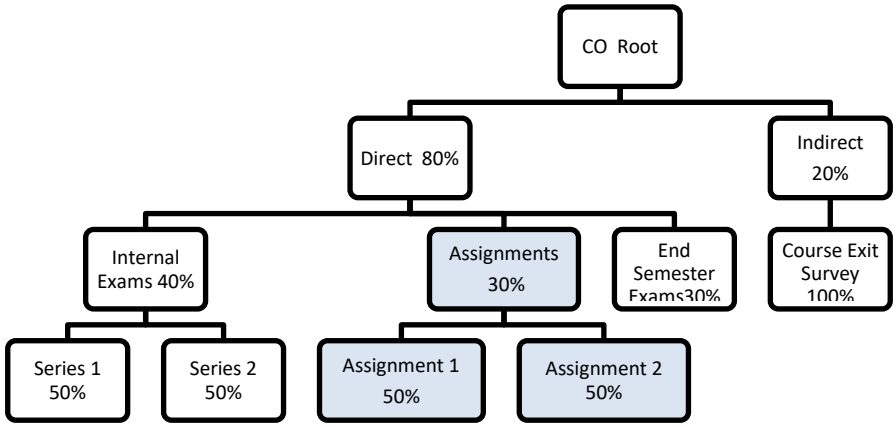
Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		**Weightage#**	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
	Internal Exam(s) 40%	Series 1	20%	x	x	x		
		Series 2	20%	x			x	x

Direct Assessment Tools**	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x		x		
		Assignment 2	15%				x	x
	End Semester Exam		30%	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hours Allotted	Topic Name	Module	Reference	Teaching Pedagogy
1	Impact of jets: Introduction to hydrodynamic thrust of jet on a flat fixed surface	1	Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017	Lecture
2	hydrodynamic thrust of jet on a fixed curved surface	1	Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017	Lecture
3	hydrodynamic thrust of jet on a flat moving surface	1	Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017	Lecture
4	Series of vanes - work done and efficiency, hinged plates and problems related	1	Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017	Lecture

5	Hydraulic Turbines : Impulse and Reaction Turbines	1	Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017	Lecture
6	Pelton Wheel â€“ Constructional features Speed ratio, jet ratio and work done , losses and efficiencies	1	Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017	Lecture
7	Pelton Wheel :- Degree of reaction â€“- Velocity triangles, problems, Eulerâ€™s equation â€“ , design of Pelton wheel, problems	1	Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017	Lecture
8	Inward and outward flow Reaction turbines- Francis Turbine â€“ Constructional features Velocity triangles, work done and efficiencies.	1	Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017	Lecture
9	Francis Turbine - Velocity triangles, work done and efficiencies, problems	1	Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017	Lecture
10	Axial flow turbine (Kaplan) Constructional features	1	Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017	Lecture
11	Velocity triangles- work done and efficiencies, problems	1	Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017	Lecture
12	Characteristic curves of turbines â€“ theory of draft tubes	2	Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017	Lecture
13	â€“ surge tanks â€“ Cavitation in turbines â€“ Governing of turbines	2	Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017	Lecture
14	Specific speed of turbine , Type Numberâ€“	2	Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017	Lecture
15	scale Laws â€“ Unit speed â€“ Unit discharge and unit power.	2	Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017	Lecture
16	Rotary motion of liquids â€“ free, forced and spiral vortex flows Rotodynamic pumps- centrifugal pump impeller types	2	Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017	Lecture
17	acceleration head - effect of acceleration and friction on indicator diagram	3	Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017	Lecture

18	acceleration head - effect of acceleration and friction on indicator diagram	3	Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017	Lecture
19	Air vessels and their purposes, saving in work done to air vessels multi cylinder pumps	3	Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017	Lecture
20	Air vessels and their purposes, saving in work done to air vessels multi cylinder pumps	3	Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017	Lecture
21	Multistage pumps- selection ofpumps- pumping devices	3	Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017	Lecture
22	hydraulic ram, Accumulator, Intensifier, Jet pumps, gear pumps, vane pump and lobe pump.	3	Subramanya, K., Hydraulic Machines, Tata McGraw Hill, 1st edition, 2017	Assignment
23	Compressors: classification of compressors,	4	Rathore, M., Thermal Engineering, Tata McGraw Hill, 1st edition, 2010	Lecture
24	Reciprocating compressor- single stage compressor,	4	Rathore, M., Thermal Engineering, Tata McGraw Hill, 1st edition, 2010	Lecture
25	Equation for work with and without clearance volume, efficiencies, problems	4	Rathore, M., Thermal Engineering, Tata McGraw Hill, 1st edition, 2010	Lecture
26	Multistage compressor, Problems related	4	Rathore, M., Thermal Engineering, Tata McGraw Hill, 1st edition, 2010	Lecture
27	Intercooler Free air delivered (FAD)	4	Rathore, M., Thermal Engineering, Tata McGraw Hill, 1st edition, 2010	Lecture
28	Centrifugal compressor- working	4	Rathore, M., Thermal Engineering, Tata McGraw Hill, 1st edition, 2010	Lecture
29	Centrifugal compressor - velocity diagram, work done, power required, width of blades of impeller and diffuser, related problems	4	Rathore, M., Thermal Engineering, Tata McGraw Hill, 1st edition, 2010	Lecture
30	Centrifugal compressor - isentropic efficiency, slip factor and pressure coefficient,	4	Rathore, M., Thermal Engineering, Tata McGraw Hill, 1st edition, 2010	Lecture
31	Axial flow compressors:- working, velocity diagram, degree of reaction, performance.	4	Rathore, M., Thermal Engineering, Tata McGraw Hill, 1st edition, 2010	Lecture

32	Axial flow compressors:- velocity diagram, degree of reaction, performance.	4	Rathore, M., Thermal Engineering, Tata McGraw Hill, 1st edition, 2010	Lecture
33	surging and chocking Roots blower	4	Rathore, M., Thermal Engineering, Tata McGraw Hill, 1st edition, 2010	Lecture
34	Vane compressor Screw compressor	4	Rathore, M., Thermal Engineering, Tata McGraw Hill, 1st edition, 2010	Lecture
35	Gas turbines: classification	5	Ganesan, V., Gas Turbines, Tata McGraw Hill, 3rd edition, 2017.	Lecture
36	Thermodynamic analysis of gas turbine cyclesopen, closed and semi closed cycle	5	Ganesan, V., Gas Turbines, Tata McGraw Hill, 3rd edition, 2017.	Lecture
37	ideal working cycle-Brayton cycle-P-v and T-s diagram, thermal efficiency	5	Ganesan, V., Gas Turbines, Tata McGraw Hill, 3rd edition, 2017.	Lecture
38	Effect of compressor and turbine efficiencies. Optimum pressure ratio for maximum specific work output with and without considering machine efficiencies.	5	Ganesan, V., Gas Turbines, Tata McGraw Hill, 3rd edition, 2017.	Lecture
39	Comparison of gas turbine and IC engines, Analysis of open cycle gas turbine	5	Ganesan, V., Gas Turbines, Tata McGraw Hill, 3rd edition, 2017.	Lecture
40	Improvements of the basic gas turbine cycles-regeneration	5	Ganesan, V., Gas Turbines, Tata McGraw Hill, 3rd edition, 2017.	Lecture
41	intercooling and reheating-cycle efficiency and work output	5	Ganesan, V., Gas Turbines, Tata McGraw Hill, 3rd edition, 2017.	Lecture
42	Condition for minimum compressor work and maximum turbine work.	5	Ganesan, V., Gas Turbines, Tata McGraw Hill, 3rd edition, 2017.	Lecture
43	Combustion chambers for gas turbines.	5	Ganesan, V., Gas Turbines, Tata McGraw Hill, 3rd edition, 2017.	Lecture
44	pressure loss in combustion process and stability loop.	5	Ganesan, V., Gas Turbines, Tata McGraw Hill, 3rd edition, 2017.	Lecture

15. **Question Bank**

Module 1				
Sl. No.	Question	Marks	CO	BL
1	Explain advantages and disadvantages of a Pelton turbine?	3	CO3	L1
2	Differentiate between inward flow and outward flow reaction turbines.	3	CO3	L1
3	Define the following terms with reference to water turbines. Obtain the relation between them. i) Hydraulic efficiency ii) Mechanical efficiency iii) Overall efficiency	3	CO3	L1
4	Define the following: i) Cross head ii) Net head iii) Hydraulic efficiency iv) Overall efficiency	3	CO3	L1
5	Define the following terms of Turbine: (i) Gross head (ii) Net head (iii)Hydraulic efficiency (iv) Mechanical efficiency	3	CO3	L1
6	Explain the constructional features of Pelton turbine	5	CO3	L1
7	(i) Find the force exerted by the jet on a stationary vertical plate. (ii) find the force exerted by a jet of water of diameter 75mm on a stationary flat plat, when the jet strikes the plate normally with velocity of 20m/s.	6	CO2	L1
8	Explain the working of Kaplan turbine with neat sketch.	6	CO3	L1
9	Differentiate the construction and working of an impulse and a reaction turbine.	3	CO3	L2
10	A nozzle forming a jet of 50 mm diameter is supplied with water under a constant head of 75 m. The jet is directed to strike perpendicularly on to a fixed flat plate. Calculate the force exerted by the jet on the plate. Take velocity coefficient of the nozzle as 0.92.	3	CO2	L2
11	A jet of 7.5cm diameter strikes a flat plate, normal of which is inclined at 45^0 to the axis of the jet with a velocity of 25m/s. Find the normal force exerted on the plate i) When the plate is stationery ii) When the plate is moving with a velocity of 15m/s in the direction of jet and away from the jet.	6	CO2	L2
12	A jet of water moving with a velocity of 22m/s impinges on a curved vane at one end tangentially. The jet leaves vane at an angle of 120^0 to the direction of motion of the vane. The velocity of the vane is 10m/s and the angle of the nozzle is 20^0. Determine i) vane angle at inlet and outlet ii) work done per kg of water.	6	CO2	L2
13	A Pelton wheel having a mean bucket diameter of 1.2m is running at 1000 r.p.m. The net head on the Pelton wheel is 840 m. If the side clearance angle is 15° and discharge through the nozzle is 0.12 m3/s. Determine: - (i) Power available at the nozzle (ii) Hydraulic efficiency of the turbine.	6	CO3	L2
14	Derive the expression for maximum hydraulic efficiency of a Pelton wheel.	6	CO3	L2

15	Show that the maximum efficiency for a semi-circular vane when the jet strikes at the centre is 59.26 %.	6	CO2	L2
16	An inward flow reaction turbine has external and internal diameters as 0.9m and 0.45 m respectively. The turbine is running at 200 r.p.m and the width of the turbine at the inlet is 0.2 m. The velocity of flow through the runner is constant and is equal to 1.8 m/s. The guide blades make an angle of 10° to the tangent of the wheel and discharge at the outlet of turbine is radial. Draw the inlet and outlet velocity triangles and determine:- (i) Relative velocity at inlet (ii) The runner blade angles (iii) Width of the runner at outlet (iv) Head at the inlet of the turbine (v) Power developed (vi) Hydraulic efficiency of the turbine.	10	CO3	L2
17	A Francis turbine develops 160kW at 150rpm under a head of 10m. The peripheral velocity at inlet and flow velocity at inlet of turbine are $\mathbf{0.3}\sqrt{2gH}$ and $\mathbf{0.9}\sqrt{2gH}$ respectively. The overall efficiency of the turbine is 78% and hydraulic efficiency is 82%. Draw velocity triangle and find i) guide blade angle and runner vane angle at inlet and ii) diameter and width of the runner at inlet.	10	CO3	L2
18	In a Pelton wheel turbine, the runner of the turbine is provided with double hemispherical cup shaped buckets instead of single curved blade. Why?	3	CO3	L3
19	The angle of deviation of a jet striking the bucket of a Pelton wheel turbine is usually less than 1800. Why?	3	CO3	L3
20	Find an expression for the efficiency of a series of moving curved vanes when a jet of water strikes the vanes at one of its tips and show that the maximum efficiency is 50%.	3	CO2	L3
21	Prove that the maximum efficiency of a jet impinging on a series of moving flat plate is 50%.	5	CO2	L3
22	Show that the maximum efficiency of a jet striking normally on a moving flat plate in the direction of jet is 8/27	6	CO2	L3
23	A Pelton wheel is to be designed for a head of 60m when running at 200r.p.m. The Pelton wheel develops 95.6475kw shaft power. The velocity of the buckets is 0.45 times the velocity of the jet, overall efficiency is 0.85 and co-efficient of the velocity is equal to 0.98	6	CO3	L3
24	Estimate the force exerted by a jet of water on an unsymmetrical moving curved plate when jet strikes tangentially at one of the tips. Also obtain the expression for work done. Assume, blade angles at inlet and exit are θ and φ and the blade is moving with a velocity u.	6	CO2	L3
25	Prove that the hydraulic efficiency of a Pelton wheel turbine is maximum when the jet velocity striking the runner is twice the tangential velocity of the runner?	7	CO3	L3
26	Derive expression for the force exerted by the jet of water on a series moving flat plate placed on the periphery of a wheel. Also find the maximum efficiency?	10	CO2	L3

27	The water fed from Idukki reservoir to Moolamattam power house is 6 m3/s at a total head of 250 m through a single penstock of 500 m long. The turbine has four Pelton wheels with two nozzles each. The efficiency of power transmission through the penstock is 90% and overall efficiency is 85%. The coefficient of velocity for each nozzle may be assumed as 0.95 and the friction factor as 0.02. Determine the (a) power output of the plant (b) diameter of each nozzle (c) penstock diameter. Assume that all the nozzles have same diameter. Assume radial outlet.	10	CO3	L3
28	An outward flow reaction turbine has the inner and outer diameters as 1.50m and 2.0 m, respectively, and is rotating at 300 rpm operating under an effective head of 60 m. The runner has 30 vanes 10 mm thick at inlet and at the outlet. The width of the passage is 30 cm throughout. The discharge through the turbine is 10 m3/s. Determine (a) the blade angles at inlet and outlet and (b) power developed by the runner.	10	CO3	L3
29	Water flows through a vertical Francis turbine at the rate of 15.5 m3/s and makes its runner to rotate at 428.4 rpm. The velocity and pressure head at the inlet of the spiral casing are 8.5 m/s and 240 m respectively and the centre line of its inlet is 3 m above the tail race level. The diameter and width of the runner at inlet are 2 m and 300 mm respectively, determine output power, guide vane angle and runner vane angle at inlet.	10	CO3	L3
30	In a projected low head hydroelectric scheme 283 m3/s of water are available under a head of 3.66 m. Alternative schemes to use Francis turbines having a specific speed of 400 or Kaplan turbines with a specific speed of 686 are investigated. The normal running speed is 50 rpm in both the schemes. Compare the proposals so far as the numbers of machines are concerned and estimate the power to be developed by each machine. The units in either installations are to be of equal power and the efficiency of each type may be assumed to be 90%.	10	CO3	L3

Module 2

Sl. No.	Question	Marks	CO	BL
1	Explain multistaging in centrifugal pumps. Where are they used?	3	CO1	L1
2	Find the number of pumps required to take water from a deep well under a total head of 89 m. All pumps are identical and running at 800 rpm. The specific speed of each pump is given as 25 while the rated capacity of each pump is 0.16 m3/s.	3	CO1	L1
3	What is meant by specific speed of a turbine? What is its significance?	3	CO3	L1
4	What is a draft tube? Why is it used in reaction turbine? What are the various types of it?	3	CO3	L1
5	Explain the working of a draft tube in a axial reaction turbine with neat sketch. What is the reason for the absence of draft tube in an impulse turbine?	3	CO1	L1
6	What is cavitation? On what factors does the cavitation in water turbines depend?	3	CO3	L1

7	What unit quantities are as applied to hydraulic turbines? Why are they important?	3	CO3	L1
8	(i) What is the significance of Type number in Turbines (ii) Define specific speed of a turbine? Derive an expression for the same.	3	CO3	L1
9	Define minimum starting speed of a centrifugal pump. Write down the equation for the same with notations.	3	CO1	L1
10	What is meant by manometric head of a centrifugal pump? What are the different ways of finding it?	3	CO1	L1
11	Define the following terms: - (i) Static head (ii) Manometric head (iii) Total Head	3	CO1	L1
12	What is Euler head of a centrifugal pump?	3	CO1	L1
13	Define the following terms of centrifugal pump (i) Suction head (ii) Delivery head (iii) Static head (iv) Manometric head.	3	CO1	L1
14	Classify different types of vortex fluid flows and write down the relevant governing equations.	3	CO1	L1
15	Explain the theory of draft tube in reaction turbine. How is the turbine performance affected in the absence of draft tube?	3	CO3	L1
16	Illustrate the functions of surge tanks.	5	CO3	L1
17	What is the function of draft tube? With neat sketch explain draft tube theory.	5	CO3	L1
18	i) What is governing of turbines? ii) With neat sketch explain the governing of impulse turbine.	5	CO3	L1
19	What is meant by cavitation in centrifugal pump? What are the effects of cavitation? How it can be eliminated.	5	CO1	L1
20	Explain NPSH and Thoma's cavitation factor in centrifugal pump	5	CO1	L1
21	Define specific speed of a centrifugal pump. Derive expression for the same.	5	CO1	L1
22	With neat sketches, explain the working servo motor mechanism of governing of a pelton turbine.	6	CO3	L1
23	Define the specific speed of a turbine and derive the expression for it. Explain the significance of specific speed in the selection of a turbine.	6	CO1	L1
24	With neat sketch explain the performance characteristic curves of a centrifugal pump.	6	CO1	L1
25	(i) With neat sketch explain various losses in pumps. (ii) What is priming and explain the necessity of priming	6	CO1	L1
26	With neat sketch explain the constructional features and working of a centrifugal pump.	6	CO1	L1

27	Give the comparison between impulse and reaction turbines	4	CO3	L2
28	The diameter of an impeller of a centrifugal pump at inlet and outlet are 30cm and 60cm respectively. Determine the minimum starting speed of the pump if it works against a head of 30cm.	4	CO1	L2
29	Draw the performance curves of a centrifugal pump. Also discuss the effect of blade outlet angles	4	CO1	L2
30	Explain the significance of NPSH in the installation of a centrifugal pump	4	CO1	L2
31	A Kaplan turbine is designed to develop 9MW power while operating under a net head of 7m. The speed ratio based on outer diameter and flow ratios are to be 2.09 and 0.68 respectively and the ratio of outer to hub diameter is 3. Assuming an overall efficiency of 85%, find the speed and specific speed of the turbine.	5	CO3	L2
32	The inlet and outlet diameter of impeller of a centrifugal pump are 40cm and 60cm. The velocity of flow at outlet is 2.5m/s and vane outlet angle is 300. Find the minimum speed of the pump to start the flow. Take manometric efficiency as 75%.	5	CO1	L2
33	The impeller of a centrifugal pump is 1m in diameter and rotates at 1500rpm. The blades are curved backward and make an angle of 300 to the tangent at the periphery. Calculate the power required if the velocity of flow at outlet is 20m/s. Determine the head to which water can be lifted when a diffuser casing reduces the outlet velocity to 60%.	5	CO1	L2
34	Define Type number in water turbines. What is its significance? Derive an expression for the same.	6	CO3	L2
35	A turbine is to operate under a head of 25 m at 200 r.p.m. The discharge is 9 m3/s.If the overall efficiency is 90 percent. Determine: -(i) Power generated (ii) Specific speed of the turbine (iii) Type of turbine.	6	CO3	L2
36	Kaplan turbine works under a head of 26.5 m, the flow rate of water being 170m3/s. The overall efficiency is 90%. Determine the power and specific speed. The turbine speed is 150 rpm.	6	CO3	L2
37	In a draft tube arrangement for a reaction turbine the flow rate is 150m3/s. Inlet area of the draft tube is 15 m2 while the outside area is 22.5 m2. The turbine runner outlet or the draft tube inlet is 0.5 m below the tailrace level. If the kinetic head recovered by the draft tube is 80% determine the pressure head at turbine outlet.	6	CO3	L2
38	A turbine is operating under a head of 25m at 200r.p.m. The discharge is 9m³/s. If the efficiency is 90%, determine: (i) Power generated (ii) Specific speed of the turbine, and (iii) Type of turbine.	6	CO3	L2
	A centrifugal pump is running at 1000 r.p.m and working against head of 20 m. The rate of flow through the pump is 0.2 m3/s. The outlet vane angle of			

39	impeller is 450 and velocity of flow at outlet is 2.5 m/s. If the Manometric efficiency of the pump is 80 percent, calculate the diameter and width of impeller at outlet.	6	CO1	L2
40	A centrifugal pump lifts 2.5m3/min of water to a height of 20m through a pipe line of 10cm diameter. The total length of the pipe line is 110m. Assuming an overall efficiency of 75% and an inlet loss of 0.3m, find the power required to drive the pump. Take coefficient of friction f = 0.012	7	CO1	L2
41	Differentiate between forced and free vortex Give some examples of occurrence. Show how the velocity and pressure vary with radius in free and forced vortex flow.	10	CO1	L2
42	The diameter and width of a centrifugal pump impeller are 50 cm and2.5 cm. The pump runs at 1200 rpm. The suction head is 6 m and the delivery head is 40 m. The frictional drop in suction is 2 m and in the delivery 8 m. The blade angle at out let is 30°. The manometric efficiency is 80% and the overall efficiency is 75%. Determine the power required to drive the pump. Also calculate the pressures at the suction and delivery side of the pump.	6	CO1	L3
43	The construction details of a centrifugal pump is a follows Impeller diameter = 50 cm, Impeller width = 2.5 cm, Speed = 1200 rpm, Suction head = 6 m, Delivery head = 40 m, Outlet blade angle = 30°. Manometric efficiency = 80% Overall efficiency = 75%. Determine the power required to drive the pump. Also calculate the pressures at the suction and delivery side of the pump. Assume the frictional drop in suction is 2 m and in the delivery 8m and inlet swirl as zero.	6	CO1	L3
Module 3				
Sl. No.	Question	Marks	CO	BL
1	Explain in brief how and when separation take place in a reciprocating pump also discuss the preventive measures to avoid that.	3	CO1	L1
2	What is an air vessel? Describe its functions.	3	CO1	L1
3	Explain the following: i) Hydraulic Accumulator ii) Vane Pump	5	CO1	L1
4	What is negative slip in a reciprocating pump? Explain with neat sketches the functions of air vessels in a reciprocating pump?	5	CO1	L1
5	Describe with the aid of neat sketch the construction and working of a Hydraulic Ram.	5	CO1	L1
6	With the aid of a sketch explain the working of a Hydraulic Accumulator?	5	CO1	L1
7	With the help of necessary sketch, explain the working of a jet pump? Where are they used?	6	CO1	L1

8	i) Define ideal indicator diagram. ii) Show that area of indicator diagram is proportional to the work done by the reciprocating pump	6	CO1	L1
9	With neat sketch explain the following (i) Hydraulic Ram (ii) Lobe pump	6	CO1	L1
10	Reciprocating pumps are called positive displacement pump why?	3	CO1	L2
11	A single acting reciprocating pump, running at 50 r.p.m delivers 0.01m³/s of water. The diameter of the piston is 200mm and stroke length 400mm. determine: i) The theoretical discharge of the pump. ii) Co-efficient of discharge iii) Slip and percentage slip of the pump.	3	CO1	L2
12	Show that the saving in work done against friction in a double acting reciprocating pump fitted with air vessel is 39.2%.	5	CO1	L2
13	Prove from first principle that the work saved in a single acting reciprocating pump by fitting an air vessel is 84.8%.	5	CO1	L2
14	How does the slip phenomenon occur in a reciprocating pump? Quantify the slip factor and comment whether the negative slip-factor is possible.	5	CO1	L2
15	The bore and stroke of a double acting reciprocating pump are 15cm and 30cm respectively. The suction and delivery heads are 3m and 30m and the pump delivers 0.62m3/min when running at 60rpm. Find the percentage slip and power required to run the pump if mechanical efficiency is 80%.	6	CO1	L2
16	A double acting reciprocating pump is fitted with an air vessel on suction side close to pump. The suction lift of pump is 4.5m. The length and diameter of suction pipe are 7.5m and 80mm respectively. The stroke of piston and its diameter both are 200mm each. Coefficient of friction is 0.01. The atmospheric head is 10.3m and separation pressure head 2.5m of water absolute. Determine i) The speed at which separation commence ii) Maximum permissible speed without air vessel.	6	CO1	L2
17	The bore and stroke of a single acting reciprocating water pump are20 cm and 30cm. The suction pipe is of 15 cm diameter and 10 m long. The delivery pipe is 12cm diameter and 28 m long. The pump is driven at 32 rpm. Determine the acceleration heads and the friction head, f = 0.02. Sketch the indicator diagram. The suction and delivery heads from atmosphere are 4 m and 16 m respectively.	6	CO1	L2
18	The diameter and stroke length of a single-acting reciprocating pump are 75 mm and 150 mm respectively. It takes its supply of water from a sump 3 m below the pump through a pipe 5 m long and 40 mm in diameter. It delivers water to a tank 12 m above the pump through a pipe 30 mm in diameter and 15 m long. If separation occurs 75 kN/m2 below the atmospheric pressure. Find the maximum speed at which pump may be operated without separation. Assume that the piston has a simple harmonic motion.	10	CO1	L2

19	Determine the maximum speed of a single-acting reciprocating pump if separation head is 3 m of water (abs). The pump is placed 3 m above the sump level and it delivers water to a tank placed 15 m above its centre line. The pump has 100 mm bore and 180 mm stroke. The diameter of suction and deliver pipe is 40 mm whereas the length of suction pipe is 4 m and that of delivery pipe 18 m.	5	CO1	L3
20	The bore and stroke of a single acting reciprocating water pump are20 cm and 30cm. The suction pipe is of 15 cm diameter and 10 m long. The delivery pipe is 12cm diameter and 28 m long. The pump is driven at 32 rpm. Determine the acceleration heads and the friction head, f = 0.02. Sketch the indicator diagram. The suction and delivery heads from atmosphere are 4 m and 16 m respectively.	7	CO1	L3
21	Determine the maximum speed of a single-acting reciprocating pump if separation head is 3 m of water (abs). The pump is placed 3 m above the sump level and it delivers water to a tank placed 15 m above its centre line. The pump has 100 mm bore and 180 mm stroke. The diameter of suction and deliver pipe is 40 mm whereas the length of suction pipe is 4 m and that of delivery pipe 18 m.	7	CO1	L3
22	A single acting reciprocating pump of 200 mm bore and 300 mm stroke runs at 30 rpm. The suction head is 4 m and the delivery head is 15 m. Considering acceleration determine the pressure in the cylinder at the beginning and end of suction and delivery strokes. Take the value of atmospheric pressure as 10.3 m of water head. The length of suction pipe is 8 m and that of delivery pipe is 20 m. The pipe diameters are 120 mm each.	10	CO1	L3
Module 4				
Sl. No.	Question	Marks	CO	BL
1	Define the following with reference to reciprocating compressors i) Isothermal efficiency ii) Adiabatic efficiency iii) Volumetric efficiency	3	CO4	L1
2	What are the advantages and disadvantages of multistage compression?	3	CO4	L1
3	How are compressors classified? List the practical applications of compressors.	3	CO4	L1
4	What is meant by surging and chocking in centrifugal compressors?	3	CO4	L1
5	What is meant by the term FAD in compressors? How FAD is found?	3	CO4	L1
6	What is clearance ratio? Write the effect of clearance volume on the performance of an air compressor.	3	CO4	L1
7	State how are the air compressors classified?	3	CO4	L1
8	Define slip factor and pressure coefficient in centrifugal compressors	3	CO4	L1

9	Explain the working of roots blower and obtain the expression for its efficiency.	3	CO4	L1
10	Compare the performance characteristics, pressure coefficient and flow coefficient for backward curved, radial and forward curved vane impeller of a centrifugal compressor?	3	CO4	L1
11	Explain the working of diffuser in a centrifugal compressor.	3	CO4	L1
12	With neat sketch explain the construction and working of a vane compressor	3	CO4	L1
13	Explain the working of (i) vane compressor and (ii) screw compressor	3	CO4	L1
14	Explain surging and choking in centrifugal compressors.	5	CO4	L1
15	Explain the methods to improve the isothermal efficiency of an air compressor.	5	CO4	L1
16	Explain the working of axial flow compressor and obtain the expression for the work done.	5	CO4	L1
17	Explain the construction and working of a roots blower.	5	CO4	L1
18	Describe with a neat sketch the construction and working of a single- stage, single-acting reciprocating air compressor?	6	CO4	L1
19	Discuss the merits and demerits of a centrifugal compressor over axial flow compressor.	6	CO4	L1
20	Write short notes on (i) FAD (ii) isothermal efficiency (iii) intercooler (iv) clearance-ratio in connection with a reciprocating compressor.	10	CO4	L1
21	Describe the principle of operation, construction and working of centrifugal compressor.	10	CO4	L1
22	Explain the principle of operation, construction and working of a centrifugal compressor with necessary sketches.	10	CO4	L1
23	With a neat sketch elaborate the working of a centrifugal compressor and derive the Euler's equation.	10	CO4	L1
24	Derive the expression for width of impeller blade for centrifugal compressor	3	CO4	L2
25	A single stage single acting reciprocating air compressor is used to compress 7x10-3 m3/min of air from a pressure of 1.013 bar to 14 bar. The index of polytropic compression is 1.3 and mechanical efficiency is 82%. Determine the volumetric efficiency and power required to drive the compressor if the clearance is 3% of the swept volume.	5	CO4	L2
26	A single acting reciprocating air compressor with air entering at 1bar and leaving at 7bar following pv1.3= constant. Free air delivered is 5.6m3/min and mean piston speed is 150m/min. Take stroke to bore ratio of 1.3 and clearance volume to be 1/5th of swept volume per stroke. The suction temperature and	5	CO4	L2

	pressure are atmospheric. Determine i) the volumetric efficiency ii) Speed of rotation and iii) Stroke and bore.			
21	A single acting, single cylinder reciprocating air compressor has a cylinder diameter of 200mm and a stroke of 300mm. Air enters the cylinder at 1bar, 27ºC. It is then compressed polytropically to 8 bar according to the law $PV1.3=C$. If the speed of the compressor is 250rpm, calculate (i) the mass of air compressed per minute and (ii) the power required in KW for driving the compressor, if mechanical efficiency is 80%. Neglect clearance.	5	CO4	L2
22	Prove that the work done per Kg of air in a compressor is given by $W = \frac{n}{n-1} RT \left[(r)^{\frac{n-1}{n}} - 1 \right]$ where =r pressure ratio.	5	CO4	L2
29	A single stage reciprocating air compressor is compressing 2kg of air per minute at 1 bar 20ºC and it delivers it at 7 bar. Assuming compression process follows the law PV1.3= Constant. Calculate indicated power input to compressor, neglect clearance.	5	CO4	L2
24	Prove that for complete inter - cooling between two stages, the compression work would be minimum when intermediate pressure $P2 = \sqrt{p1 \times p3}$ where p1 and p3 are suction and delivery pressure respectively.	5	CO4	L2
31	Compare axial flow compressor with centrifugal compressor.	5	CO4	L2
32	Distinguish surging and stalling phenomenon happens at off design condition in axial flow compressor?	5	CO4	L2
33	Draw the stage velocity triangles for an axial compressor with upstream guide vanes, rotor blades and diffuser blades.	5	CO4	L2
34	A single stage single acting reciprocating air compressor compresses 7x10-3 m3of air per second from 1.0132 bar to 14 bar. The index of polytropic compression is 1.3 and mechanical efficiency 82%. If clearance is 3% of the swept volume, determine the volumetric efficiency and power required to drive the compressor and show the process on P-v diagram.	6	CO4	L2
35	A three stage single acting reciprocating compressor has perfect intercooling. The pressure and temperature at the end of suction stroke in LP cylinder is 1.013 bar and 150 C respectively. If 8.4m3 of free air is delivered by the compressor at 70 bar per minute and work done is minimum, calculate 1) L P and I P delivery pressure 2) Ratio of cylinder volume and 3) Total indicated power, assume n= 1.2	6	CO4	L2
36	Derive the volumetric efficiency of a reciprocating compressor considering clearance volume.	6	CO4	L2
	An axial flow compressor draws in air at 200C and delivers it at 500C. Assuming 50% degree of reaction, calculate the velocity of flow and number			

37	of stages if blade velocity is 100m/s, work factor as 0.85. Assume the blades are symmetrical and air inlet and exit angle $\alpha = 100$, $\beta = 400$	6	CO4	L2
38	An axial flow compressor draws air at 200C and delivers at 500C. Assuming 50% reaction, calculate the velocity of flow if the blade velocity is 100m/s, Take work factor as 0.85. Assume $\alpha 1 = 100$, $\beta 1 = 400$. Also calculate the number of stages.	6	CO4	L2
39	Derive expression of work done for axial flow compressor.	6	CO4	L2
40	Air at a temperature of 3050K flows in a centrifugal compressor running at 16000 rpm. Isentropic efficiency of the compressor is 80%. Outer diameter of the blade tip is 600mm. Take slip factor as 0.85. Calculate (i) The temperature rise of air passing through the compressor (ii) The static pressure ratio.	6	CO4	L2
41	Derive the expression of degree of reaction of an axial flow air compressor in terms of blade angles and blade velocity.	6	CO4	L2
42	Obtain the expressions for volumetric efficiency of an air Compressor in terms of clearance ratio, index of compression and pressure ratio.	7	CO4	L2
43	A double acting air compressor works with an indicated power of 37kW. Air is drawn at 1 bar and 300 K and compressed, according to the law $PV^{1.2}$ = Constant to 7 bar. The compressor runs at 200 r.p.m with average piston speed 2.5 m/s. Neglect clearance. Find the dimensions of the cylinder.	10	CO4	L2
44	Derive an expression for indicated work of a reciprocating air compressor by neglecting clearance volume.	10	CO4	L2
45	Derive the condition for minimum work required for a 2-stage reciprocating air compressor.	10	CO4	L2
46	A single acting reciprocating compressor has bore of 25cm and a stroke of 35cm. The compressor runs at 650rpm. The clearance volume is 4% of swept volume. The index of expansion and compression is 1.3. The suction conditions are 0.95 bar and 25oC. The delivery pressure is 6 bar. The atmospheric pressure and temperature are 1.013 bar and 20oC. Determine: i) FAD ii) Volumetric efficiency iii) Indicated power input.	10	CO4	L2
47	Draw the indicator diagram of a single acting reciprocating compressor with clearance volume and explain the working. Also derive the expression for work done in terms of pressure ratio and effective swept volume.	10	CO4	L2
48	A centrifugal compressor has a compression ratio of 4:1 with an isentropic efficiency 88% when running at 14000 rpm and including air at 250C. Curved vanes at inlet gives the air a pre -whirl of 180 to axial direction at all radii and the mean diameter of eye is 245mm. Absolute air velocity at inlet is 120m/s. Impeller tip diameter is 580mm. Calculate the slip factor.	10	CO4	L2
	A centrifugal compressor running at 1500rpm has internal and external diameters of the impellers are 250mm and 500mm respectively the air enters the impeller radially. Determine the work done by the compressor per kg of air			

49	and degrees of reaction.	10	CO4	L2
50	Deduce an equation for the work done on a reciprocating compressor in terms of pressure ratio using P-v diagram. Assume the process of compression fallows polytropic according to pvn = a constant.	5	CO4	L3
51	Prove that for a multi stage compressor with perfect intercooling between stages, the work done is minimum when the intermediate pressure is the geometric mean of the suction and delivery pressure between successive stages.	6	CO4	L3
52	Obtain an expression for minimum work to be done on a two-stage reciprocating compressor with perfect intercooling.	6	CO4	L3
53	A double acting single-stage reciprocating compressor delivers air at the rate of 15 m3/min. (at 1 bar and 150C). The suction pressure and temperature in the cylinder are 1 bar and 320C. The delivery pressure is 7 bar and compression and expansion index is 1.3. The clearance volume is 5% of the swept volume. Calculate indicated power and volumetric efficiency.	10	CO4	L3
54	A three stage single acting reciprocating compressor has perfect intercooling. The pressure and temperature at the end of suction stroke in LP cylinder is 1.013 bar and 150 C respectively. If 8.4m3 of free air is delivered by the compressor at 70 bar per minute and work done is minimum, calculate 1) L P and I P delivery pressure 2) Ratio of cylinder volume and 3) Total indicated power, assume n= 1.2	10	CO4	L3
55	A centrifugal compressor draws in air at temperature of 270C running at 18000rpm. The outer diameter of blade tip is 550mm, slip factor is 0.82, and isentropic total head efficiency is0.76. Calculate i) the temperature rise of air passing through the compressor ii) the static pressure ratio. Assume the velocities of air at inlet and outlet is same. Take Cp =1.005kJ/kgK.	10	CO4	L3
56	A centrifugal compressor running at 1440 rpm handles air at 101kPa and 210C and isentropically compresses it to a pressure 6 bar. The inner and outer diameters of impeller are 14cm and 28cm respectively. The width of the blade at the inlet is 250 mm. The blade angles are 160 and 400 at entry and exit. Calculate the mass flow rate of air, degree of reaction, power input and width of blades at outlet.	10	CO4	L3
Module 5				
Sl. No.	Question	Marks	CO	BL
1	How are gas turbines classified? Compare gas turbines and I. C. engines, based on speed and mechanical efficiency.	3	CO5	L1
2	Draw the combustion chamber of a gas turbine showing air entries at various stages.	3	CO5	L1
3	Explain ideal and actual brayton cycle.	5	CO5	L1
4	Explain stablity loop in gas turbines.	5	CO5	L1
5	With neat sketch explain the main components of gas turbine.	6	CO5	L1

6	With the help of T-S diagrams explain how intercooling, reheating and Regeneration improve the performance of gas turbine cycle.	10	CO5	L1
7	Differentiate between open cycle gas turbine and closed cycle gas turbine.	3	CO5	L2
8	Discuss the stability loop of a gas turbine combustion chamber.	3	CO5	L2
9	What is the difference between open cycle and closed cycle gas turbine plant?	6	CO5	L2
10	Compare open cycle and closed cycle gas turbines.	6	CO5	L2
11	Compare gas turbine and IC engine.	6	CO5	L2
12	Air enters the compressor of a gas turbine plant operating on Brayton cycle at 1 bar, 30oC. The pressure ratio in the cycle is 7. Calculate the maximum temperature in the cycle and the cycle efficiency. Assume turbine work is 2.5 times the compressor work. Take the ratio of specific heats as 1.4.	6	CO5	L2
13	Explain three methods for the improvement of efficiency of open cycle gas turbine power plant with necessary T&S diagrams.	6	CO5	L2
14	Air enters the compressor of an open cycle constant pressure gas turbine at a pressure of 1 bar and temperature of 30oC. The pressure of the air after compression is 5 bar. The isentropic efficiencies of compressor and turbine are 80% and 85% respectively. The air-fuel ratio used is 80:1. If the flow rate of air is 3.0 kg/s, find: (i) Power developed. (ii) Thermal efficiency of the cycle. Take calorific value of fuel as 42000 kJ/kg. Assume cp = 1.005 kJ/kg K and γ = 1.4 for air and gases.	10	CO5	L2
15	Discuss the means of improving the specific output and thermal efficiency of the simple open cycle gas turbine plant.	10	CO5	L2
16	In an open cycle constant pressure gas turbine, air enters the compressor at 1.02 bar and 27oC. The pressure of air after the compression is 4.08 bar. The isentropic efficiencies of the turbine and compressor are 80% and 85% respectively. The air fuel ratio used is 80:1. Find the power output and thermal efficiency of the cycle if the flow rate of air is 2.5 kg/sec. Take cp = 1 KJ/kg K and Υ = 1.4 for air and gases. Calorific value of fuel used is 41720 kJ/kg.	10	CO5	L2
17	Explain the effect of regeneration on gas turbine plant output and efficiency.	10	CO5	L2
18	Derive an expression for air standard efficiency of a constant pressure gas turbine cycle in terms of pressure ratio. State your assumptions. Discuss the effect of pressure ratio on cycle output and efficiency.	10	CO5	L2
19	What are all the modifications that could be carried out in Brayton cycle? Why? (All modifications on Rankine cycle applicable here.- reheat/regeneration/intercooling)	10	CO5	L2
20	Discuss: Types of combustion chambers in gas turbines. The concept of combustion intensity and combustion efficiency.	10	CO5	L2
21	Derive the expression for optimum pressure ratio for maximum work output.	6	CO5	L3
22	Derive an expression for optimum pressure ratio for maximum specific work output in Brayton cycle.	10	CO5	L3
23	Air enters a simple gas turbine at 100 kPa and 300 K. The compression ratio is 8:1. The maximum temperature in the cycle is 1300 K. Find the (i) air standard efficiency (ii) compressor and turbine work (iii) work ratio. (Similar numericals)	10	CO5	L3
24	Dervieconditions for (best performance) Minimum compressor work,Maximum turbine work	10		L3
	Air enters an open cycle gas turbine plant at 1 bar and 30 °C. The pressure ratio of the plant is 5.6. Compression is carried out in two stages with perfect			

25	intercooling in between. Maximum temperature of the cycle is limited to 700 ^{o}C. Isentropic efficiency of both the compressors are 85% and that of turbine is 90%. Air flow rate is 1.2 kg/S. Determine the power developed and efficiency of the plant. Cp = 1.02 kJ/kgK and γ = 1.41 for both air and gas. Mass of fuel can be neglected.	10	CO5	L3
26	Find the required air fuel ratio in a gas turbine whose turbine and compressor efficiencies are 85% and 80 % respectively. The maximum cycle temperature is 875 0C. the working fluid can be taken as air (cp = 1 kJ/kgK and Υ = 1.4) which enters the compressor at 1 bar and 27 0C. the pressure ratio is 4. The fuel used has a calorific value of 42000 kJ/kg. there is a loss of 10% of calorific value in the combustion chamber	10	CO5	L3

Prepared By : Manoj Jose Kalathil

Checked By : Asha K R, Subject committee chairman

Approved By : Dr. Ramdas T, HOD ME

Course Code & Name: HUT200 Professional Ethics

1. Prescribed Syllabus

Module	Topic	Hours
1	Morals, values and Ethics – Integrity- Academic integrity-Work Ethics- Service Learning- Civic Virtue-Respect for others- Living peacefully- Caring and Sharing- Honestly- courage-Cooperation commitment-Empathy-Self Confidence -Social Expectations	5
2	Senses of Engineering Ethics - Variety of moral issues- Types of inquiry-Moral dilemmas –Moral Autonomy –Kohlberg's theory- Gilligan's theory- Consensus and Controversy-Profession and Professionalism-Models of professional roles-Theories about right action –Self- interest-Customs and Religion- Uses of Ethical Theories.	5
3	Engineering as Experimentation – Engineers as responsible Experimenters- Codes of Ethics- Plagiarism-A balanced outlook on law - Challenges case study- Bhopal gas tragedy	5
4	Collegiality and loyalty – Managing conflict- Respect for authority-Collective bargaining- Confidentiality-Role of confidentiality in moral integrity-Conflicts of interest- Occupational crime- Professional rights-Employee right- IPR Discrimination.	5
5	Multinational Corporations- Environmental Ethics- Business Ethics-Computer Ethics -Role in Technological Development-Engineers as Managers- Consulting Engineers- Engineers as Expert witnesses and advisors-Moral leadership.	5

2. Text Books (T)

T1. M Govindarajan, S Natarajan and V S Senthil Kumar, Engineering Ethics, PHI Learning Private Ltd, New Delhi,2012.

T2. R S Naagarazan, A text book on professional ethics and human values, New age international (P) limited, New Delhi, 2006.

3. Reference Books (R)

R1. Mike W Martin and Roland Schinzinger, Ethics in Engineering, 4th edition, Tata McGraw Hill Publishing Company Pvt Ltd, New Delhi,2014.

R2. Charles D Fleddermann, Engineering Ethics, Pearson Education/ Prentice Hall of India, New Jersey, 2004.

R3. Charles E Harris, Michael S Protchard and Michael J Rabins, Engineering Ethics- Concepts and cases, Wadsworth Thompson Learning, United states,2005.

R4. http://www.slideword.org/slidestag.aspx/human-values-and-Professional-ethics.

4. Course Objectives

1. To create awareness on professional ethics for engineers.
2. To instil human values and integrity
3. To respect the rights of others and develop a global perspective

5. Course Pre / Co-requisite

NIL

6. Course Outcomes

On successful completion of this course students shall be able to

CO1: Understand the core values that shape the ethical behaviour of a professional.

CO2: Adopt a good character and follow an ethical life.

CO3: Explain the role and responsibility in technological development by keeping personal ethics and legal ethics

CO4: Solve moral and ethical problems through exploration and assessment by established experiments.

CO5: Apply the knowledge of human values and social values to contemporary ethical values and Global issues.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1								M			M				
CO2								M			M				
CO3								H			M				

CO4								**H**			**M**				
CO5								**H**			**M**				

8. Justification for CO-PO-PSO Correlation

CO1	**PO8**	By understanding Morals, Values and Ethics properly they can apply them to fulfil their social responsibilities and expectations.
	PO11	Understanding of Professional Ethics and human values enables them to apply and prove their knowledge and understanding of Engineering and Management principles in multi-disciplinary environments
CO2	**PO8**	An ethical life and good character makes them committed to Professional Ethics, responsibilities and norms of their Engineering practice.
	PO11	By acquiring an understanding of ethical principles and adoption of good character they can prove their might in engineering and management principles. It will help them to be a good member of a team or leader, managing projects in various environments.
CO3	**PO8**	Learning and understanding the importance of human and social values will enable to apply ethical principles to the engineering practice.
	PO11	Understanding the importance of professional and personal ethics will help to demonstrate and manage principle's in multidisciplinary environments.
CO4	**PO8**	By understanding the ways to solve different moral and ethical problems will helps to get committed to one's profession taking the responsibilities of the engineering practice.
	PO11	Developing the capacity to explore solution for moral and ethical problems, will help to perform better as a leader or member of a team.
CO5	**PO8**	**Developing** effective listening skills help to analyse and understand various engineering problems
	PO11	By understanding the ethical principles related to global issues, will enable to understand engineering and management principles and apply these to one's own work.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	NIL		

11. Internal Assessment mark allocation (as per university curriculum)

(Provide details as mentioned in syllabus)

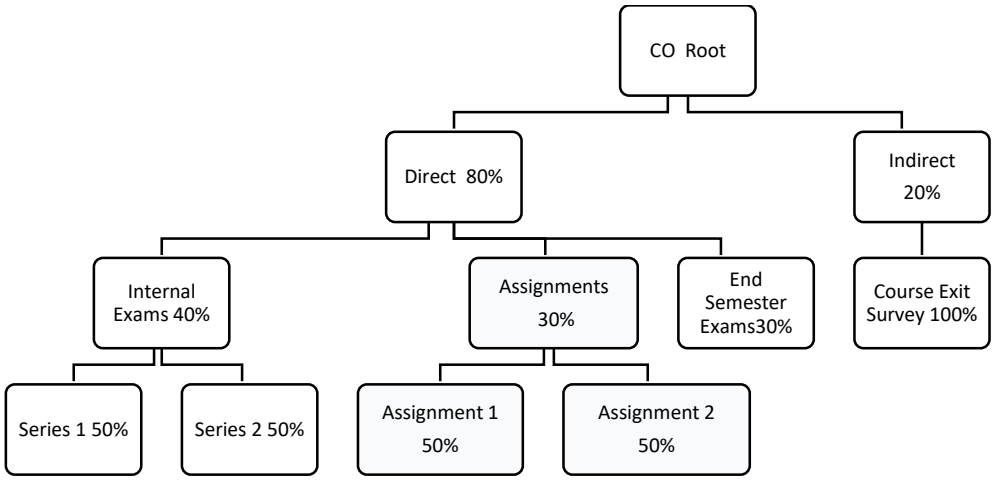
Attendance - 10 marks
Continuous Assessment Test - 25 marks

Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		Weightage #	CO 1	CO 2	CO 3	CO 4	CO 5
Direct Assessment Tools**	Internal Exam(s) - 40%	Series 1	20%	x	x			
		Series 2	20%			x	x	
	Assignment (s)/ Course Project /Quiz etc. - 30%	Assignment 1	15%	x	x			
		Assignment 2	15%			x	x	x
	End Semester Exam		30%	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x

13. **Assessment Configuration**



14. Course Plan

Sl. no	Topic Name	Module	Reference	Teaching Pedagogy
1	Morals, values and Ethics, Integrity, Academic Integrity,Work Ethics	1	T1, T2, R1	Lecture

2	Service Learning, Civic Virtue, Respect for others, Living peacefully	1	T1, T2, R1	Lecture
3	Caring and Sharing, Honesty, Courage,	1	T1, T2, R1	Lecture
4	Co-operation, commitment, Empathy	1	T1, T2, R1	Lecture
5	Self Confidence, Social Expectations	1	T1, T2, R1	Lecture
6	Senses of Engineering Ethics, Variety of moral issues, Types of inquiry	2	T1, T2, R1	Lecture
7	Moral dilemmas, Moral Autonomy, Kohlberg's theory	2	T1, T2, R1	Lecture
8	Gilligan's theory, Consensus and Controversy, Profession& Professionalism,	2	T1, T2, R1	Lecture
9	Models of professional roles, Theories about right action	2	T1, T2, R1	Lecture
10	Self interest-Customs and Religion, Uses of Ethical Theories	2	T1, T2, R1	Lecture
11	Engineering as Experimentation, Engineers as responsible Experimenters	3	T1, T2, R1	Lecture
12	Codes of Ethics,Plagiarism,	3	T1, T2, R1	Lecture
13	A balanced outlook on law	3	T1, T2, R1	Lecture
14	Challenger case study,	3	T1, T2, R1	Lecture
15	Bhopal gas tragedy	3	T1, T2, R1	Lecture
16	Collegiality and loyalty, Managing conflict, Respect for authority	4	T1, T2, R1	Lecture
17	Collective bargaining, Confidentiality, Role of confidentiality in moral integrity	4	T1, T2, R1	Lecture
18	Conflicts of interest	4	T1, T2, R1	Lecture
19	Occupational crime, Professional rights, Employee right,	4	T1, T2, R1	Lecture
20	IPR, Discrimination	4	T1, T2, R1	Lecture
21	Multinational Corporations, Environmental Ethics,	5	T1, T2, R1	Lecture
22	Business Ethics, Computer Ethics	5	T1, T2, R1	Lecture
23	Role in Technological Development, Moral leadership	5	T1, T2, R1	Lecture
24	Engineers as Managers, Consulting Engineers,	5	T1, T2, R1	Lecture

25	Engineers as Expert witnesses and advisors	5	T1, T2, R1	Lecture
26				

15. Question Bank

Module 1				
Sl. No.	**Questions**	**Marks**	**CO**	**BL**
1	Define empathy. What is the difference between empathy and sympathy?	3	CO1	L1
2	Define 'respect for others'.	3	CO1	L1
3	Describe 'Living peacefully.	3	CO1	L1
4	Why sharing and caring are important for a professional?	3	CO1	L2
5	Define work Ethics.	3	CO1	L1
6	What are the two approaches to Engineering ethics?	3	CO1	L1
7	List two methods of developing self confidence. OR Examine the relevance of self-confidence and factors that shape it.	3	CO1	L2
8	Distinguish between morality and ethics. OR Discuss the terms ethics and morals.	3	CO1	L1
9	List the factors that enhance the self confidence in a person.	3	CO1	L2
10	Describe about civic virtue and how is it related to respect for others.	3	CO1	L2
11	Define integrity	3	CO1	L1
12	What is a civic virtue and how is it related to respect for others?	3	CO1	L2
13	Define commitment	3	CO1	L1
14	Explain the term moral absolutism.	3	CO1	L1
15	What is the significance of work ethics	3	CO1	L1

16	Explain the terms caring and sharing. OR Explain the role of caring and sharing in a workplace.	3	CO1	L1
17	Explain professionalism	3	CO1	L1
18	Explain spirituality	3	CO1	L1
19	Write a note on “Social Expectations”.	6	CO1	L2
20	Explain the need of cooperation and commitment.	8	CO1	L2
21	Define and explain the scope and importance of professional ethics in Engineering. Elucidate the relevance of academic integrity in Engineering with examples.	6 8	CO1	L1
22	Summarize the importance of human values in this era and list out few core human values. Exemplify service learning and its importance. How is it related to experimental learning.	6 8	CO1	L2
23	a) Explain the qualities of service learning. b) Describe the qualities required to live a peaceful life.	7 7	CO1	L1
24	Explain the steps for developing a strong work ethic. Classify courage based on the type of risk.	8 6	CO1	L2
25	Explain about academic integrity and write the five pillars of academic integrity.	14	CO1	L1
26	Explain the core elements of a strong work ethics.	14	CO1	L2
27	With the help of examples, distinguish between 'morality' and 'ethics' . Explain the different aspects of academic integrity.	7 7	CO1	L1
28	Explain the different types of human values. Explain the role of Co-operation and commitment in ethical practice.	7 7	CO1	L2
29	Explain academic integrity and its five pillars.	14	CO1	L1

30	Define Self-confidence, the factors that shape it and the methods that can develop self confidence in an individual	14	CO1	L2
31	How integrity plays a major role in work ethics. Discuss with suitable examples.	9	CO1	L2
	Module 2			
1	What is professionalism	4	CO2	L1
2	State the senses of engineering ethics.	3	CO2	L2
3	Define the three types of inquiries. OR Summarize the types of inquiries.	3	CO2	L2
4	What are the different types of enquiries in solving ethical problems?	3	CO2	L2
5	What are the situations when moral dilemmas arise? OR Explain moral dilemma.	3	CO2	L2
6	What are the types of ethics depending upon the morality of humanity?	3	CO2	L2
7	Differentiate consensus and controversy in Engineering ethics.	3	CO2	L2
8	List out the models of professional roles.	3	CO2	L2
9	Explain in detail about the characteristics or criteria's to achieve professionalism.	3	CO2	L2
10	What is Moral autonomy ?	3	CO2	L2
11	Explain Gil1ligan's theory of moral development.	3	CO2	L2
12	What is meant by consequentialist theories?	3	CO2	L2
13	Compare and contrast tradition and custom. Give an example.	3	CO2	L2
14	What is self-interest?	3	CO2	L2
15	Explain Normative Senses.	3	CO2	L2
16	Discuss the concept of moral development with the help of Kohlberg's theory of moral development.	3	CO2	L2
17	Describe in detail about various Consequentialist theories	10	CO2	L2

18	Discuss the motives of professionalism and the models for professional engineers.	10	CO2	L2
19	What are the models of professional roles attributed to Engineers	10	CO2	L2
20	Compare and Contrast Kohlberg's and Gilligan's Theories with real life examples.	14	CO2	L2
21	Distinguish between Kohlberg's and Gilligan's approach to ethical (moral) judgements and compare the interpretation (moral development theory) of Kohlberg and Gilligan, with an illustrative example	14	CO2	L2
22	List and explain different ethical theories	14	CO2	L2
23	(a) Explain the various reasons for an employee to behave unethically in an organisation. (7) (b) What are the logical steps in solving moral dilemma? (7)	14	CO2	L2
24	(a) Compare Gilligan's theory with Kohlberg theory on moral development. (7) (b) Explain the term consensus and controversy in Engineering ethics. (7)	14	CO2	L2
25	(a) Explain the three main levels of moral developments, deviced by Carol Gilligan. (7) (b) Discuss on three types of inquiries. (7)	14	CO2	L2
26	List and explain the varieties of moral issues. (14)	14	CO2	L2
27	a) Explain the causes of Moral Dilemmas.(7) b) Describe the different types of inquiries in solving ethical problems (7)	14	CO2	L2
28	a) Explain the types of Ethical theories. (8) b) Compare Gilligan's theory with Kohlberg's theory on moral development. (6)	14	CO2	L2
29	a) Interpret the different professional roles that engineers should adopt.(6) b) Describe in detail about Ethical Theory of Right Action.(8)	14	CO2	L2

30	a) lllustrate the importance of consensus and the problem of controversy, while considering moral autondrny in engineering ethics with the help of examples. (6) b) Outline on moral development and the three stages of Kohlberg's theory of moral development. (8)	14	CO2	L2
Module 3				
1	What is meant by conscientiousness?	3	CO3	L1
2	List the responsibilities of Engineers to the society.	3	CO3	L1
3	Explain significance of "informed consent" when bringing an engineering product to market? OR What are the essential conditions for a valid informed consent.	3	CO3	L2
4	Define the term moral autonomy	3	CO3	L1
5	What are the 3 features common to most of the codes of ethics? OR Explain the term “codes of ethics” OR List out the limitations of Codes of Ethics. OR List out the roles of code of ethics.	3	CO3	L2
6	Explain the term comprehensive perspective.	3	CO3	L1
7	Explain ‘Balanced outlook on law’.	3	CO3	L2
8	What is meant by the term accountability of an engineer	3	CO3	L2
9	Evaluate the importance of accountability in a professional’s life.	7	CO3	L2
10	Summarize the elements that should make an engineer a responsible experimenter? Or Evaluate how an Engineer can be a responsible experimenter.	7	CO3	L2
11	What are the essential characteristics of an engineer, as a responsible social experimenter?	7	CO3	L2
12	Illustrate the role of engineers as experimenters.	7	CO3	L2

13	Compare and contrast engineering experiments with standard experiments	7	CO3	L2
14	What are the different roles and functions of “Code of ethics”?	14	CO3	L2
15	Explain the Bhopal gas tragedy. Discuss the violation of moral, ethics, and professional codes of standards in it.	14	CO3	L3
16	Write a brief report on Bhopal Gas Tragedy. List a few factual issues, conceptual issues, and moral/normative issues in the Bhopal Gas Tragedy.	14	CO3	L3
17	Explain the moral, conceptual, and factual issues that lead to Challenger tragedy of 1986. Discuss the safety lessons one can learn from the challenger case?	10	CO3	L3
18	Write a brief report on Challenger disaster. Discuss the safety lessons one can learn from the Challenger case?	14	CO3	L3
19	Evaluate the importance of accountability in a professional's life. (7) Evaluate how an Engineer can be a responsible experimenter. (7)	14	CO3	L3
20	Explain Babylon’s building code & United States steamboat code	14	CO3	L3
21	Enumerate the responsibility of engineers to the society as an experimenter. (6) Justify on engineering projects being considered as experimentations. Explain with the help of a diagram. (8)	14	CO3	L3
22	Assess how Engineering societies can promote ethics and name a few such professional organizations/societies. (6) Recap challenger case and mention the moral solution along with the obligations of such businesses. (8)	14	CO3	L3
23	Enumerate the advantages and important roles played by code of ethics.(8) Explain the similarities between Engineering projects and standards experiments. (6)	14	CO3	L3

24	Describe the factual issues, conceptual issues and moral/normative issues in the Challenger space shuttle incident.(8) List and describe any three types of industrial standards with suitable examples. (6)	14	CO3	L3
Module 4				
1	What is meant by collective bargaining?	3	CO4	L1
2	Enlist the different types collective bargaining	3	CO4	L1
3	Define professional rights	3	CO4	L1
4	What is confidentiality and why is it needed.	3	CO4	L1
5	Explain the term confidentiality	3	CO4	L2
6	Illustrate collegiality.	3	CO4	L1
7	Explain the significance of intellectual property rights.	3	CO4	L1
8	Explain what is meant by copyright?	3	CO4	L2
9	Recall plagiarism and how it could be avoided.	3	CO4	L2
10	Conclude how moonlighting leads to conflict of interest.	3	CO4	L2
11	Explain occupational crime. OR What are occupational crimes give examples	8	CO4	L2
12	Elaborate the term Respect for Authority	5	CO4	L2
13	Describe the six major steps involved in the process of collective bargaining	6	CO4	L2
14	Explain collective bargaining	7	CO4	L2
15	Narrate the various methods of managing conflicts	10	CO4	L2
16	How conflicts can be managed in a workplace	6	CO4	L2
17	Explain the terms a) Collegiality b) Loyalty	6	CO4	L2
18	Explain IPR, Patents and trade secrets OR Differentiate between patents and trade secrets.	7	CO4	L2

19	Write notes on (a)Institutional authority (b)expert authority (c)Types of loyalty.	14	CO4	L2
20	Explain in detail the 'risk benefit analysis and reducing risk'(8) Explain the advantages & disadvantages of collective bargaining. (6)	14	CO4	L2
21	Explain the Conflict Management Process (7) Explain the 'intellectual property rights (7)	14	CO4	L2
22	Explain the various justifications for confidentiality. (7) Explain how you can improve collegiality in an organisation where you are presently employed. (7)	14	CO4	L2
23	Explain the significance of different types of Authority in an organisation. (7) Discuss about the various rights of an engineer. (7)	14	CO4	L2
24	Explain the different steps in managing conflicts in an organization(7) Describe the major steps involved in the process of collective bargaining. (7)	14	CO4	L2
25	Exemplify conflicts of interest & conflicts in interest (6) Illustrate various rights of an engineer as a professional. (8)	14	CO4	L2
26	Describe on intellectual property rights and explain in detail the needs of protection of intellectual property. (6) Enumerate the elements/instruments of intellectual property rights. (8)	14	CO4	L2
27	Examine the different provisions protected under professional rights.(6) Recall the types of conflicts of interest. (8)	14	CO4	L2
Module 5				
Sl. No.	**Questions**	**Marks**	**CO**	**BL**

1	Mention the advantages enjoyed by host countries due to MNC'S. OR Define Multinational company with an example. OR What is meant by multinational corporations?	3	CO5	L1
2	Define Environmental ethics	3	CO5	L1
3	Define the characteristics of Engineers as Managers. OR What is meant by Engineers as Managers?	3	CO5	L1
4	What is business ethics? OR List any three characteristics of Business Ethics. OR List out the importance of Business Ethics.	3	CO5	L1
5	Differentiate between patent and trade secret.	3	CO5	L1
6	List any three responsibilities of consulting engineers. OR Write short notes on Consulting Engineers.	3	CO5	L1
7	Inspect the impact of technology transfer on different institutions/ entities.	3	CO5	L1
8	State the requirements for engineers who act as advisors in planning and policy making. OR How does Engineers act as Advisors? OR Describe the various requirements for engineers who act as advisors.	3	CO5	L1
9	Define computer ethics OR What are the ten commandments of computer ethics?	3	CO5	L1
10	List out a few sample codes of ethics	3	CO5	L1
11	How does engineers act as Expert Witnesses?	3	CO5	L2
12	Justify the need of moral leadership in today's business environment?	3	CO5	L2
13	Discuss in detail about the moral and ethical issues involved in the use of computers and internets with example	14	CO5	L2

14	Discuss the following in detail (a) Engineers as consultants (b) Engineers as expert witnesses	14	CO5	L2
15	Explain on computer ethics. State and describe the moral and ethical issues related to computer technology. (10) Ascertain the causes of conflicts while cases are managed by project managers. (4)	14	CO5	L3
16	Explain the requirement of moral leadership for engineers (4) Define environmental ethics. Elucidate the ethical duties of engineers towards environment as experimenters by mentioning the environmental impacts of engineering activity. (10)	14	CO5	L3
17	Describe the two world views on Environmental ethics. (8) Explain the different types of issues in Computer Ethics.(6)	14	CO5	L3
18	Explain the features, advantages and limitations of MNCs.	14	CO5	L3
19	Explain the characteristics of Business ethics (7) Explain the role of computers in technological development (7)	14	CO5	L3
20	Explain human centred Environmental ethics with nature centred ethics.(7) Explain the different types of issues in computer ethics.(7)	14	CO5	L3
21	Discuss about the role of engineers as expert witness. (7) What are the various conflict situations faced by a project manager managing a work site? (7)	14	CO5	L3
22	Explain the role of engineers as 'Managers' . (7) Explain the role of engineers as 'expert witness' and 'advisors". (7)	14	CO5	L3
23	Explain the characteristics of i)Business Ethics and (ii) Computer Ethics"	14	CO5	L3

Prepared By : ASHA K R, Course Faculty

Checked By: ……., Course committee Chairperson

Approved by : KANAKA XAVIER, VP- Academics

Course Code & Name: MCN202 Constitution of India

1. Prescribed Syllabus

Module	Topic	Hours
1	Definition, historical back ground, features, preamble, territory, citizenship	4
2	State, fundamental rights, directive principles, duties.	6
3	The machinery of the union government.	5
4	Government machinery in the states	5
5	The federal system, Statutory Institutions, miscellaneous provisions.	5

2. Text Books (T)

T1. D D Basu, Introduction to the constitution of India, Lexis Nexis, New Delhi, 24e,2019
T2. PM Bhakshi, The constitution of India, Universal Law, 14e,2017

3. Reference Books (R)

R1. Ministry of law and justice, The constitution of India, Govt of India, New Delhi,2019.
R2. JN Pandey, The constitutional law of India, Central Law agency, Allahabad, 51e,2019MV Pylee, India's Constitution, S Chand and company, New Delhi, 16e,2016

4. Course Objectives

The study of their own country constitution and studying the importance environment as well as understanding their own human rights help the students to concentrate on their day today discipline. It also gives the knowledge and strength to face the society and people.

5. Course Pre / Co-requisite

Nil

6. Course Outcomes

After completion of the course, student will be able to
CO 1: Explain the background of the present constitution of India and features.
CO 2: Utilize the fundamental rights and duties.
CO 3: Understand the working of the union executive, parliament and judiciary.
CO 4 :Understand the working of the state executive, legislature and judiciary.
CO 5 :Utilize the special provisions and statutory institutions.
CO 6: Show national and patriotic spirit as responsible citizens of the country

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO1						M	M	M		M		
CO2						H	H	H		H		
CO3						H	M	H		H		
CO4						H	M	H		H		
CO5						H	M	H		H		
CO6						H	H	H		M		

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	PO6	The engineer and society: Understanding the Constitution's background helps students recognize the societal, legal, and cultural contexts in which they operate as engineers.
	PO7	Environment and sustainability: The Constitution contains provisions related to the environment and sustainable development. By understanding these features, students can appreciate their role in contributing to society and making decisions that align with environmental sustainability
	PO8	Ethics: Knowledge of the Constitution forms the basis of ethical responsibility, guiding students to uphold the laws and ethical principles of the nation. It helps them understand the importance of legality, fairness, and justice in their professional and personal lives.
	PO10	Communication: Understanding the Constitution is essential for effective communication, particularly when discussing legal or civic matters.
CO2	PO6	The engineer and society: Recognizing and utilizing fundamental rights and duties helps students understand their roles and responsibilities in a democratic society, where they must be aware of their rights and obligations as citizens and engineers
	PO7	Environment and sustainability: Fundamental duties include respecting public resources and the environment, aligning with the need to promote sustainable practices in both professional and personal settings
	PO8	Ethics: Fundamental rights and duties are closely tied to ethical behavior. Utilizing these rights and duties fosters respect for justice and fairness, which are vital ethical principles for engineers.

	PO10	Communication: Understanding and utilizing fundamental rights enables effective communication about the rights and responsibilities of individuals and groups. This awareness allows students to navigate civic discourse and express ideas clearly and responsibly in public and professional contexts
CO3	PO6	The engineer and society: A clear understanding of the functioning of the union executive, parliament, and judiciary enables students to appreciate how laws and policies are formulated, implemented, and interpreted in society, which is essential for responsible citizenship..
	PO7	Environment and sustainability: The functioning of the union and state governments plays a crucial role in formulating environmental laws and policies. Understanding these workings helps students align their actions with national and global sustainability goals.
	PO8	Ethics: Understanding the structure of governance and the roles of various branches of the government enables students to engage ethically with legislative and judicial processes, ensuring they follow legal and ethical norms in their professional activities
	PO10	Communication: Understanding the functioning of government institutions is critical for effective communication, especially when addressing political, legal, and social issues. It enables students to articulate their ideas about governance, policies, and reforms clearly.
CO4	PO6	PO6- The engineer and society: This understanding helps students connect the state-level legislative and executive processes with their responsibilities as engineers in a particular region. It empowers them to engage with local governance and policies, influencing sustainable development and social wellbeing
	PO7	Environment and sustainability: State governments often have specific policies related to regional environmental issues. Understanding the state-level executive, legislature, and judiciary helps students understand how policies related to sustainability are enacted and enforced in different states.
	PO8	Ethics: Understanding how state institutions work and their ethical standards allows students to engage with local governance in a morally responsible manner, ensuring that their professional actions align with legal and ethical guidelines.
	PO10	Communication: Effective communication about state policies, laws, and governance is crucial for students, especially when working on regional projects or engaging with local stakeholders.
	PO6	PO6- The engineer and society: Special provisions and statutory institutions often regulate industries, educational practices, and research initiatives. Understanding how these institutions function helps students align their professional practices with national laws and frameworks

CO5	PO7	Environment and sustainability: Statutory institutions often include bodies focused on environmental regulations and policies. Familiarity with these institutions enables students to engage in sustainable practices that comply with legal requirements and promote environmental responsibility.

	PO8	Ethics: Utilizing special provisions and statutory institutions allows students to engage with legal and ethical standards in their professional roles. It reinforces the need for adherence to norms and laws in professional conduct.
	PO10	Communication: Clear communication of the provisions and regulations governed by statutory bodies ensures students can work effectively within the legal boundaries, and also communicate these provisions to stakeholders, clients, and collaborators.
CO6	PO6	The engineer and society: CO6 encourages students to take responsibility for societal welfare and participate actively in national progress. It fosters an understanding of how engineers can contribute to societal wellbeing, national development, and the overall prosperity of the country.
	PO7	Environment and sustainability: A national and patriotic spirit often includes a commitment to sustainable practices, recognizing that a healthy environment is crucial for the nation's long-term growth. Students are encouraged to contribute to sustainability efforts that benefit both their communities and the nation.
	PO8	Ethics: National pride and patriotic spirit are grounded in ethical responsibility toward one's country and its people. This mindset fosters integrity, professionalism, and a commitment to contributing positively to society.
	PO10	Communication: Promoting a patriotic spirit includes communicating effectively about national achievements, challenges, and solutions. It enables students to discuss national issues responsibly, showcasing their commitment to their country's progress and well-being

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	Nil	Nil	

11. Internal Assessment mark allocation (as per university curriculum)

(Provide details as mentioned in syllabus)

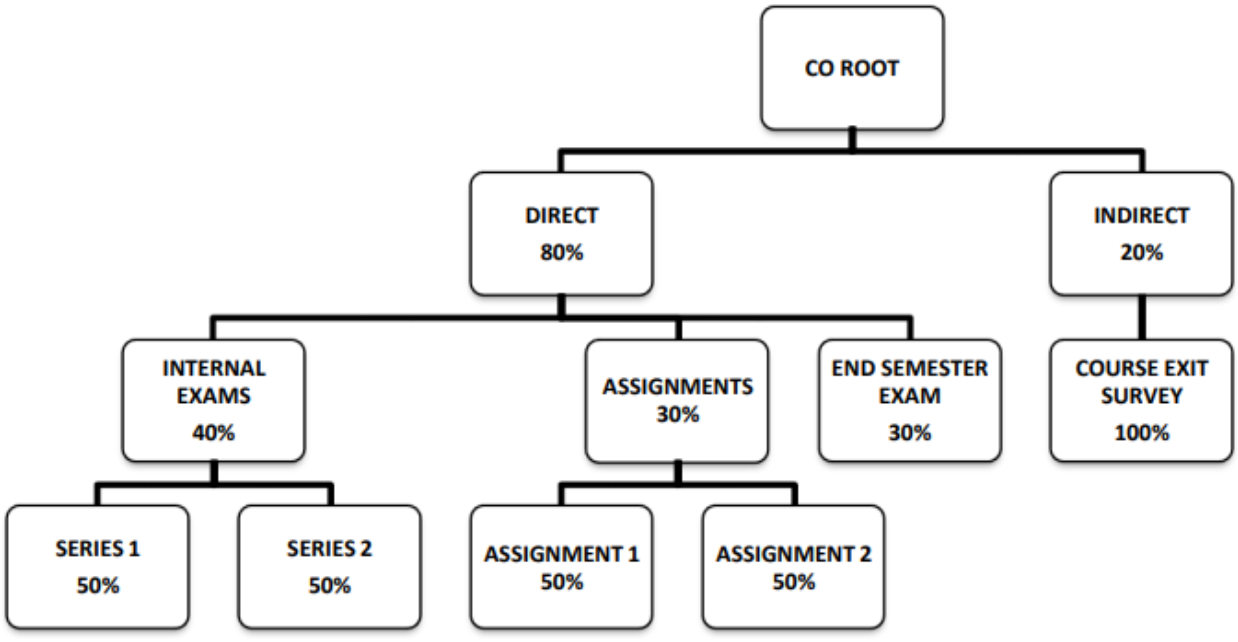
Attendance - 10 marks
Continuous Assessment Test - 25 marks
Assignment (s)/ Course Project - 15 marks

Total - 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		Weightage #	CO1	CO2	CO3	CO4	CO5	CO6
Direct Assessment Tools**	Internal Exam(s) 40%	Series 1	20%	x	x				
		Series 2	20%			x	x		
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x	x				
		Assignment 2	15%			x	x	x	x
	End Semester Exam		30%	x	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x	x

13. **Assessment Configuration**



14. **Course Plan**

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1.	Introduction to the course	1		Lecture
2.	Definition of constitution	1	T1	Lecture
3.	historical back ground, salient features of the constitution	1	T1	Lecture
4.	Preamble of the constitution, union and its territory	1	T1	Lecture
5.	Meaning of citizenship, types	1	T1	Lecture
6.	termination of citizenship.	1	T1	Lecture
7.	Definition of state, fundamental rights, general nature, classification	2	T1	Lecture
8.	right to equality, right to freedom, right against exploitation	2	T1	Lecture
9.	Right to freedom of religion, cultural and educational rights,	2	T1	Lecture
10	right to constitutional remedies. Protection in respect of conviction for offences	2	T1	Lecture
11	Directive principles of state policy	2	T1	Lecture
12	classification of directives, fundamental duties.	2	T1	Lecture
13	First Internal Examination			
14	The Union executive, the President, the vice President, the council of ministers	3	T1	Lecture
15	, the Prime minister, Attorney-General, functions	3	T1	Lecture
16	The parliament, composition, Rajya Sabha, Lok Sabha	3	T1	Lecture

17	qualification and disqualification of membership, functions of parliament	3	T1	Lecture
18	Union judiciary, the supreme court, jurisdiction, appeal by special leave.	3	T1	Lecture
19	The State executive, the Governor, the council of ministers	4	T1	Lecture
20	the Chief minister, advocate general, union Territories.	4	T1	Lecture
21	The State Legislature, composition, qualification and disqualification of membership, functions	4	T1	Lecture
22	The state judiciary, the high court, jurisdiction, writs jurisdiction	4	T1	Lecture
23	Second Internal Examination			
24	Relations between the Union and the States, legislative relation, administrative relation	5	T1	Lecture
25	financial Relations, Inter State council, finance commission.	5	T1	Lecture
26	Emergency provision, freedom of trade commerce and inter course, comptroller and auditor general of India	5	T1	Lecture
27	public Services, public service commission, administrative Tribunals	5	T1	Lecture
28	Official language, elections, special provisions relating to certain classes, amendment of the Constitution.	5	T1	Lecture
29	Revision	1-5	T1	Discussion

15. Question Bank

Module 1

Sl. No	Question	Marks	CO	BL
1.	Define Citizenship by Naturalization.	3	CO1	L1
2.	List out the purpose of Preamble.	3	CO1	L1
3.	Define "Fundamental Right".	3	CO1	L1
4.	State the meaning of "Equal protection of the laws".	3	CO1	L1
5.	Define Citizenship	3	CO1	L1
6.	Recall the meaning and significance of Constitution	3	CO1	L1
7.	List any five features of Constitution of India	3	CO1	L1
8.	Define Preamble of Constitution	3	CO1	L1
9	List out the sources borrowed while drafting the Constitution of India.	3	CO1	L1
10	Define the term Constitution and elucidate two fundamental features that distinguish the Indian Constitution.	3	CO1	L1
11	List down four sources of Indian Constitution with relevant sources borrowed while drafting the Constitution of India.	7	CO1	L1
12	Outline the ways of the establishment and formation of new states.	7	CO1	L1
13	Define Constitution of India with comparison with other countries	7	CO1	L1
14	Discuss the term Union and its territories	7	CO1	L1
15	Explain the term Constitution.	3	CO1	L2
16	Explain whether the Preamble is a part of the Constitution or not.	3	CO1	L2
17	Describe the meaning and significance of the constitution.	3	CO1	L2
18	Explain the concept of Union and its territory	3	CO1	L2
19	"India is a Sovereign nation". Explain.	3	CO1	L2
20	Explain the preamble of Indian Constitution	3	CO1	L2
21	Explain deprivation of citizenship.	3	CO1	L2
22	Explain salient features of Indian Constitution	3	CO1	L2
23	Explain the term partly rigid and partly flexible constitution	4	CO1	L2
24	Explain the term Union and its territory	4	CO1	L2
25	Explain the historical background that led to the framing of Constitution of India	4	CO1	L2
26	Explain why Indian Constitution is sometimes called a "borrowed" constitution.	4	CO1	L2
27	As a citizen of India, interpret the declaration of the preamble of our constitution	7	CO6	L2
28	Explain the term citizenship and its types	7	CO1	L2

29	Describe the process through which Indian Citizenship could be acquired	**7**	**CO1**	**L2**
30	Explain the mode of acquisition and termination of Citizenship	**7**	**CO1**	**L2**
31	Write important provisions of The Indian Independence Act, 1947.	**7**	**CO1**	**L2**
32	Describe four classes of people who were deemed to be citizens of India at the time of the commencement of the constitution.	**7**	**CO1**	**L2**
33	The Constitution of India has provisions borrowed from other Constitutions. Discuss with relevant provisions.	**7**	**CO1**	**L2**
34	Discuss the formation of the Union and its territories.	**7**	**CO1**	**L2**
35	Explain the law respecting the acquisition and loss of Indian Citizenship at the commencement of the Constitution.	**7**	**CO1**	**L2**
36	Explain the modes of acquiring Citizenship under Citizenship Act, 1955.	**7**	**CO1**	**L2**
37	Discuss the term partly rigid and partly flexible constitution.	**3**	**CO1**	**L3**
38	A person who migrated to India from Pakistan after 18th July 1948. Determine whether such a person is a citizen of India or not.	**3**	**CO1**	**L3**
39	Examine the modes of acquisition and termination of citizenship.	**7**	**CO1**	**L3**
40	Examine the Salient Features of Indian Constitution.	**7**	**CO1**	**L3**
41	Explain in detail the salient features of the Indian constitution.	**10**	**CO1**	**L2**
42	Explain the mode of acquisition and termination of citizenship.	**10**	**CO1**	**L2**
43	Discuss the significance of Preamble to the Constitution of India and its role in reflecting the ideals of the Constitution.	**10**	**CO1**	**L3**
	MODULE 2			
1	Define State, under Article 12 of the Constitution	**3**	**CO2**	**L1**
2	Define Uniform Civil code.	**3**	**CO2**	**L1**
3	List down the fundamental rights guaranteed to a citizen by the Constitution of India.	**3**	**CO2**	**L1**
4	State the meaning of “Equality of law”.	**3**	**CO2**	**L1**
5	Write a note on abolition of untouchability.	**3**	**CO2**	**L1**
6	Differentiate rights and duties with examples	**3**	**CO2**	**L1**
7	State the meaning of “Equal protection before law”.	**3**	**CO2**	**L1**
8	List the protection that are available to the Indian citizen against conviction	**3**	**CO2**	**L1**
9	List the rights of the minorities in India	**3**	**CO2**	**L1**
10	List and explain any three fundamental duties as outlined in the Constitution.	**3**	**CO2**	**L1**
11	Discuss the Right to Constitutional Remedies.	**3**	**CO2**	**L1**
12	List the fundamental duties of an Indian citizen	**7**	**CO2**	**L1**
13	Define Directive principles of state policy	**7**	**CO2**	**L1**

14	Recall the differences between fundamental rights and directive principles of State policy	**7**	**CO2**	**L1**
15	Explain the concept of 'equality before the law'.	**3**	**CO2**	**L2**
16	"No person shall be prosecuted and punished for the same offence more than once." Discuss this clause	**3**	**CO2**	**L2**
17	Discuss the origin of Fundamental Rights.	**3**	**CO2**	**L2**
18	Discuss the Right to Information.	**3**	**CO2**	**L2**
19	Discuss the Right against forced Labour.	**3**	**CO2**	**L2**
20	Discuss whether Judiciary is included in the definition of state.	**3**	**CO2**	**L2**
21	Examine the justifications for constitutional incorporation of Fundamental Rights.	**3**	**CO2**	**L2**
22	Discuss the Freedom of Association.	**3**	**CO2**	**L2**
23	Discuss Equality of Opportunity in Public Employment.	**3**	**CO2**	**L2**
24	As a citizen of India explain the advantages you enjoy	**3**	**CO6**	**L2**
25	Explain the significance of Article 14-18 in Indian Constitution.	**3**	**CO2**	**L2**
	MODULE 3			
1	List down the qualifications required for the Prime Minister of India.	**3**	**CO3**	**L2**
2	List down the Privileges and Immunities of the President.	**3**	**CO3**	**L1**
3	Recall the five specialities of Supreme Court	**3**	**CO3**	**L1**
4	Compare Lok Sabha and Rajya Sabha	**3**	**CO3**	**L1**
5	List the duties of Attorney General	**3**	**CO3**	**L1**
6	Discuss the qualifications required for an individual to become a member of Parliament in India	**3**	**CO3**	**L1**
7	List down what qualifications must an individual possess to be appointed as a Supreme Court Judge	**3**	**CO3**	**L1**
8	Outline the procedure of election and removal of the President of India.	**7**	**CO3**	**L1**
9	Outline the different functions and powers of the parliament.	**7**	**CO3**	**L1**
10	List the different functions of Parliament	**7**	**CO3**	**L1**
11	Recall the differences between Rajya Sabha and Lok Sabha with at least five points	**7**	**CO3**	**L1**
12	Explain how the President exercises the power of pardon.	**3**	**CO3**	**L2**
13	Distinguish between Lok Sabha and Rajya Sabha.	**3**	**CO3**	**L2**
14	Explain the process of Impeachment of a Judge of the Supreme Court.	**3**	**CO3**	**L2**
15	Describe the Legislative functions of Parliament.	**3**	**CO3**	**L2**
16	Discuss the procedure for impeachment of judges of the Supreme Court.	**3**	**CO3**	**L2**
17	Explain the Functions and Rights of the Attorney General.	**3**	**CO3**	**L2**
18	Describe the constitutional emergency powers granted to the President	**3**	**CO3**	**L2**

19	Explain how Union Executive is elected and formed	**7**	**CO3**	**L2**
20	Discuss how a citizen can be qualified or disqualified as an MP	**7**	**CO3**	**L2**
21	Explain the powers of President of India	**7**	**CO3**	**L2**
22	Describe the constitutional position and essential qualifications of Vice-president of India	**7**	**CO3**	**L2**
23	Explain various jurisdiction of Supreme Court	**7**	**CO3**	**L2**
24	Explain the powers and functions of President of India as outlined in the Constitution.	**7**	**CO3**	**L2**
25	Discuss the Constitutional provisions related to the office of the Prime Minister in India.	**7**	**CO3**	**L2**
26	Explore the grounds and circumstances under which a person may be disqualified from being a member of either Loksabha or Rajyasabha	**7**	**CO3**	**L2**
27	Discuss the jurisdiction and powers of Supreme Court as enshrined in the Constitution of India.	**7**	**CO3**	**L2**
28	Use any example from Indian History to explain the emergency powers of the President	**3**	**CO3**	**L3**
29	Mr. X who was elected as a member of Rajya Sabha has been holding the post of Chairperson of the State Film Development Council. The M.P was not receiving any allowances or honorarium attached to the	**7**	**CO3**	**L3**
	Module 4			
1	Define Principle of Res Judicata.	**3**	**CO4**	**L1**
2	Define the term discretionary power.	**3**	**CO4**	**L1**
3	Define Writ jurisdiction	**3**	**CO4**	**L1**
4	List the procedures for the appointment of Chief Minister	**3**	**CO4**	**L1**
5	Define Court of Record	**3**	**CO4**	**L1**

6	Mention how are High Court judges appointed and the essential qualifications required to be a High Court judge.	**3**	**CO4**	**L1**
7	List down the responsibilities carried out by the advocate general of the state	**3**	**CO4**	**L1**
8	Write short note on Ex-post facto law and No Double Jeopardy	**3**	**CO4**	**L1**
9	a) Define the constitution of the High court. b) List the essential qualifications required for the appointment of High court Judge.	**7**	**CO4**	**L1**
10	Recall the differences between State Government and Union Territory	**7**	**CO4**	**L1**
11	Define State Legislative Assembly in detail	**7**	**CO4**	**L1**
12	Explain the role of Governor	**3**	**CO4**	**L2**
13	Summarize the functions and duties of the Chief Minister.	**3**	**CO4**	**L2**
14	Explain the functions of the State Legislature.	**3**	**CO4**	**L2**
15	Explain the duties of advocate general of the state	**3**	**CO4**	**L2**
16	Discuss the constitution of High Courts	**3**	**CO4**	**L2**
17	a. Discuss the functions of State Legislature. b. Discuss the jurisdiction of High Court.	**7** **7**	**CO4**	**L2**
18	a. Discuss the powers of Governor. b. Discuss the jurisdiction of Supreme court.	**7** **7**	**CO4**	**L2**
19	Present a critical view on the Appellate Jurisdiction of the High Court	**3**	**CO4**	**L3**
20	Evaluate the concept of Judicial Review in the context of state laws	**3**	**CO4**	**L5**
21	Present a short essay on the following a. Legislative assembly a. Legislative Council	**7** **7**	**CO4**	**L3**

22	b. "Article 226 states that the High Court has the power to issue directions, orders, writs for any purpose". Present the different writs issued by the High court for the protection of Fundamental Rights. c. Present briefly the functions of Speaker and Deputy Speaker of the Legislative Assembly.	**7** **7**	**CO4**	**L3**
23	a) Discuss the role of High Courts in state judiciary. b) Discuss the qualifications, appointment process and functions of the Advocate General	**8** **6**	**CO4**	**L2**
24	a) List out the different jurisdiction and powers enjoyed by the High Court and explain original and writ jurisdiction in detail b) What are the powers enjoyed by the Governor	**10** **4**	**CO4**	**L2**
25	a) Explain the powers and functions of Chief Minister and State Legislature in Indian constitution. b) b) Explain the qualifications needed for governor?	**10** **4**	**CO4**	**L2**
26	a) Explain the qualifications and disqualifications of membership of the state legislature. b) Explain Writ of Habeas Corpus.	**10** **4**	**CO4**	**L2**
	MODULE 5			
1	Enumerate various functions of the Finance Commission.	**3**	**CO5**	**L1**
2	Discuss the functions of CAG of India.	**3**	**CO5**	**L1**
3	List the procedures for amending the Constitution	**3**	**CO5**	**L1**
4	Define Election Commission of India	**3**	**CO5**	**L1**
5	List down the functions of UPSC	**3**	**CO5**	**L1**
6	Define National Emergency	**3**	**CO5**	**L1**
7	Identify the importance of establishment of administrative tribunals	**3**	**CO5**	**L1**
8	State the theory of Basic Structure under Indian Constitution	**7**	**CO5**	**L1**
9	Outline the relation of Central and State Government on economic basis	**7**	**CO5**	**L1**
10	List the functions of Comptroller and Auditor General of India	**7**	**CO5**	**L1**

11	a. Define administrative tribunals. b. List the functions of state administrative tribunals.	**7**	**CO5**	**L1**
12	The Tribunal is not a substitute for the High Court. Comment.	**3**	**CO5**	**L2**
13	Explain State Emergency.	**3**	**CO5**	**L2**
14	Explain the 44th Amendment of the Constitution	**3**	**CO5**	**L2**
15	Discuss the purpose behind the establishment of Administrative Tribunals.	**3**	**CO5**	**L2**
16	Discuss the provisions related to declaration of Emergency in India.	**3**	**CO5**	**L2**
17	Explain parliamentary legislation in the state field	**7**	**CO5**	**L2**
18	Discuss the effects of national and financial emergencies	**7**	**CO5**	**L2**
19	State to what extent the Basic Structure theory acts as a limitation on the Amending power of the Parliament of India. Support your answer with relevant case laws.	**7**	**CO5**	**L2**
20	Explain how the constitution handles an emergency situation in the country	**7**	**CO5**	**L2**
21	Discuss the scheme of distribution of revenue sources between Centre and State.	**7**	**CO5**	**L2**

Prepared By : Ms.Rose Paul, Course Faculty

Checked By : Ms. Sheeja M K, Course Committee Convener

Course Code & Name: MEL202 FM & HM Lab

1. Prescribed Syllabus

Sl No	Experiments
1	Determination of coefficient of discharge and calibration of Notches.
2	Determination of coefficient of discharge and calibration of Orifice meter.
3	Determination of coefficient of discharge and calibration of Venturi meter.
4	Determination of hydraulic coefficients of orifices.
5	Determination of Chezy's constant and Darcy's coefficient on pipe friction apparatus.
6	Determine the minor losses in pipe.
7	Experiments on hydraulic ram.
8	Reynold's experiment.
9	Bernoulli's experiment.
10	Determination of metacentric height and radius of gyration of floating bodies.
11	Performance test on positive displacement pumps.
12	Performance test on centrifugal pumps, determination of operating point and efficiency.
13	Performance test on gear pump.
14	Performance test on Impulse turbines.
15	Performance test on reaction turbines (Francis and Kaplan Turbines).
16	Speed variation test on Impulse turbine.
17	Determination of best guide vane opening for Reaction turbine.
18	Impact of jet

2. Text Books (T)

T1. Yunus A. Cengel, John M. Cimbala; Fluid Mechanics- Fundamentals and Applications (in SI Units); McGraw Hill, 2010.

T2. Bansal R.K, Fluid Mechanics and Hydraulic Machines (SI Units); Laxmi Publications, 2011.

T3. Modi P.N and Seth S.M, "Hydraulics and Fluid Mechanics Including Hydraulic Machines" Standard Book House, New Delhi, 20th Edition, 2015

3. Reference Books (R)

R1. Graebel. W. P, "Engineering Fluid Mechanics", Taylor & Francis, Indian Reprint, 2011

R2. Robert W. Fox, Alan T. McDonald, Philip J. Pritchard, “Fluid Mechanics and Machinery”, John Wiley and sons, 2015.
R3. J. Frabzini, 'Fluid Mechanics with Engineering Applications', McGraw Hill, 1997

4. Course Objectives

This lab is mainly focussed to develop a platform where the students can enhance their engineering knowledge in the fluid mechanics domain by applying their theoretical knowledge acquired.

5. Course Pre / Co-requisite

MET203 Mechanics of Fluids

6. Course Outcomes

After the completion of the course the student will be able to
CO1: Determine the coefficient of discharge of flow measuring devices (notches, orifice meter and Venturimeter)
CO2: Calibrate flow measuring devices (notches, orifice meter and Venturimeter)
CO3: Evaluate the losses in pipes
CO4: Determine the metacentric height and stability of floating bodies
CO 5 Determine the efficiency and plot the characteristic curves of different types of pumps and turbines.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	L						M	H	M		M		H	H
CO2	M	L						M	H	M		M		H	H
CO3	M	L						M	H	M		M		H	H
CO4	M	L						M	H	M		M		H	H
CO5	M	L						M	H	M		M		H	H

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	PO1	Mathematical knowledge required to determine the coefficient of discharge of flow measuring devices contributes to skills in solving engineering problems. Medium correlation is due the fact that this involves standard and moderate knowledge of mathematics, science and engineering fundamentals.
	PO2	Analyzing the different coefficient of discharge of flow measuring devices will help the students to analyze complex engineering problems and to reach

		substantiated conclusions using first principles of mathematics and engineering. Low correlation is due the fact that this involves basic engineering knowledge to formulate and analyze complex problems.
	PO8	Follow ethical practices in representation of data and creation of reports.
	PO9	Learn to work as a member of a team in conducting experiments and will be encouraged to work individually to analyse the data obtained and form conclusions
	PO10	Communicate effectively in a team and write effective reports and inferences
	PO12	The ability to engage in independent and lifelong learning in the broadest context of experimental knowledge
	PSO3	By gaining deep knowledge students will be able to apply the fundamental principles of fluid mechanics and analyse multi-disciplinary systems to determine the coefficient of discharge of flow measuring devices
CO2	**PO1**	Analytical knowledge required for the calibration of flow measuring devices contributes to skills in solving engineering problems. Medium correlation is due the fact that this involves standard and moderate knowledge of mathematics, science and engineering fundamentals.
	PO2	Analyzing the calibration of flow measuring devices will help the students to analyze complex engineering problems and to reach substantiated conclusions using first principles of mathematics and engineering. Low correlation is due the fact that this involves basic engineering knowledge to formulate and analyze complex problems.
	PO8	Follow ethical practices in representation of data and creation of reports.
	PO9	Learn to work as a member of a team in conducting experiments and will be encouraged to work individually to analyse the data obtained and form conclusions
	PO10	Communicate effectively in a team and write effective reports and inferences
	PO12	Ability to engage in independent and lifelong learning in the broadest context of experimental knowledge.
	PSO3	By gaining knowledge students will be able to design and analyse multi-disciplinary systems by calibration of flow measuring devices and arrive at valid conclusions.
CO3	**PO1**	Theoretical knowledge required for the evaluation of major and minor losses in pipes contributes to skills in solving engineering problems. Medium correlation is due the fact that this involves standard and moderate knowledge of mathematics, science and engineering fundamentals.
	PO2	Analyzing the evaluation of major and minor losses in pipes will help the students to analyze complex engineering problems and to reach substantiated conclusions using first principles of mathematics and engineering. Low correlation is due the fact that this involves basic engineering knowledge to formulate and analyze complex problems.
	PO8	Follow ethical practices in representation of data and creation of reports.
	PO9	Learn to work as a member of a team in conducting experiments and will be encouraged to work individually to analyse the data obtained and form conclusions.
	PO10	Communicate effectively in a team and write effective reports and inferences.
	PO12	Ability to engage in independent and lifelong learning in the broadest context of experimental knowledge

	PSO3	By gaining knowledge students will be able to design and analyse multi-disciplinary systems by calibration of flow measuring devices and arrive at valid conclusions.
CO4	**PO1**	Theoretical knowledge required for the determination of metacentric height and stability of floating bodies contributes to skills in solving engineering problems. Medium correlation is due the fact that this involves standard and moderate knowledge of mathematics, science and engineering fundamentals.
	PO2	Analyzing the metacentric height and stability of floating bodies will help the students to analyze complex engineering problems and to reach substantiated conclusions using first principles of mathematics and engineering. Low correlation is due the fact that this involves basic engineering knowledge to formulate and analyze complex problems.
	PO8	Follow ethical practices in representation of data and creation of reports
	PO9	Learn to work as a member of a team in conducting experiments and will be encouraged to work individually to analyse the data obtained and form conclusions.
	PO10	Communicate effectively in a team and write effective reports and inferences.
	PO12	Ability to engage in independent and lifelong learning in the broadest context of experimental knowledge.
	PSO3	By gaining deep knowledge students will be able to analyse the stability of a floating vessel and interpret data regarding the stability and arrive at valid conclusions.
CO5	**PO1**	Analytical knowledge required for determining the pump/turbine efficiencies contributes to skills in solving engineering problems. Medium correlation is due the fact that this involves standard and moderate knowledge of mathematics, science and engineering fundamentals
	PO2	Analyzing the characteristic curves of different types of pumps and turbines will help the students to analyze complex engineering problems and to reach substantiated conclusions using first principles of mathematics and engineering. Low correlation is due the fact that this involves basic engineering knowledge to formulate and analyze complex problems.
	PO8	Follow ethical practices in representation of data and creation of reports.
	PO9	Learn to work as a member of a team in conducting experiments and will be encouraged to work individually to analyse the data obtained and form conclusions.
	PO10	Communicate effectively in a team and write effective reports and inferences.
	PO12	Ability to engage in independent and lifelong learning in the broadest context of experimental knowledge.
	PSO3	By gaining in depth knowledge students will be able to design and analyse multi-disciplinary systems by determining the efficiency and characteristics curve of pumps and turbines.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs

11. Assessment Pattern (as per university curriculum)

(Provide details as mentioned in syllabus)

Continuous Internal evaluation - 75 marks

End Semester Examination - 75 marks

Total -150 marks

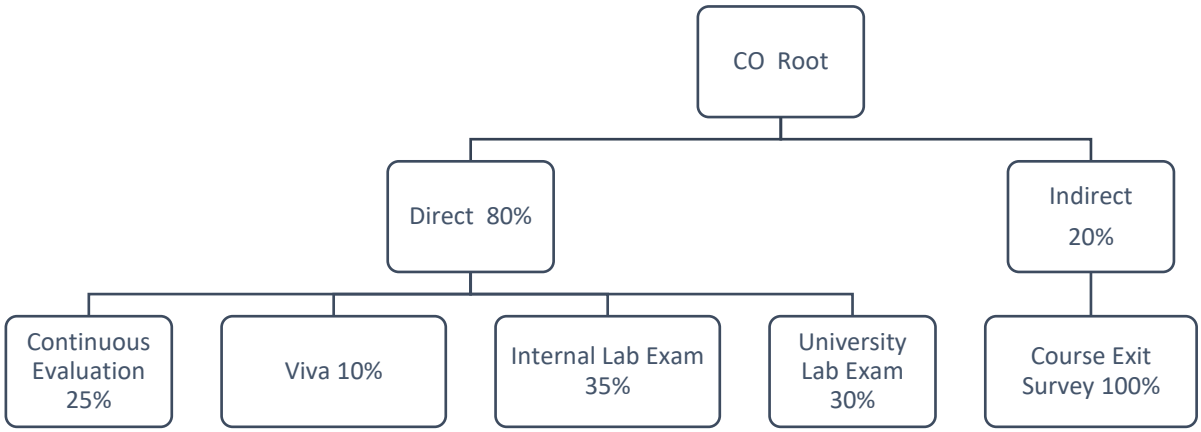
Evaluation criteria (as per syllabus)

Sl. No	Nature of Evaluation	Evaluation Pattern	Topics of Evaluation	Duration	Weightage of marks
1.	**Continuous Internal evaluation (75 marks)**				
a.	Attendance	90%-100% - 15 marks 85% -90% - 13.5 marks 75% -85 % - 12 marks 70% - 75% - 10.5 marks 65% - 70% - 9 marks 60% - 65% - 7.5 marks	NA	NA	20%
b.	Continuous Assessment	20 marks for performance (Records) Total no. of experiments: 10 Total – 200 marks will be converted to 20 while calculating internals	Each experiment	2.5 hours	26.67%
c.	Viva Voce	10 marks for viva. Total no. of experiments: 10 Total – 100 marks will be converted to 10 while calculating internals	Each experiment	2.5 hours	13.33%
d.	Internal Test	Preliminary Work – 10 marks Conducting Experiment – 10 marks Performance and Result – 5 marks Viva – 5 marks Total – 30 marks	All Experiments	2.5 hours	40%
2.	**End Semester Examination (75 marks)**				
a.	End semester Examination	(a) Preliminary work: 15 Marks (b) Implementing the work/ Conducting the experiment: 10 Marks (c) Performance, result and inference (usage of equipment's and troubleshooting): 25 Marks (d) Viva voce: 20 marks (e) Record: 5 Marks	All Experiments	3 hours	100%

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools	Weightage	CO1	CO2	CO3	CO4	CO5
Direct Assessment Tools 80%	Continuous Evaluation Experiment wise CO mapping	25%	x	x	x	x	x
	Viva – Voce Experiment wise CO mapping	10%	x	x	x	x	x
	Internal Lab Exam	35%	x	x	x	x	x
	End Semester Exam – 50%	**50%**	x	x	x	x	x
Indirect Assessment Tool 20%	Course Exit Survey	100%	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Weeks (W)	Experiments	Relevance to COs
1	Determination of coefficient of discharge and calibration of Venturimeter	**CO1, CO2**
2	Determination of coefficient of discharge and calibration of Triangular Notch	**CO1, CO2**
3	Determination of Chezy’s constant and Darcy’s coefficient on pipe friction apparatus.	**CO3**
4	Determination of Minor Losses in a pipe flow	**CO3**
5	Determination of metacentric height and radius of gyration of floating bodies	**CO4**
6	Performance test on centrifugal pump	**CO5**

7	Performance test on reciprocating pump	**CO5**
8	Performance test on gear pump	**CO5**
9	Performance test on Pelton Wheel Turbine	**CO5**
10	Performance test on Francis Turbine	**CO5**
Total No. of Hours	30	

Prepared By : Mr. Avinesh Pyarilal, (Subject Faculty)

Checked By : Ms. Asha K R (Subject group coordinator)

Approved By : Dr. Ramadas T (HOD - ME)

Course Code & Name: MEL204 Machine tool lab -1

1. Prescribed Syllabus

Sl No	Experiments
1	Study of lathe tools
2	Exercises on centre lathe:- Facing, plain turning, step turning and parting
3	Exercises on Drilling machine
4	Exercises on shaping machine: - flat surfaces, grooves and key ways.
5	Exercises on slotting machine: - flat surfaces, grooves and key ways.
6	Exercises on Grinding machine • Exercise on surface grinding, cylindrical grinding and tool grinding etc.
7	Exercises on Welding machine Exercises on arc and gas welding: - butt welding and lap welding of M.S. sheets.
8	Heat treatment study:–Effect on mechanical properties and microstructure of ferrous and nonferrous metals
9	Studies of various quenching mediums, Carryout heat treatments on steel based on ASM handbook vol.4 and observe the hardness obtained.

2. Text Books (T)

T1. Acherkan N. S. “Machine Tool”, Vol. I, II, III and IV, MIR Publications.
T2. HMT, Production Technology, Tata McGraw Hill.
T3. W. A. J. Chapman, Workshop Technology Part I, ELBS & Edward Arnold Publishers.

3. Reference Books (R)

Nil

4. Course Objectives

To understand the parts of various machine tools and impart hands on experience on lathe, drilling, shaping, milling, slotting, grinding, tool and cutter grinding machines.
2. To develop knowledge and importance of metal cutting parameters such as feed, velocity and depth of cut etc on cutting force and surface roughness obtainable.
3. To develop fundamental knowledge on tool materials, cutting fluids and tool wear Mechanisms.
4. To apply knowledge of basic mathematics to calculate the machining parameters for different machining processes.
5. To study process parameters and practice on arc and gas welding technologies.
6. To gain knowledge on the structure, properties, heat treatment, testing and applications of ferrous and non ferrous metals

5. Course Pre / Co-requisite

MET 204 - Manufacturing Process

6. Course Outcomes

After the completion of the course the student will be able to

CO1: The students can operate different machine tools with understanding of work holders and operating principles to produce different part features to the desired quality.

CO2: Apply cutting mechanics to metal machining based on cutting force and power consumption.

CO3: Select appropriate machining processes and process parameters for different metals.

CO4: Fabricate and assemble various metal components by welding and students will be able to visually examine their work and that of others for discontinuities and defects.

CO5: Infer the changes in properties of steel on annealing, normalizing, hardening and tempering.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1			H										M		M
CO2		H											M		M
CO3				M											M
CO4	M												M		M
CO5					M								M		M

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	PO3	By acquiring the knowledge students are able to position, hold and locate work material and cutting tools in various basic machine tools to design solutions for various engineering problems.
	PSO1	Students will be able to use the concurrent techniques in various basic machine tools for product development with least wastage.
	PSO3	Basic Understanding of proper positioning, holding and locating work material and cutting tools in various basic machine tools helps to design and manufacture as required in a multidisciplinary workspace.
CO2	PO2	Practical knowledge on lathe machine enables the student to identify appropriate speed, feed and depth of cut for various processes.
	PSO1	Students will be able to use the concurrent techniques involved in lathe machining so as to produce the required model with least wastage.
	PSO3	Basic Understanding of appropriate speed, feed and depth of cut for various processes on lathe machines, helps to design and manufacture as required in a multidisciplinary workspace.
CO3	PO4	By Identifying various process parameters and their influence on surface properties of various metals, students will be able to analyse complex engineering activities with an understanding of the limitations .

	PSO3	By Identifying various process parameters and their influence on surface properties of various metals students will be able to design and analyse mechanically related multi-disciplinary systems.
CO4	**PO1**	By acquiring the fundamental knowledge of welding processes students are able to choose suitable welding process for different metals.
	PSO1	Students will be able to use the concurrent welding techniques so as to produce the required model with least wastage.
	PSO3	Basic Understanding of welding process, helps to design and manufacture as required in a multidisciplinary workspace
CO5	**PO5**	By acquiring the knowledge of fundamental heat treatment process, students are able to model complex engineering activities.
	PSO1	Students will be able to use the concurrent heat treatment techniques so as to produce the required model with least wastage
	PSO3	Basic understanding of various heat treatment processes, students will be able to manufacture as required in a multidisciplinary workspace

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs

11. Assessment Pattern (as per university curriculum)

(Provide details as mentioned in syllabus)

Continuous Internal evaluation - 75 marks

End Semester Examination - 75 marks

Total -150 marks

Evaluation criteria (as per syllabus)

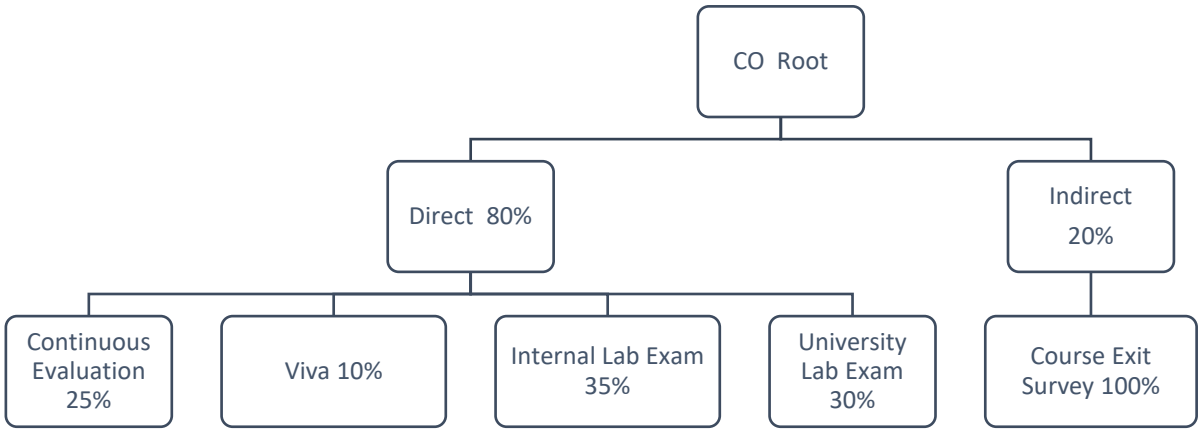
Sl. No	Nature of Evaluation	Evaluation Pattern	Topics of Evaluation	Duration	Weightage of marks
1.	**Continuous Internal evaluation (75 marks)**				
a.	Attendance	90%-100% - 15 marks 85% -90% - 13.5 marks 75% -85 % - 12 marks 70% - 75% - 10.5 marks	NA	NA	20%

		65% - 70% - 9 marks 60% - 65% - 7.5 marks			
b.	Continuous Assessment	20 marks for performance (Records) Total no. of experiments: 10 Total – 200 marks will be converted to 20 while calculating internals	Each experiment	2.5 hours	26.67%
c.	Viva Voce	10 marks for viva. Total no. of experiments: 10 Total – 100 marks will be converted to 10 while calculating internals	Each experiment	2.5 hours	13.33%
d.	Internal Test	Preliminary Work – 10 marks Conducting Experiment – 10 marks Performance and Result – 5 marks Viva – 5 marks Total – 30 marks	All Experiments	2.5 hours	40%
2.	**End Semester Examination (75 marks)**				
a.	End semester Examination	(a) Preliminary work: 15 Marks (b) Implementing the work/ Conducting the experiment: 10 Marks (c) Performance, result and inference (usage of equipment's and troubleshooting): 25 Marks (d) Viva voce: 20 marks (e) Record: 5 Marks	All Experiments	3 hours	100%

12. **Assessment – CO Mapping** (Put' x' if mapping is present)

	Tools	Weightage	CO1	CO2	CO3	CO4	CO5
Direct Assessment Tools 80%	Continuous Evaluation Experiment wise CO mapping	25%	x	x	x	x	x
	Viva – Voce Experiment wise CO mapping	10%	x	x	x	x	x
	Internal Lab Exam	35%	x	x	x	x	x
	End Semester Exam – 50%	**50%**	x	x	x	x	x
Indirect Assessment Tool 20%	Course Exit Survey	100%	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Weeks (W)	Experiments	Relevance to COs
1	Safety precautions in machine shop	**CO1, CO2**
2	Study of lathe tools	**CO1, CO2**
3	Exercises on centre lathe:- Facing, plain turning, step turning and parting	**CO3**
4	Exercises on Drilling machine-Drilling	**CO3**
5	Exercises on shaping machine: - flat surfaces, grooves and key ways.	**CO4**
6	Exercises on slotting machine: - flat surfaces, grooves and key ways.	**CO5**
7	Exercises on Grinding machine • Exercise on surface grinding, cylindrical grinding and tool grinding etc.	**CO5**
8	Exercises on Welding machine Exercises on arc and gas welding: - butt welding and lap welding of M.S. sheets.	**CO5**
9	Heat treatment study:–Effect on mechanical properties and microstructure of ferrous and non ferrous metals	**CO5**
10	Studies of various quenching mediums, Carryout heat treatments on steel based on ASM handbook vol.4 and observe the hardness obtained.	**CO5**
Total No. of Hours	30	

Prepared By : Dr. Manoj Jose Kalathil, (Subject Faculty)

Checked By : Dr. Manoj Jose Kalathil (Subject group coordinator)

Approved By : Dr. Ramadas T (HOD - ME)

Semester: 5

Curriculum

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MET301	MECHANICS OF MACHINERY	3-1-0	4	4
B	MET303	THERMAL ENGINEERING	3-1-0	4	4
C	MET305	INDUSTRIAL & SYSTEMS ENGINEERING	3-1-0	4	4
D	MET307	MACHINE TOOLS AND METROLOGY	3-1-0	4	4
E	HUT300	INDUSTRIAL ECONOMICS AND FOREIGN TRADE	3-0-0	3	3
F	MCN301	DISASTER MANAGEMENT	2-0-0	3	3
S	MEL331	MACHINE TOOLS LAB-II	0-0-3	3	2
T	MEL333	THERMAL ENGINEERING LAB-I	0-0-3	3	2
R/M/H	VAC	Remedial/Minor/Honours course	3-1-0	4*	4
TOTAL				25/29	23/27

Course Code & Name: MET301 Mechanics of Machinery

1. Prescribed Syllabus

Module	Topic	Hours
1	Introduction to kinematics and mechanisms - various mechanisms, kinematic diagrams, degree of freedom- Grashof's criterion, inversions, coupler curves mechanical advantage, transmission angle. straight line mechanisms exact, approximate. Displacement, velocity analysis– relative motion - relative velocity. Instantaneous centre -Kennedy's theorem.	**9**
2	Acceleration analysis- Relative acceleration - Coriolis acceleration - graphical and analytical methods. Cams - classification of cam and followers - displacement diagrams, velocity and acceleration analysis of SHM, uniform velocity, uniform acceleration, cycloidal motion Graphical cam profile synthesis, pressure angle.	**8**
3	Gears – Classification- terminology of spur gears – law of gearing -tooth profiles- involute spur gears- contact ratio - interference - backlash - gear standardization – interchangeability. Gear trains - simple and compound gear trains - planetary gear trains. Kinematic synthesis (planar mechanisms) - type, number and dimensional synthesis – precision points. Graphical synthesis for motion - path and prescribed timing – function generator. 2 position and 3 position synthesis – overlay Method. Freudenstein's equation	**8**
4	Static force analysis- Analysis of four bar linkages and slider crank mechanism, graphical method, Matrix method, principle of virtual work. Analysis of four bar and slider crank mechanisms with sliding and pin friction. Gyroscopic couples-spin, precession and applied gyroscopic couple vectors-effects on the stability of two wheelers, four wheelers, sea vessels and air crafts, application of gyroscopes	**12**
5	Static balancing-dynamic balancing-balancing of several masses in the same plane-several masses in different planes-graphical and analytical method-force and couple polygons. Balancing of reciprocating masses - Single cylinder engine-multi cylinder engine -V-engine	**10**

2. Text Books (T)

T1. Ballaney P. L., Theory of Machines and Mechanisms, Khanna Publishers,2005
T2. S. S. Rattan, Theory of Machines, Tata Mc Graw Hill,2009

3. Reference Books (R)

R1. C. E. Wilson, P. Sadler, Kinematics and Dynamics of Machinery, Pearson Education,2005.
R2. D.H. Myskza, Machines and Mechanisms Applied Kinematic Analysis, Pearson Education,2013
R3. G. Erdman, G. N. Sandor, Mechanism Design: Analysis and synthesis Vol I & II, Prentice Hall of India,1984.
R4. Ghosh, A. K. Malik, Theory of Mechanisms and Machines, Affiliated East West Press,1988

R5. J. E. Shigley, J. J. Uicker, Theory of Machines and Mechanisms, McGraw Hill,2010

R6. Norton, Kinematics and Dynamics of Machinery, Tata McGraw Hill,2009

4. Course Objectives

a) This course aims to introduce the students to the fundamentals of the kinematics of various mechanisms and also its analysis for its displacement, velocity, and acceleration.
b) The course will also cover the design of cams, theory and analysis of gears, gear trains and synthesis of mechanisms. The static force analysis of planar mechanisms and concept of gyroscopic couple along with its effect has also been included.
c) This course also aids students in estimating unbalance in rotating and reciprocating masses and suggesting methods to overcome it.

5. Course Pre / Co-requisite

Engineering Mechanics (EST 100)

6. Course Outcomes

After the completion of the course the students will be able to

CO 1: Explain the fundamentals of kinematics, various planar mechanisms and interpret the basic principles of mechanisms and machines

CO 2: Perform analysis and synthesis of mechanisms

CO 3: Solve the problem on cams and gear drives, including selection depending on requirement.

CO 4 Calculate the gyroscopic effect in various situations

CO 5 Analyse rotating and reciprocating masses for its unbalance

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO 1	M														
CO 2	H	H	H	M	M										H
CO 3	H	H	M	M	M										H
CO 4	H	M	L	L	L										M
CO 5	H	M	M	L	M										M

8. Justification for CO-PO-PSO Correlation

CO1	**PO1**	The knowledge on kinematics, various planar mechanisms and interpret the basic principles of mechanisms and machines are applied to solve the engineering problems. Medium correlation is due to the fact that this involves only conceptual Knowledge of mathematics and science to analyse the complex engineering principles and theorems.
CO2	**PO1**	The principles of analysis and mechanisms are used to solve problems in science and engineering. High correlation is due to the fact that deep knowledge is provided in understanding the synthesis of mechanisms.

	PO2	The complex engineering problems involving planar mechanics are studied and logical conclusions based on first principles of mathematics and engineering are drawn. High correlation is due to the fact that deep knowledge is provided to solve such problems.
	PO3	The planar mechanisms that meet certain requirements are developed. High correlation is due to the fact that it gives deep knowledge on considering environmental concerns and public safety issues.
	PO4	Analysis and synthesis are done for various mechanisms in order to reach a valid conclusion via experiment design, problem analysis and interpretation, and information synthesis. Medium correlation is due to the fact that it imparts knowledge only regarding design and analysis.
	PO5	Application of appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling are analysed. Medium correlation is due to the fact that only certain techniques are provided to solve complex engineering activities.
	PSO3	The principles of science and engineering can be understood by understanding various mechanisms and its synthesis. High correlation is due to the fact that the analysis and synthesis of mechanisms are used to analyse multi-disciplinary systems.
CO3	**PO1**	The mechanisms of cam and follower are carefully analysed. High correlation is due to the fact that deep knowledge is given estimating the velocity of gear and various other terminologies.
	PO2	Analysis on engineering problems related to cam mechanism and gear mechanisms are used. High correlation is due to the fact that they can reach substantiated conclusions using first principles of mathematics and Engineering.
	PO3	The principles of complex engineering problems involving cam and gear mechanisms are analysed. Medium correlation is due to the fact that only analysis is done to solve the complex problems.
	PO4	The complex problems are studied involving cams and gear drives using research methods such as design of selection based on requirement, experiments, data analysis and interpretation, and information synthesis are used to obtain accurate results. Medium correlation is due to the fact that only design interpretations are provided to solve the problems.
	PO5	The mechanisms of cam and follower are carefully analysed using modern tools. Medium correlation is presented due to the fact that only conceptual knowledge is needed for the prediction and modelling to complex engineering activities.
	PSO3	The working and design principles of science and engineering can be understood by knowing about the working of cams, gears and its selection depending on requirements. High correlation is due to the fact that the deep knowledge of cam and gear drives are used to analyse multi-disciplinary systems.
CO4	**PO1**	The knowledge of gyroscopic effects in a variety of settings, such as the reaction of a vehicle's four wheels negotiating a curve is used to solve engineering problems. High correlation is due to the fact that deep knowledge of mathematics, science, engineering fundamentals, and an engineering specialisation for the solution of complex engineering problems of gyroscopes.
	PO2	Analysis on engineering problems related to gyroscopic effects are used. Medium correlation is due to the fact that they can reach substantiated conclusions using first principles of mathematics and Engineering.
	PO3	The knowledge on gyroscopic effect in various situations are needed for solving complex engineering problems. Low correlation is due to the fact that only small consideration is given for cultural, socioeconomic and environmental factors.

	PO4	The complex problems are studied about the gyroscopic effects in various situations using research methods such as design of selection based on requirement, experiments, data analysis and interpretation, and information synthesis are used to obtain accurate results. Low correlation is due to the fact that only design interpretations are provided to solve the problems.
	PO5	Application of appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling are analysed. Low correlation is due to the fact that only basic knowledge is needed for modern tool usage in study of gyroscopic effects.
	PSO3	The gyroscopic effects in various situations can be studied. Medium correlation is due to the fact that only design process is used to analyse the multi-disciplinary systems.
CO5	**PO1**	Knowledge of rotating and reciprocating masses and its unbalance are necessary to solve the engineering problems. High correlation is due to the fact that this involves the deep knowledge of mathematics and science to solve the complex engineering problems.
	PO2	The knowledge of rotating and reciprocating masses are used to identify, formulate and analyse the complex engineering problems. Medium correlation is due to the fact that this involves only conceptual knowledge using first principles of mathematics, science and engineering.
	PO3	The principles of balancing of rotating and reciprocating masses are used to solve complex engineering problems regarding human safety and comfort. Medium correlation is presented due to the fact that only conceptual knowledge on the importance of environmental considerations are involved.
	PO4	The working principles balancing rotating and reciprocating masses are used to understand the basics and possible research areas of engineering. Low correlation is presented due to the fact that only basic knowledge is mostly applicable in real world engineering.
	PO5	Modern tools are used to analyse rotating and reciprocating masses for unbalance. Medium correlation is presented due to the fact that only conceptual knowledge is needed for the prediction and modelling to complex engineering activities.
	PSO3	Analysis of rotating and reciprocating masses and its balancing can be studied. Medium correlation is due to the fact that conceptual knowledge of unbalance is used to analyse the multi-disciplinary systems.

9. Curricular gaps (if any)

Klein's Construction for finding velocity and acceleration of slider crank mechanism

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1.	Klein's Construction for finding velocity and acceleration	NPTEL Video	PO1, PO2, PSO1

11. Internal Assessment mark allocation (as per university curriculum)

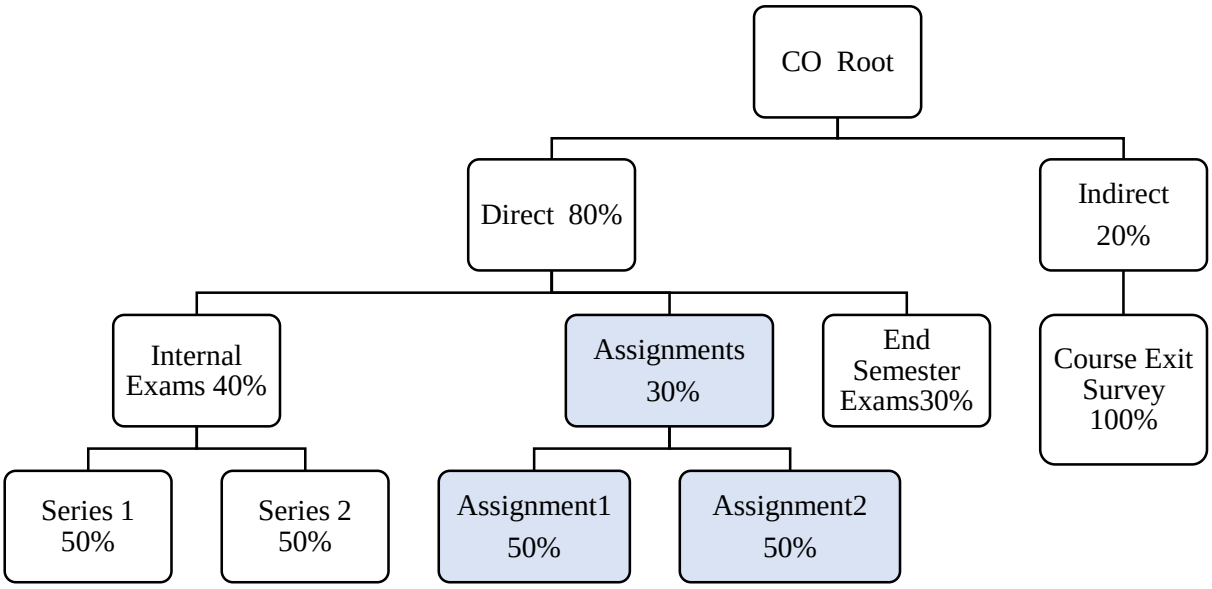
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		Weightage#	CO1	CO2	CO3	CO4	CO5
Direct Assessment Tools**	Internal Exam(s) 40%	Series 1	50%	x	x	x		
		Series 2	50%				x	x
	Assignment (s) 30%	1	50%	x	x			
		2	50%			x	x	x
	End Semester Exam - 30%		100%	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

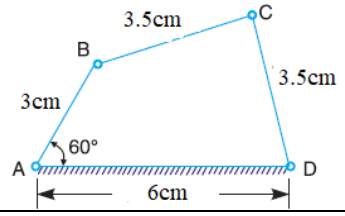
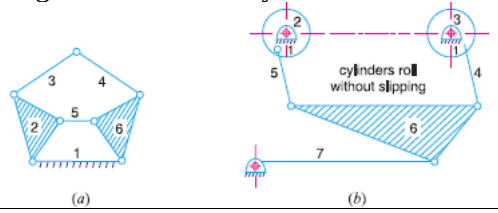
Sl.no	Topic Name	Module	Reference	Teaching Pedagogy
1	Introduction to kinematics and mechanisms	1	T1, T2	Lecture
2	Various mechanisms	1	T1, T2	Lecture
3	Various mechanisms	1	T1, T2	Lecture
4	Kinematic diagrams, degree of freedom, Grashofâ€™s criterion	1	T1, T2	Lecture

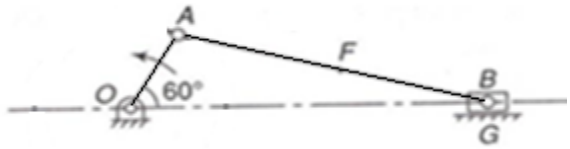
5	Kinematic diagrams, degree of freedom, Grashofâ€™s criterion	1	T1, T2	Remedial
6	Inversions	1	T1, T2	Lecture
7	Coupler curves mechanical advantage, transmission angle.	1	T1, T2	Lecture
8	Displacement, velocity analysis,	1	T1, T2	Tutorial
9	Displacement, velocity analysis,	1	T1, T2	Tutorial
10	Kennedyâ€™s theorem.	1	T1, T2	Remedial
11	Acceleration analysis- Relative acceleration	2	T1, T2	Lecture
12	Acceleration analysis- Relative acceleration	2	T1, T2	Lecture
13	Coriolis acceleration	2	T1, T2	Tutorial
14	Graphical and analytical methods.	2	T1, T2	Tutorial
15	Cams - classification of cam and followers	2	T1, T2	Lecture
16	Displacement diagrams, velocity and acceleration analysis of SHM,	2	T1, T2	Lecture
17	Uniform velocity,	2	T1, T2	Remedial
18	acceleration and cycloidal motion	2	T1, T2	Lecture
19	Graphical cam profile synthesis, pressure angle.	2	T1, T2	Tutorial
20	Graphical cam profile synthesis	2	T1, T2	Tutorial
21	Gears terminology of spur gears law of Gearing	3	T1, T2	Lecture
22	involute spur gears - contact ratio- interference-backlash - gear standardization-nterchangeability	3	T1, T2	Lecture
23	Gear trains - simple and compound gear trains -	3	T1, T2	Lecture
24	planetary gear trains	3	T1, T2	Remedial
25	Kinematic synthesis (planar mechanisms) - type, number and dimensional synthesis	3	T1, T2	Lecture
26	precision points.	3	T1, T2	Lecture
27	Graphical synthesis for motion - path and prescribed timing - function generator. 2 position	3	T1, T2	Tutorial
28	3 position synthesis	3	T1, T2	Lecture
29	Overlay Method. Freudenstein's equation	3	T1, T2	Tutorial

30	Overlay Method. Freudenstein's equation	3	T1, T2	Remedial
31	Static force analysis- Analysis of four bar linkages	4	T1, T2, R1, R6	Lecture
32	Static force analysis- slider crank mechanism	4	T1, T2, R1, R6	Lecture
33	Graphical method, Matrix method	4	T1, T2, R1, R6	Lecture
34	Graphical method, Matrix method	4	T1, T2, R1, R6	Tutorial
35	principle of virtual work	4	T1, T2, R1, R6	Lecture
36	Analysis of four bar and slider crank mechanisms with sliding and pin friction.	4	T1, T2, R1, R6	Remedial
37	Gyroscopic couples-spin, precession and applied gyroscopic couple vectors	4	T1, T2, R1, R6	Tutorial
38	Gyroscopic couples-spin, precession and applied gyroscopic couple vectors	4	T1, T2, R1, R6	Lecture
39	Effects on the stability of two wheelers , Four wheelers,	4	T1, T2, R1, R6	Tutorial
40	Effects on the stability of sea vessals and air crafts	4	T1, T2, R1, R6	Tutorial
41	Static balancing-	5	T1, T2, R1, R6	Lecture
42	balancing of several masses in the same plane	5	T1, T2, R1, R6	Lecture
43	several masses in different planes-graphical and analytical method	5	T1, T2, R1, R6	Tutorial
44	force and couple polygons	5	T1, T2, R1, R6	Remedial
45	force and couple polygons	5	T1, T2, R1, R6	Tutorial
46	Balancing of reciprocating masses -Single cylinder engine	5	T1, T2, R1, R6	Lecture
47	multi cylinder engine-v engine-	5	T1, T2, R1, R6	Lecture
48	inline engine	5	T1, T2, R1, R6	Remedial

15. Question Bank

Module 1				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	Explain the term kinematic link. Give the classification of kinematic link.	5	CO1	L2
2	What is kinematic inversion?	3	CO1	L1

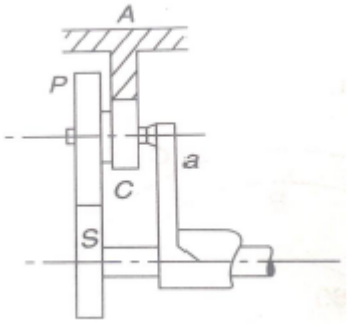
3	What is a machine? Giving example, differentiate between a machine and a structure.	5	CO1	L2
4	Explain any one inversion of single slider crank mechanism.	3	CO 1	L1
5	Write notes on complete and incomplete constraints in lower and higher pairs, illustrating your answer with neat sketches	5	CO1	L2
6	Explain different kinds of kinematic pairs giving example for each one of them.	5	CO1	L2
7	Describe the term mechanical advantage in a four bar mechanism.	3	CO 2	L1
8	Explain the terms: 1. Lower pair, 2. Higher pair, 3. Kinematic chain, and 4. Inversion.	5	CO1	L2
9	Explain the term coupler curve.	3	CO 1	L1
10	Explain mechanical advantages and transmission angle	5	CO1	L1
11	What way a mechanism differs from a machine?	5	CO1	L2
12	State and prove Kennedy's theorem.			
13	Find the Instantaneous centre of the given mechanism. 	3	CO 2	L1
14	What is the significance of degrees of freedom of a kinematic chain when it functions as a mechanism? Give examples.	5	CO1	L2
15	Determine the mobility (degrees of freedom) of the mechanism shown in Fig. 5.39 (a) and (b) using Kutzbach mobility criterion and classify them. 	10	CO1	L4
16	Explain Grubler's criterion for determining degree of freedom for mechanisms. Using Grubler's criterion for plane mechanism, prove that the minimum number of binary links in a constrained mechanism with simple hinges is four.	10	CO1	L5
17	Sketch and explain the various inversions of a slider crank chain.	10	CO1	L4
18	Sketch and describe the four-bar chain mechanism. Why it is considered to be the basic chain?	10	CO1	L2
19	Show that slider crank mechanism is a modification of the basic four bar mechanism.	10	CO1	L2
20	Draw and explain any 2 exact straight line mechanism and 2 approximate straight line mechanism.	12	CO 1	L2
21	Sketch slider crank chain and its various inversions, stating actual machines in which these are used in practice.	10	CO1	L2
22	Draw and explain any 2 inversions of each four bar mechanism and single slider crank mechanism with an application.	12	CO 1	L2
23	The crank and connecting rod of a theoretical steam engine are 0.5 m and 2 m long respectively. The crank makes 180 r.p.m. in the clockwise direction. When it has turned 45° from the inner dead centre position, determine: (a) velocity of piston, (b) angular velocity of connecting rod, (c) velocity of point E on the connecting rod 1.5 m from the piston (gudgeon) pin, (d) velocities of rubbing at the pins of the crank shaft.	12	CO 2	L3
24	Given a four bar mechanism ABCD with following dimensions. Find the			

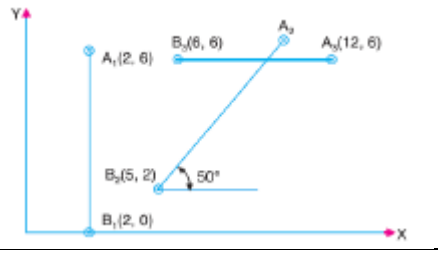
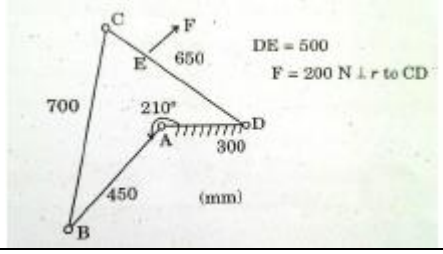
	velocity of joint C and angular velocities of link CD and BC if the angular velocity of link AB is 10 rad/sec in clockwise direction. Dimensions of various links are AB = 30cm, BC=CD=35cm, AD(fixed) = 60cm, angle BAD = 60^O.Use graphical method			
25	Sketch and describe the working of two different types of quick return mechanisms. Give examples of their applications. Derive an expression for the ratio of times taken in forward and return stroke for one of these mechanisms.	10	CO1	L3
26	Sketch and explain any two inversions of a double slider crank chain.	10	CO1	L2
27	In a slider crank mechanism, the crank OA is 0.48m long and rotates at 20 rad/s in the counter-clockwise direction. The length of the connecting rod is 1.6m. When the crank turns 60^O from the inner-dead centre, determine; a. Velocity of the slider B b. Angular velocity of the connecting rod Velocity of rubbing at the pin at O of the crank shaft and at the pin B of the piston if radiuses are 30mm and 20mm respectively. 	12	CO 2	L3
28	Identify the kinematic chains to which the following mechanisms belong: 1. Steam engine mechanism; 2. Beam engine; 3. Whitworth quick return motion mechanism; 4. Elliptical trammels.	10	CO1	L2

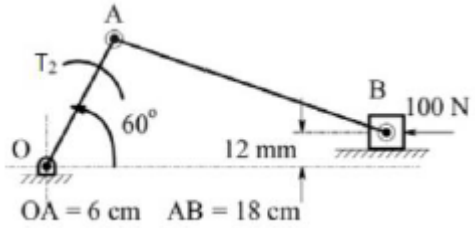
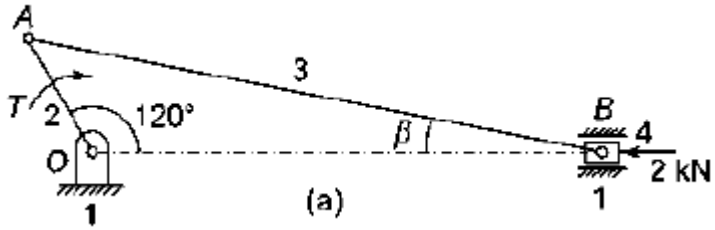
Module 2

Sl. No.	Question	Marks	CO	BL
1	Write short notes on cams and followers.	5	CO2	L2
2	List down the different types of cams.	3	CO 3	L1
3	Explain with sketches the different types of followers.	5	CO3	L1
4	Why a roller follower is preferred to that of a knife-edged follower?	5	CO2	L2
5	Define the following terms as applied to cam with a neat sketch: - (*a*) Base circle, (*b*) Pitch circle, (*c*) Pressure angle, and (*d*) Stroke of the follower.	3	CO2	L1
6	What are the different types of motion with which a follower can move?	5	CO2	L2
7	Draw the displacement, velocity and acceleration diagrams for a follower when it moves with simple harmonic motion. Derive the expression for velocity and acceleration during outstroke and return stroke of the follower.	10	CO2	L4
8	Draw the displacement, velocity and acceleration diagrams for a follower when it moves with uniform acceleration and retardation. Derive the expression for velocity and acceleration during outstroke and return stroke of the follower.	10	CO2	L4
9	Derive expressions for displacement, velocity and acceleration for a tangent cam operating on a radial-translating roller follower:	10	CO2	L4
10	Design cam to give the following motion to a knife-edged follower : (1) Outstroke during 60° of cam rotation; (2) Dwell for the next 30° of cam rotation; (3) Return stroke during next 60° of cam rotation, and (4) Dwell for the remaining 210° of cam rotation. The stroke of the follower is 40 mm and the minimum radius of the cam is 50 mm. The follower moves with uniform velocity during both the outstroke and return strokes. a) The axis of the follower passes through the axis of the cam shaft. b) the axis of the follower passes 20mm offset to the axis of cam shaft.	12	CO 3	L3
11	Derive the expressions for displacement, velocity and acceleration for a circular arc cam operating a flat-faced follower	10	CO2	L4

	(*i*) when the contact is on the circular flank, and (*ii*) when the contact is on circular nose.			
12	A disc cam is to give uniform motion to a knife edge follower during out stroke of 50 mm during the first half of the cam revolution. The follower again returns to its original position with uniform motion during the next half of the revolution. The minimum radius of the cam is 50 mm and the diameter of the cam shaft is 35 mm. Draw the profile of the cam when 1. the axis of follower passes through the axis of cam shaft, and 2. the axis of follower is offset by 20 mm from the axis of the cam shaft.	10	CO2	L4
13	Design a cam to give the following motion to a knife-edged follower : (1) Outstroke during 90° of cam rotation; (2) Dwell for the next 45° of cam rotation; (3) Return stroke during next 90° of cam rotation, and (4) Dwell for the remaining of cam rotation. The stroke of the follower is 3cm and the minimum radius of the cam is 4 cm. The follower moves with uniform velocity during both the outstroke and return strokes. The axis of the follower passes through the axis of the cam shaft.	12	CO 3	L3
14	Explain how the acceleration of a point on a link (whose direction is known) is obtained when the acceleration of some other point on the same link is given in magnitude and direction.	10	CO2	L4
15	Draw the acceleration diagram of a slider crank mechanism.	5	CO2	L4
16	Explain how the coriolis component of acceleration arises when a point is rotating about some other fixed point and at the same time its distance from the fixed point varies.	10	CO2	L4
17	Derive an expression for the magnitude and direction of coriolis component of acceleration	5	CO2	L3
18	Sketch a quick return motion of the crank and slotted lever type and explain the procedure of drawing the velocity and acceleration diagram, for any given configuration of the mechanism.	10	CO2	L4
MODULE 3				
1	Explain undercutting. What are its causes?	5	CO3	L1
2	How do we bring interchangeability of gears?	5	CO3	L1
3	Draw the sketch of a simple epicyclic gear train. Mention its advantages over other type of gear trains.	5	CO3	L1
4	What are the different forms of gear tooth?	3	CO3	L1
5	The number of teeth in the gear shown in the Figure 6 are as follows: TS= 18; TP= 24; TC= 12 and TA=72 P and C forms a compound gear carried by the arm a and the annular gear A is held stationary. Determine the speed of the output at a. Also find the holding torque required on A if 5 kW is delivered to S at 800 rpm with an efficiency of 94%. In case the annulus A rotates at 100 rpm in the same direction as S, what will be the new speed of a?	12	CO3	L3

				
6	What is interference in gears? Discuss its effects. What are the conditions necessary to avoid interference? Explain.	12	CO3	L1
7	A pair of spur gear having 20 and 40 teeth is in mesh. The pinion being driving element rotates at 2000 rpm. Find the sliding velocity between teeth faces (i) At the point of engagement; (ii) At the pitch point; and (iii) At the point of disengagement. Assume the gear teeth are of 20° involute form. Addendum is 5 mm and module is 5 mm. Find also the angle through which pinion turns while one pair of teeth is in contact.	12	CO3	L3
8	A pinion A has 20 teeth and is rigidly fixed to a motor shaft. The wheel B has 25 teeth gears with A and also with a fixed annular wheel D. The pinion C has 20 teeth and it is fixed to the wheel B and gears with annular wheel E which is keyed to the machine shaft. Band C can rotate together on a pin carried by an arm which rotates about the shaft on which A is fixed. Gears A. D and E are co-axial while B and C are compound wheels. If the motor runs at 1000 rpm, find the speed of rotation of the machine shaft.	12	CO3	L3
9	Explain with neat sketches different types of gear train.	7	CO3	L1
10	With neat sketch explain the working of an automotive differential.	7	CO3	L1
11	Two mating spur gears with module of 6.5 mm have 19 and 47 teeth of 20° pressure angle, and 6.5 mm addendum. Determine the number of pairs of teeth in contact and the angle turned through by the larger wheel for one pair of teeth in contact.	12	CO3	L3
12	A 200 involute pinion with 20 teeth drives a gear having 60 teeth. Module is 8mm, addendum of each gear is 10mm. State whether interference occurs or not.	12	CO3	L3
13	How will you choose precision points in synthesis?	5	CO2	L2
14	**What all are the tasks of synthesis of a mechanism? Explain.**	**5**	**CO2**	**L1**
15	Determine the lengths of all the four links in a four bar chain for which the length of the smallest being 10cm, to generate Y= log10 X in the interval $1 \leq x \leq 10$ for three accuracy points. The range of angle of input link and output link are $45° \leq \theta \leq 105^0$ and $135° \leq \phi \leq 225°$.	12	CO2	L3
16	Explain overlay method for kinematic synthesis. What are its applications?	12	CO2	L2
17		12	CO2	L3

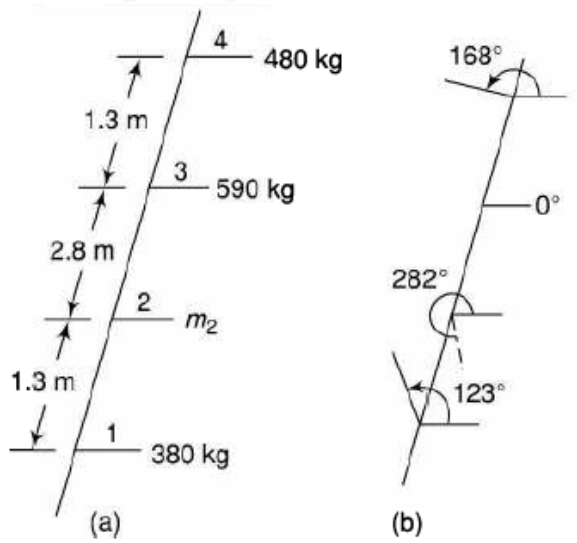
	Determine the proportions of four bar mechanism, by using three precision points, to generate $y= x^{1.5}$, where 'x' varies between 1 and 4. Take $\theta_1 =30^0$, $\Delta\theta= 90^0$, $\phi_1 =90^0$, $\Delta\phi= 90^0$. Take length of the fixed link as 25 mm			
18	**Synthesize a four bar mechanism to guide a rod AB through three consecutive positions A1B1, A2B2 and A3B3 as shown in the figure below.** 	12	CO2	L3
MODULE 4				
1	Explain the principle of virtual work applied in a slider crank mechanism	3	CO4	L1
2	In a four-bar mechanism ABCD the crank AB 5 cm long makes 60° with fixed link AD. Link Be = 7 cm, CD = 9 cm and AD = 10 cm. A force of 8 N at 73.5° acts on BC at a distance of 4 cm from B. Determine the reactive torque on link AB	12	CO4	L3
3	**Explain the static equilibrium conditions of two forces, three forces, two forces and a torque member.**	5	CO4	L1
4	Explain static force analysis by principle of virtual work.		CO4	
4	In a four-bar mechanism ABCD the crank AB = 5 cm long makes 60° with fixed link AD. Link BC = 7 cm, CD = 9 cm and AD = 10 cm. A force of 8 N at 73.5° acts on BC at a distance of 4 cm from B. Determine the reactive torque to be applied on link AB so that the system is in static equilibrium.	12	CO4	L3
	What do you mean by gyroscopic couple? Derive a relation for its magnitude.		CO4	L2
	Explain the gyroscopic effect on four wheeled vehicles.		CO4	L3
	A four wheeled motor car of mass 2 tones has height of C.G of 60 cmm above ground level. The engine parts and transmission are equivalent to flywheel of 80 kg with radius of gyration of 15 cm and their axes coincide with axis of wheel. The car negotiates a curve of 60 cm radius at 72 km/hr with over all gear ratio 4:1. The radius of road wheel is 30 cm and its M.I is 3 kg cm2. Assuming wheel track as 1.5m, weight distribution as 50:50, determine the reaction at each wheel.	12	CO4	L3
5	Explain with an example the static force analysis of a slider crank mechanism in which friction is considered for sliding and revolute pairs.	12	CO4	L2
6	Find the torque required to be applied to link AB of the linkage shown in figure below to maintain static equilibrium. The force F is perpendicular to link CD acting at E. The dimensions of the links are in mm. 	12	CO4	L3

7	The applied load on the piston of an offset slider-crank linkage shown in figure below is 100 N, and the coefficient of friction between the slider and the guide is 0.27, using any method ,determine the magnitude and sense of torque T2 applied on OA for the static equilibrium of the linkage.  	12	CO4	L3
8	Determine the required input torque on the crank of slider crank mechanism for the static force equilibrium when the applied piston load is 1500 N. The length of the crank and connecting rod are 40 mm and 100 mm respectively and the crank has turned through 45^0 from the inner dead centre	12	CO2	L3
9	**Define the terms precession, axis of precession and axis of spinning with suitable figure.**	3	CO4	L1
10	**A slider crank mechanism with the following dimensions is acted upon by a force F=2KN act at B as shown in the figure. OA=100mm. AB=450mm. Determine the input torque T on the link OA for the static equilibrium of the mechanism for the given configuration.**  	12	CO2	L3
11	**An aeroplane flying at 240 km/hr turns towards left and complete a quarter circle of 60 m radius. The mass of the rotary engine and the propeller of the plane amounts to 450 kg with a radius of gyration of 320 mm. The engine speed is 2000 rpm, clockwise when viewed from the rear. Determine the gyroscopic couple on the aircraft and state its effects. In what way is the effect changed when** **(i) Aeroplane turns towards right** **Engine rotates clockwise when viewed from the front (nose end) and aero plane turns left?**	12	CO4	L3
12	**A disc with radius of gyration of 60mm and a mass of 4kg is mounted centrally on a horizontal axle of 80mm length between the bearings. It spins about the axle at 800rpm counter-clockwise when viewed from the right-hand side bearing. The axle precesses about a vertical axis at 50rpm in the clockwise direction when viewed from above. Determine the resultant reaction at each bearing due to the mass and the gyroscopic effect.**	12	CO4	L3
13	**Define the term gyroscopic couple.**	3	CO4	L1

14	*A four-link mechanism with the following dimensions is acted upon by a force 80 ∠150° N on the link DC [Fig. 12.8(a)]:* *AD = 500 mm, AB = 400 mm, BC = 1000 mm, DC = 750 mm, DE = 350 mm* *Determine the input torque T on the link AB for the static equilibrium of the mechanism for the given configuration.*	**12**	**CO2**	**L3**
15	*A slider-crank mechanism with the following dimensions is acted upon by a force F = 2 kN at B as shown in Fig. 12.7(a):* *OA = 100 mm, AB = 450 mm.* *Determine the input torque T on the link OA for the static equilibrium of the mechanism for the given configuration.*	**12**	**CO2**	**L3**
16	The turbine rotor of a ship has a mass of 3500 kg. It has a radius of gyration of 0.45 m and a speed of 3000 r.p.m. clockwise when looking from stern. Determine the gyroscopic couple and its effect upon the ship: 1. when the ship is steering to the left on a curve of 100 m radius at a speed of 36 km/h. 2. when the ship is pitching in a simple harmonic motion, the bow falling with its maximum velocity. The period of pitching is 40 seconds and the total angular displacement between the two extreme positions of pitching is 12 degrees.	12	CO4	L3
17	An aeroplane makes a complete half circle of 50 metres radius, towards left, when flying at 200 km per hr. The rotary engine and the propeller of the plane has a mass of 400 kg and a radius of gyration of 0.3 m. The engine rotates at 2400 r.p.m. clockwise when viewed from the rear. Find the gyroscopic couple on the aircraft and state its effect on it.	12	CO4	L3
18	A four-wheeled trolley car of mass 2500 kg runs on rails, which are 1.5 m apart and travels around a curve of 30 m radius at 24 km / hr. The rails are at the same level. Each wheel of the trolley is 0.75 m in diameter and each of the two axles is driven by a motor running in a direction opposite to that of the wheels at a speed of five times the speed of rotation of the wheels. The moment of inertia of each axle with gear and wheels is 18 kg-m2. Each motor with shaft and gear pinion has a moment of inertia of 12 kg-m2. The centre of gravity of the car is 0.9 m above the rail level. Determine the vertical force exerted by each wheel on the rails taking into consideration the centrifugal and gyroscopic effects. State the centrifugal and gyroscopic effects on the trolley.	12	CO4	L3
MODULE 5				
1	**Differentiate static and dynamic balancing.**	3	CO5	L1
2		3	CO5	L2

	Explain the steps in the dynamic force analysis of a four bar mechanism.			
3	**Explain the need of balancing?**		CO5	L1
4	**Explain partial balancing in reciprocating engines?**		CO5	L1
5	Derive an expression for maximum swaying couple.	5	CO5	L2
6	With a neat sketch briefly describe the working of cradle type balancing machine.	5	CO5	L1
7	Four masses A, B, C, D are completely balanced. Masses C & D make angles of 900 and 1950 respectively with that of mass B in CCW direction. The rotating mass have following properties:- mB =25 kg, mC = 40kg, mD = 35 kg rA= 150 mm, rB = 200 mm, rC = 100 mm, rD = 180 mm. Planes B and C are 250mm apart. Find: (1) mass A and its angular position with that of mass B. (2) Positions of all the planes relative to the plane of mass A	12	CO5	L3
8	Single cylinder vertical engine has a bore of 45 mm and a stroke of 50 mm has a connecting rod of 150 mm long. The mass of reciprocating parts is 80 kg. The engine runs at a speed of 2000 rpm. On the expansion stroke with a crank at 20^{o} from the TDC, gas pressure is 700 kN/mm2. Determine (a) net force acting on the piston, (b) resultant load on the gudgeon pin (c) thrust on the cylinder walls	12	CO5	L3
9	A shaft carries four masses A, B, C and D which are placed in parallel planes perpendicular to the longitudinal axis. The unbalanced masses at planes B and C are 3.6 kg and 2.6kg respectively and both are assumed to be concentrated at a radius of 25mm while the masses in planed A and D are both at a radius of 40mm.The angle between the planes B and C is 100° and that between B and A is 190°, both angles being measured in counter clock wise direction from the plane B .The planes containing A and B are 250mm apart and those containing B and C are 500mm.If the shaft is to be completely balanced ,determine i.) Masses at the planes A and D, ii.) the distance between the planes C and D iii) the angular position of the mass D.	12	CO5	L3
10	A five cylinder in-line engine running at 750 r.p.m. has successive cranks 144° apart, the distance between the cylinder centre lines being 375 mm. The piston stroke is 225mm and the ratio of the connecting rod to the crank is 4. Examine the engine for balance of primary and secondary forces and couples. Find the maximum values of these and the position of the central crank at which these maximum values occur. The reciprocating mass for each cylinder is 15 kg.	12	CO5	L3

11	*The following data refer to a two-cylinder uncoupled locomotive:* *Rotating mass per cylinder = 280 kg* *Reciprocating mass per cylinder = 300 kg* *Distance between wheels = 1400 mm* *Distance between cylinder centres = 600 mm* *Diameter of treads of driving wheels = 1800 mm* *Crank radius = 300 mm]* *Radius of centre of balance mass = 620 mm* *Locomotive speed = 50 km/hr* *Angle between cylinder cranks = 90°* *Dead load on each wheel = 3.5 tonne* *Determine the* *(i) balancing mass required in the planes of driving wheels if whole of the revolving and two-third of the reciprocating mass are to be balanced* *(ii) swaying couple* *(iii) variation in the tractive force* *(iv) maximum and minimum pressure on the rails* *(v) maximum speed of locomotive without lifting the wheels from the rails*	12	CO5	L3
12	*The following data refer to a four-coupled wheel locomotive with two inside cylinders:* *Pitch of cylinders = 600 mm* *Reciprocating mass/cylinder = 315 kg* *Revolving mass/cylinder = 260 kg* *Distance between driving wheels = 1.6 m* *Distance between coupling rods = 2 m* *Diameter of driving wheels = 1.9 m* *Revolving parts for each coupling rod crank = 130 kg* *Engine crank radius = 300 mm* *Coupling rod crank radius = 240 mm* *Distance of centre of balance mass in planes of Driving wheels from axle centre = 750 mm* *Angle between engine cranks = 90°* *Angle between coupling rod crank with adjacent engine crank = 180°*	12	CO5	L3

13	*A four-cylinder oil engine is in complete primary balance. The arrangement of the reciprocating masses in different planes The stroke of each piston is 2r mm. Determine the reciprocating mass of the cylinder 2 and the relative crank positions.*  	12	CO5	L3
14	*Each crank and the connecting rod of a four-crank in-line engine are 200 mm and 800 mm respectively. The outer cranks are set at 120° to each other and each has a reciprocating mass of 200 kg. The spacing between adjacent planes of cranks are 400 mm, 600 mm and 500 mm. If the engine is in complete primary balance, determine the reciprocating masses of the inner cranks and their relative angular positions. Also find the secondary unbalanced force if the engine speed is 210 rpm.*	12	CO5	L3

15	*The cylinder axes of a V-engine are at right angles to each other. The weight of each piston is 2 kg and of each connecting rod is 2.8 kg. The weight of the rotating parts like crank webs and the crank pin is 1.8 kg. The connecting rod is 400 mm long and its centre of mass is 100 mm from the crank-pin centre. The stroke of the piston is 160 mm. Show that the engine can be balanced for the revolving and the primary force by a revolving countermass. Also, find the magnitude and the position if its centre of mass from the crankshaft centre is 100 mm.* *What is the value of the resultant secondary force if the speed is 840 rpm?*	12	CO5	L3
16	*The cylinders of a twin V-engine are set at 60° angle with both pistons connected to a single crank through their respective connecting rods. Each connecting rod is 600 mm long and the crank radius is 120 mm. The total rotating mass is equivalent to 2 kg at the crank radius and the reciprocating mass is 1.2 kg per piston. A balance mass is also fitted opposite to the crank equivalent to 2.2 kg at a radius of 150 mm. Determine the maximum and minimum values of the primary and secondary forces due to inertia of the reciprocating and the rotating masses if the engine speed is 800 rpm.*	12	CO5	L3
17	*The stroke of each piston of a six-cylinder two-stroke in-line engine is 320 mm and the connecting rod is 800 mm long. The cylinder centre lines are spaced at 500 mm. The cranks are at 60° apart and the firing order is 145236. The reciprocating mass per cylinder is 100 kg and the rotating parts are 50 kg per crank. Determine the out-of-balance forces and couples about the mid plane if the engine rotates at 200 rpm.*	12	CO5	L3

Prepared By : Jibin Jose, Course Faculty

Checked By : Nisha B Nair, Subject Group Coordinator

Approved by : Dr. Ramadas T, HoD (ME)

Course Code & Name: MET303 Thermal Engineering

1. Prescribed Syllabus

Module	Topic	Hours
1	Steam engineering- Rankine cycle, Modified Rankine cycle, Relative efficiency, Improvement in steam cycles-Reheat, Regenerative and Binary vapour cycle. Steam Boilers: Types of boilers, Cochran boiler, Babcock and Wilcox boiler, Benson boiler, La Mont boiler, Loeffler boiler, Velox boiler, Boiler Mountings and Accessories. Steam nozzles: -Types of nozzle, Velocity of steam, mass flow rate, critical pressure ratio and its significance, effect of friction, super saturated flow.	9
2	Steam turbines: classification, compounding of turbines-pressure velocity variation, velocity diagrams, work done, efficiency, condition for maximum efficiency, multistage turbines condition line, stage efficiency. Steam turbine performance-reheat factor, degree of reaction, cycles with reheating and regenerative heating, governing of turbines.	9
3	Actual cycle analysis of IC engines- Deviation of actual engine cycle from ideal cycle, variable specific heats. Rotary engines, Stratified charge engine, Super charging and turbo charging. Performance Testing of I C Engines- Indicator diagram, mean effective pressure. Torque, Engine power- BHP, IHP. Engine efficiency, mechanical efficiency, volumetric efficiency, thermal efficiency, relative efficiency and Specific fuel consumption. Morse test, Heat balance test and Retardation test.	9
4	Combustion in I.C. Engines- Analysis of fuel combustion-A/F ratio, equivalence ratio, excess air. Combustion phenomena in S.I. engines; Ignition limits, stages of combustion in S.I. Engines, Ignition lag, velocity of flame propagation, auto ignition, detonation; effects of engine variables on detonation; theories of detonation, octane rating of fuels; pre-ignition; S.I. engine combustion chambers. Combustion in C.I. Engines; delay period; variables affecting delay period; knock in C.I. engines, Cetane rating; C.I. engine combustion chambers. Air pollution from I.C. Engine and its control: Pollutants from S.I. and C.I. Engines, Methods of emission control.	9
5	Refrigeration– Reversed Carnot cycle, Air refrigeration system-Reversed Joule cycle. Vapour compression systems-simple cycle - representation on T- s and P- h Diagrams. Effect of operating parameters on COP, Methods of improving COP of simple cycle, Super heating and under cooling. Psychometric properties – specific humidity, relative humidity and degree of saturation, thermodynamic equations, enthalpy of moisture, DBT, WBT and DPT, psychrometers, psychometric chart. Psychometric processes-adiabatic mixing, sensible heating and cooling, humidifying and	9

	dehumidifying, air washer, bypass factor, sensible heat factor, Comfort and industrial air conditioning, Comfort air conditioning-factors affecting human comfort, Effective temperature, comfort chart, Summer air conditioning, factors affecting, cooling load estimation.	

2. Text Books (T)

T1. Rudramoorthy , Thermal Engineering, McGraw Hill Education India, 2003.
T2. R.K Rajput, Thermal Engineering, Laxmi publications, 2010.
T3. Arora C. P, Refrigeration and Air-Conditioning, McGraw-Hill, 2008.
T4. Arora S. C. and Domkundwar, Refrigeration and Air-Conditioning, Dhanpat Rai, 2010.

3. Reference Books (R)

R1. V. Ganesan, Fundamentals of IC engines, Tata McGraw-Hill, 2002.
R2. J.B.Heywood, I.C engine fundamentals. McGraw-Hill, 2011.
R3. Rathore, Thermal Engineering, McGraw Hill Education India, 2010.
R4. Dossat. R. J, Principles of Refrigeration, Pearson Education India, 2002.
R5. Stoecker W.F, Refrigeration and Air-Conditioning, McGraw-Hill Publishing Company, 2009.

4. Course Objectives

This course involve the application of principles studied in thermodynamics to different energy conversion systems like steam turbine, steam nozzle, steam powerplant, IC engines and refrigeration systems. This course also covers the methods for improving and evaluating the performance of different energy conversion systems. This course also helps to understand the combustion phenomenon in IC engines.

5. Course Pre / Co-requisite

MET202 ENGINEERING THERMODYNAMICS

6. Course Outcomes

After completion of the course, student will be able to

CO1: Explain the working of steam power cycle and related components
CO2: Discuss the working of steam turbines and methods for evaluating the performance
CO3: Illustrate the performance testing and evaluation of IC engines
CO4: Explain the combustion phenomenon and pollution in IC engines
CO5: Discuss the principles of refrigeration and air-conditioning and basic design considerations

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	H	H	M												
CO2	H	H	M												M
CO3	H	H	M												
CO4	H	H	M												
CO5	H	H	M												M

8. Justification for CO-PO-PSO Correlation

CO	PO / PSO	Justification
CO1	PO1	Analytical knowledge of steam power cycle and related components will empower the student to solve complex engineering problems related to the same.
	PO2	By explaining the working of steam power cycle and related components the student will be able to identify, formulate, review research literature, and analyze complex engineering problems
	PO3	By gaining knowledge about steam power plants the student will be able to design solutions for complex engineering problems and design system, components or processes that meet the specified needs with appropriate consideration for the societal, and environmental considerations.
CO2	PO1	Analytical knowledge of performance of steam power cycles will empower the student to solve complex engineering problems.
	PO2	By discussing the working of steam turbines and methods for evaluating the performance the student will be able to identify, formulate, review research literature, and analyze complex engineering problems
	PO3	By gaining knowledge about steam power plant performance evaluation methods, the student will be able to design solutions for complex engineering problems and design system, components or processes that meet the specified needs with appropriate consideration for the societal, and environmental considerations.
	PSO3	By gaining knowledge students will be able to design and analyse multidisciplinary systems related to improving the performance of steam power plants.
CO3	PO1	Analytical knowledge of performance of I.C. engines will empower the student to solve complex engineering problems.
	PO2	By illustrating the performance testing and evaluation of IC engines the student will be able to identify, formulate, review research literature, and analyze complex engineering problems

	PO3	By gaining knowledge about I. C. engine performance evaluation methods, the student will be able to design solutions for complex engineering problems and design system, components or processes that meet the specified needs with appropriate consideration for the societal, and environmental considerations.
CO4	**PO1**	Knowledge of the combustion phenomenon and pollution in IC engines will empower the student to solve complex engineering problems especially improving the performance and emissions.
	PO2	By explaining the combustion phenomenon and pollution in IC engines, the student will be able to identify, formulate, review research literature, and analyze complex engineering problems
	PO3	By gaining knowledge about combustion phenomenon and pollution in IC engines, the student will be able to design solutions for complex engineering problems and design system, components or processes that meet the specified needs with appropriate consideration for the societal, and environmental considerations especially the environmental part.
CO5	**PO1**	Analytical knowledge of refrigeration and Air conditioning systems will empower the student to solve complex engineering problems.
	PO2	By discussing the principles of refrigeration and air-conditioning and basic design considerations the student will be able to identify, formulate, review research literature, and analyze complex engineering problems
	PO3	By gaining knowledge about refrigeration and Air conditioning systems, the student will be able to design solutions for complex engineering problems and design system, components or processes that meet the specified needs with appropriate consideration for the societal, and environmental considerations.
	PSO3	By gaining knowledge of ARC systems and its design considerations, students will be able to design and analyse multi-disciplinary systems related to improving the performance of steam power plants.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1.	Visit to thermal engineering lab	Live demo on IC Engines, and refrigeration and air conditioning systems	PO1, PO2

11. Internal Assessment mark allocation (as per university curriculum)

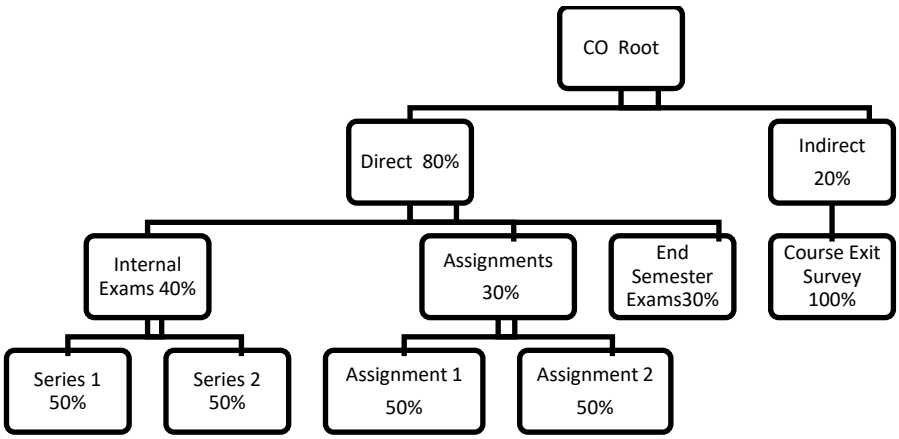
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		Weightage#	CO1	CO2	CO3	CO4	CO5
Direct Assessment Tools	Internal Exam(s) 40%	Series 1	20%	x	x	x		
		Series 2	20%			x	x	x
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x	x			
		Assignment 2	15%			x	x	x
	End Semester Exam		30%	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hour	Topic	Mod.	Reference(s)	Teaching Pedagogy
1	Introduction to Thermal Engineering	1	R.K Rajput, Thermal Engineering	Lecture
2	Steam engineering- Rankine cycle	1	R.K Rajput, Thermal Engineering	Lecture
3	Steam engineering- Rankine cycle,	1	R.K Rajput, Thermal Engineering	Lecture
4	Modified Rankine cycle, Relative efficiency	1	R.K Rajput, Thermal Engineering	Tutorial
5	Improvement in steam cycles- Reheat, Regenerative	1	R.K Rajput, Thermal Engineering	Lecture
6	Problems on Rankine cycle	1	R.K Rajput, Thermal Engineering	Lecture
7	Binary vapor cycle	1	R.K Rajput, Thermal Engineering	Lecture
8	Boiler Mountings and Accessories	1	R.K Rajput, Thermal Engineering	Tutorial
9	Steam nozzles:-Types of nozzle- Velocity of steam	1	R.K Rajput, Thermal Engineering	Lecture
10	mass flow rate, critical pressure ratio and its significance	1	R.K Rajput, Thermal Engineering	Lecture
11	mass flow rate, critical pressure ratio and its significance	1	R.K Rajput, Thermal Engineering	Lecture
12	effect of friction, super saturated flow.	1	R.K Rajput,	Remedial

			Thermal Engineering	
13	Steam turbines: classification	2	R.K Rajput, Thermal Engineering	Lecture
14	compounding of turbines-pressure	2	R.K Rajput, Thermal Engineering	Lecture
15	velocity variation, velocity diagrams	2	R.K Rajput, Thermal Engineering	Lecture
16	Velocity diagram	2	R.K Rajput, Thermal Engineering	Tutorial
17	Work done, efficiency, condition for maximum efficiency,	2	R.K Rajput, Thermal Engineering	Lecture
18	multistage turbines-condition line, stage efficiency	2	R.K Rajput, Thermal Engineering	Lecture
19	Steam turbine performance-reheat factor, degree of reaction	2	R.K Rajput, Thermal Engineering	Lecture
20	cycles with reheating and regenerative heating	2	R.K Rajput, Thermal Engineering	Tutorial
21	governing of turbines	2	R.K Rajput, Thermal Engineering	Remedial
22	Actual cycle analysis of IC engines- Deviation of actual engine cycle from ideal cycle,	3	R.K Rajput, Thermal Engineering	Lecture
23	variable specific heats.	3	R.K Rajput, Thermal Engineering	Lecture
24	Stratified charge engine, Super charging and turbo charging.	3	R.K Rajput, Thermal Engineering	Remedial

25	Performance Testing of I C Engines- Indicator diagram, mean effective pressure.	3	R.K Rajput, Thermal Engineering	Lecture
26	Torque, Engine power- BHP, IHP. Engine efficiency, mechanical efficiency, volumetric efficiency, thermal efficiency and relative efficiency, Specific fuel consumption.	3	R.K Rajput, Thermal Engineering	Lecture
27	Morse test, Heat balance test	3	R.K Rajput, Thermal Engineering	Lecture
28	Morse test, Heat balance test	3	R.K Rajput, Thermal Engineering	Tutorial
29	Combustion in I.C. Engines- Analysis of fuel combustion- A/F ratio, equivalence ratio, excess air.	4	R.K Rajput, Thermal Engineering	Lecture
30	Combustion phenomena in S.I. engines; Ignition limits, stages of combustion in S.I. Engines,	4	R.K Rajput, Thermal Engineering	Lecture
31	Ignition lag, velocity of flame propagation, auto ignition, detonation;	4	R.K Rajput, Thermal Engineering	Lecture
32	effects of engine variables on detonation; theories of	4	R.K Rajput, Thermal Engineering	Tutorial
	detonation, octane rating of fuels			
33	preignition; S.I. engine combustion chambers.	4	R.K Rajput, Thermal Engineering	Lecture

34	Combustion in C.I. Engines; delay period; variables affecting delay period	4	R.K Rajput, Thermal Engineering	Remedial
35	Air refrigeration system- Reversed Joule cycle.	5	R.K Rajput, Thermal Engineering	Lecture
36	Vapour compression systems simple cycle - representation on T- s and P- h Diagrams.	5	R.K Rajput, Thermal Engineering	Tutorial
37	Effect of operating parameters on COP, Methods of improving COP of simple cycle	5	R.K Rajput, Thermal Engineering	Lecture
38	Super heating and under cooling.	5	R.K Rajput, Thermal Engineering	Lecture
39	Psychometric properties and Psychometric properties	5	R.K Rajput, Thermal Engineering	Lecture
40	Psychometric processes- adiabatic mixing, sensible heating and cooling,	5	R.K Rajput, Thermal Engineering	Tutorial
41	humidifying and dehumidifying, air washer, bypass factor, sensible heat factor.	5	R.K Rajput, Thermal Engineering	Lecture
42	Comfort and industrial air conditioning, Comfort air conditioning factors affecting human comfort	5	R.K Rajput, Thermal Engineering	Lecture
43	Effective temperature, comfort chart, Summer air conditioning,	5	R.K Rajput, Thermal Engineering	Lecture
44	factors affecting, cooling load estimation.	5	R.K Rajput, Thermal Engineering	Tutorial

45	Problems in refrigeration	5	R.K Rajput, Thermal Engineering	Remedial

15. Question Bank

Module 1				
Sl. No.	Question	Marks	CO	BL
1	Draw a simple layout showing the four basic components in a steam power.	3	CO1	L2
2	Give the classification of boilers based on any three criteria and give one example for each type.	3	CO1	L1
3	List one advantage and one disadvantage of the reheat cycle and of the regenerative cycle.	3	CO1	L1
4	Define Nozzle efficiency and explain the effect of friction on Nozzle efficiency.	3	CO1	L1
5	Draw the T-S diagram of a reheat cycle. Mention two advantages of the reheat cycle.	3	CO1	L2
6	What is a binary vapour power cycle? Give one example.	3	CO1	L2
7	With neat sketch explain the working of La Mont Boiler	7	CO1	L2
8	Explain the state of Plane stress condition with appropriate sketches.	**3**	**CO1**	**L2**
9	Derive the expression for mass flow rate of steam through a nozzle and obtain the condition for maximum discharge.	7	CO1	L3
10	In an ideal Rankine cycle saturated vapor enters the turbine at 80 bar and saturated liquid exits the condenser at a pressure of 0.08 bar. The net power output of the cycle is 100 MW. The turbine have an isentropic efficiency of 85%. Pump work can be neglected. Determine for the cycle (i) the thermal efficiency, (ii) the mass flow rate of the steam, and (iii) the rate of heat transfer into the working fluid as it passes through the boiler.	7	CO1	L3
11	With the help of a figure explain the working of Babcock and Wilcox boiler	7	CO1	L2
12	Dry saturated steam enters a frictionless adiabatic nozzle with negligible velocity at a temperature of 300 °C. It is then expanded to a pressure of 40 bar. For a mass flow rate of 4 kg/s,	7	CO1	L3
13	Explain regenerative cycle with help of T-s diagram	7	CO1	L2
14	With the help of a figure explain the working of a Velox boiler and mention its merits and demerits over other high pressure boilers.	7	CO1	L2
15	Derive the expression for critical pressure ratio of flow of steam through nozzle.	7	CO1	L3

16	An ideal regenerative steam cycle operates with the steam entering the turbine at 30 bar and 500 °C and is exhausted at 0.1 bar. A feed water heater is used, which operates at 5 bar. Calculate (a) the thermal efficiency, (b) specific steam consumption and (c) average temperature of heat addition. Compare these to an ideal Rankine cycle operates between same conditions.	14	CO1	L3

Module 2

Sl. No.	Question	**Marks**	**CO**	**BL**
1	Define the degree of reaction for a steam turbine.	3	CO2	L1
2	Define reheat factor for multistage expansion in turbines and name three factors on which its value depends.	3	CO2	L1
3	What is degree of reaction and what is its value for an impulse turbine?	3	CO2	L1
4	Define the following as related to steam turbine. a)Speed ratio b)Stage efficiency c)Diagram efficiency	3	CO2	L1
5	Differentiate between impulse and reaction steam turbines.	3	CO2	L2
6	Explain velocity compounding of steam turbines.	3	CO2	L2
7	The steam is supplied to an impulse turbine at a velocity of 1000 m/s at an angle of 20o. The blade velocity is 300 m/s and the blades are symmetrical. The mass flow rate of steam is 0.5 kg/s. Allowing a friction factor of 0.8 , determine (i) Blade efficiency (ii) Power developed (iii) Stage efficiency, if the nozzle efficiency is 95%.	7	CO2	L3
8	With necessary diagrams explain the difference between velocity and pressure compounding in steam turbines.	7	CO2	**L2**
9	Draw the velocity triangle for a 50% reaction turbine and derive the expressions for work done and blade efficiency.	7	CO2	**L2**
10	What is the purpose of governing of steam turbine? Explain any one method of governing.	7	CO2	**L2**
11	A Parsons reaction turbine running at 500rpm with 50% reaction develops 100 KW per kg of the steam. The exit angle of the blade is 20 degree and the steam velocity at inlet is 1.5 times blade velocity. Determine (i) Blade velocity (ii) Blade inlet angle	7	CO2	**L3**
12	What is reheat factor and explain why its value is always greater than 1?	7	CO2	**L3**
13	The velocity of steam leaving nozzles of an impulse turbine is 1000 m/s and the nozzle angle is 20º . Blade velocity is 400 m/s and blade velocity coefficient is 0.8. Calculate for a mass flow rate of 1 kg/s and symmetrical blading, (i) The blade inlet angle	7	CO2	**L3**

	(ii) Driving force on wheel (iii) The axial thrust (iv) Diagram power (v) Diagram efficiency			
14	With the help of figures explain throttle governing, nozzle governing and by-pass governing.	9	CO2	L2
15	Explain degree of reaction of a steam turbine and derive an expression for it.	5	CO2	L2
16	In an impulse turbine, the mean diameter of the blades is 1.05 m and the speed is 3000 rpm. The nozzle angle is 18°, speed ratio is 0.42, and the friction factor is 0.84. The outlet blade angle is to be made 3° less than the inlet angle. The steam flow is 10 kg/s. Draw the velocity diagrams for the blades and calculate (a) the tangential thrust, (b) the axial thrust, (c) the resultant thrust, (d) the power developed, and (e) the blade efficiency.	14	CO2	L3

Module 3

Sl. No.	Question	**Marks**	**CO**	**BL**
1	Define Brake thermal efficiency and volumetric efficiency of an IC Engine	3	CO3	L1
2	What are the advantages of stratified charge engine?	3	CO3	L1
3	Differentiate between supercharging and turbo charging	3	CO3	L2
4	What is meant by specific fuel consumption?	3	CO3	L1
5	What is air standard cycle and why does the fuel air cycle differ from the air standard cycle? List any two reasons.	3	CO3	L1
6	Explain the procedure for conducting a retardation test.	3	CO3	L2
7	What is supercharging? What are the effects of supercharging the engine?	7	CO3	L2
8	A six cylinder gasoline engine operates on the four stroke cycle. The bore of each cylinder is 80 mm and the stroke 100 mm. At a speed of 4000 rpm the fuel consumption is 20 kg/hr and the torque developed is 150 Nm. Calculate (i) the brake power (ii) the brake mean effective pressure (iii) brake thermal efficiency if the calorific value of the fuel is 43000 kJ/kg	7	CO3	L3
9	Explain the procedure of Morse test to find out the Friction power of the Engine.	7	CO3	L2
10	A six cylinder, four stroke Diesel engine develops 150 KW at 2000 rpm. It's brake specific fuel consumption is 300 gm/kWh. Calculate the quantity of fuel to be injected per cycle per cylinder. Specific gravity of the fuel is 0.85	7	CO3	L3
11	How can we find the frictional power of a single cylinder engine?	7	CO3	L2

12	The following observations were made during a trial of a single – cylinder, four-stroke cycle gas engine having cylinder diameter of 18 cm and stroke 24 cm:, Speed of engine is 500 rpm, Mean effective pressure = 5 bar, Net load on the brake wheel = 40 kg, Effective diameter of brake wheel = 1 m, Brake specific fuel consumption = 300 g/kWh, Calorific value of fuel at NTP = 30 MJ/kg. Estimate the mechanical and brake thermal efficiencies of the engine.	7	CO3	L3
13	Briefly explain the following: (i) time loss factor (ii) heat loss factor (iii) exhaust blow down factor	7	CO3	L2
14	Explain the concept of stratified charge engines and methods for charge stratification. Mention its advantages.	7	CO3	L2
15	A four-cylinder gasoline engine works on four strokes develops a brake power of 20.9 kW. A morse test was conducted on the engine and brake power obtained when each cylinder made inoperative by short circuiting the spark plug are 14.9, 14.3, 14.8 and 14.5 kW respectively. Find the indicated power, friction power and mechanical efficiency when all cylinders are firing?	7	CO3	L3
16	The following observations were made during a trial of a single cylinder 4 stroke diesel engine. Cylinder diameter = 20 cm, Stroke = 40 cm, mean effective pressure 6 bar, torque = 407 Nm, Speed = 250 rpm, fuel consumption = 4 kg/h, Calorific value of the fuel = 43 MJ/kg, cooling water flow rate = 4.5 kg/min, Air used per kg of fuel = 30 kg, rise in cooling water temperature = 45 oC, Temperature of exhaust gas = 420 0C, room temperature = 20 0C, specific heat of exhaust gas = 1 kJ/kg K and specific heat of water = 4.18 kJ/kgK. Find mechanical efficiency, brake thermal efficiency, specific fuel consumption and prepare the heat balance sheet in KJ/hr.	14	CO3	L3
Module 4				
Sl. No.	Question	**Marks**	**CO**	**BL**
1	What is the equivalence ratio of combustion and what is its significance?	3	CO4	L2
2	What do you mean by Cetane number?	3	CO4	L2
3	Explain equivalence ratio and its significance in IC engine combustion	3	CO4	L2
4	Explain the effects of any three variables on detonation in SI Engines	3	CO4	L2
5	Define stoichiometric ratio, equivalence ratio and excess air.	3	CO4	L1
6	Enumerate the difference between Petrol knock and diesel knock.	3	CO4	L1

7	The petrol used in SI engine is assumed to have a chemical formula C7H16. Determine (a) the stoichiometric air fuel ratio (b) If 50% excess air is supplied, and then find the volumetric composition of the dry exhaust products. Air contains 23%	7	CO4	L3
8	Explain the different stages of combustion in SI Engine with the help of a Pressure - crank angle diagram.	7	CO4	L2
9	What is meant by delay period? Discuss the factors that affect the delay period in a C.I. engine.	7	CO4	L2
10	Discuss any two emission control methods employed in reducing the emission in CI Engine	7	CO4	L2
11	Make a comparison of knock in SI engine and CI Engine	7	CO4	L2
12	What is Cetane number? Explain how C.I. engine fuels are rated .	7	CO4	L2
13	Name the stages of combustion in a S.I. engine and explain with the aid of a pressure – crank angle diagram.	7	CO4	L2
14	List any four emission control method used in I.C. engines and explain any one.	7	CO4	L2
15	With help of a p-θ diagram explain stages of CI engine combustion.	7	CO4	L2
16	What are the requirements of SI engine combustion chamber? With help of figure explain different types of SI engine combustion chamber designs.	7	CO4	L2
17	How is the Octane number of a fuel determined?	7	CO4	L2

Module 5

Sl. No.	Question	**Marks**	**CO**	**BL**
1	Why reversed Carnot cycle is practically impossible to execute?	3	CO5	L2
2	List the basic psychrometric processes in air conditioning and represent all the processes in the Psychometric chart.	3	CO5	L1
3	Explain DBT,WBT and DPT	3	CO5	L2
4	Explain the working of vapour compression refrigeration system with aid of T-s or P-h diagram	3	CO5	L2
5	With help of a figure explain air refrigeration cycle.	3	CO5	L2
6	Explain Bypass factor, Absolute humidity and relative humidity.	3	CO5	L2
7	What is the effect of following operating conditions on the performance of a vapour compression refrigeration system (i) lowering the evaporator pressure (ii) Subcooling of the liquid refrigerant?	7	CO5	L3
8	An ideal vapour compression system uses R-12 as the refrigerant. The system uses an evaporation temperature of 0oC and a condenser temperature of 40oC. The capacity of the system is 7 TR. Determine (i) the mass flow rate of refrigerant (ii) power required to run the compressor (iii) heat rejected in the condenser	7	CO5	L3

	(iv) COP of the system. Take Cp for superheated vapour as 0.6 kJ/kg.			
9	Define (i) Effective temperature (ii) Sensible heat factor	4	CO5	L2
10	A Carnot refrigeration cycle absorbs heat at 300 K and rejects it at 600 K. (i) Calculate the coefficient of performance of this refrigeration cycle. (ii) If the cycle is absorbing 1000 kJ/min at 300 K, how many kJ of work is required per minute? (iii)If the work required is 500 kJ/min, what is the temperature of heat rejection if the temperature of heat absorption and heat absorbed remains same (iv) An inventor claims that the cycle is absorbing 2000 kJ/min with the same power input and temperature limits as of question (ii).Is this possible? Explain with reasons.	7	CO5	L3
11	Write any six factors that affects the human comfort	7	CO5	L2
12	Explain the effect of the following factors on COP of vapour compression refrigeration system with the help of T-s diagram and P-h diagram : (i) Subcooling (ii) Superheating (iii) Condenser pressure (iv) Evaporator pressure	7	CO5	L2
13	Show four psychrometric processes on a psychrometric chart	7	CO5	L2
14	A food storage locker requires a refrigeration system of 42 kW capacity at an evaporator temperature of −5°C and a condenser temperature of 40°C. The refrigerant, R-12, is sub-cooled by	14	CO5	L3
15	The atmospheric air at 30 °C DBT and 70% RH enters a cooling coil at the rate of 220 m3/min. The coil DPT = 15 °C and its Bypass Factor = 0.15. Determine (a) the temperature of air leaving the cooling coil, (b) the capacity of the cooling coil in TR, (c) the amount of water vapour removed per minute, and sensible heat factor for the process.	7	CO5	L3

Prepared By : Prof. Jobin Jose (Subject Faculty)

Checked By : Prof. Asha K R (Subject Group Coordinator)

Approved By : Dr. Ramadas (HoD-ME)

Course Code & Name: MET 305 INDUSTRIAL AND SYSTEMS ENGINEERING

1. Prescribed Syllabus

Module	Topic	Hours
1	Introduction to Industrial Engineering - Evolution of modern Concepts in Industrial Engineering - Functions of Industrial Engineering - Field of application of Industrial Engineering - Design function - Objectives of design- Development of designs- prototype, production and testing - Human factors in design - Principles of good product design- tolerance design- quality and cost considerations- product life cycle- standardization, simplification, diversification- concurrent engineering- comparison of production alternatives - Economic aspects- C-V-P analysis – simple problems	**8**
2	Introduction to materials management – objectives – Types of material handling equipments - principles of material handling – Material selection – value analysis – make or buy decisions Purchasing and procedures. Basic inventory management - Inventory -Functions,	**6**
3	Industrial relations- Psychological attitudes to work and working conditions - fatigue- Methods of eliminating fatigue- Effect of Communication in Industry- Industrial safety-personal protective devices-, causes and effects of industrial disputes- Collective bargaining- Trade union - Workers participation in management. Module 4 (7 Hours)	**7**
4	Principles of Lean Manufacturing(LM) – Basic elements of LM– Introduction to LM Tools- Conventional Manufacturing versus Lean Manufacturing - Need for LM. Agile manufacturing - Definition, business need, conceptual frame work, characteristics, and generic features	**7**
5	Introduction of enterprise resource planning (ERP)- Concept of Enterprise, ERP Overview - Integrated information system - Myths about ERP – Evolution of ERP- Benefits of ERP implementation - Success and failure factors of ERP implementation - Small, medium and large enterprise vendor solutions- ERP and related technology: Business intelligence (BI), E-Commerce and E-Business, Business Process Reengineering (BPR), Data warehousing, Data mining, Online Analytical Processing(OLAP), Product lifecycle management(PLC), Supply chain management(SCM), Customer relationship management (CRM)- ERP implementation challenges - Emerging trends on ERP	**6**

2. Text Books (T)

T1. Martand T. Telsang, “Industrial Engineering & Production Management”, S. ChandandCompany Limited, 2018.
T2. M. Mahajan, “Industrial Engineering & Production Management”, Dhanpat Rai &Co. (P)Limited, 2015.
T3. Alexis Leon, “ERP Demystified”, Tata McGraw Hill Education Private Limited, NewDelhi, 2008.

3. Reference Books (R)

R1. Kjell Zandin and Harold Maynard, “Maynard's Industrial Engineering Handbook”, McGraw-Hill Education, 2001.
R2. Philips E. Hicks, “Industrial Engineering and Management – A new perspective”, McGraw Hill International Editions, New York, 1994
R3. B. Kumar “Industrial Engineering and Management “, Khanna Publishers,2013.
R4. S.R. Devadasan, V. Mohan Sivakumar, R. Murugesh and PR Shalij, “Lean and AgileManufacturing: Theoretical, Practical

4. Course Objectives

To facilitate the students to acquire knowledge about management principles and practices of an industry

5. Course Pre / Co-requisite

NIL

6. Course Outcomes

After completion of the course, student will be able to
CO1: CO1 Implement various tools and techniques in industrial engineering
CO 2 Calculate the inventory system for a given requirement
CO 3 Explain the importance of industrial relations
CO 4 Select the lean manufacturing tools to find and eliminate wastes
CO 5 Identify the framework of agile manufacturing
CO 6 Identify core and extended modules of enterprise resource planning.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO 3
CO1	M				M				M		M	M		M	M
CO2	H			M						M	M	M			M
CO3						L			M	M	L	M		M	M
CO4	M	L		M	L						M	M			M
CO5				M	L				M		M	M		M	M
CO6	M				H						M	M			M

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	**PO1**	Knowledge of various techniques used in Industrial Engineering can be used.
	PO5	Knowledge of various techniques used in Industrial Engineering can be utilised for solving complex activities of design and manufacturing process used in industries.
	PO9	The students will be able to interact with experts with in team members.
	PO11	Information's of various techniques and tools used in Industrial Engineering can be used effectively for project management and finance.
	PO12	Lifelong learning can be achieved with the knowledge of various techniques used in Industrial Engineering
	PSO2	Students will be able to maintain ethical attitude in industry.
CO2	**PO1**	Students will be able to calculate inventory system for effective utilisation of resources
	PO4	The student will be able to find solutions for complex engineering problems considering the society from the inventory system knowledge.
	PO10	Knowledge of inventory will be used to communicate effectively for solving complex activities.
	PO12	Lifelong learning can be achieved with the knowledge of inventory system.
	PO11	Information's of inventory system used in Industrial Engineering can be used effectively for project management and finance.
	PSO2	Students will be able to maintain ethical attitude in industry
CO3	**PO6**	Importance of Industrial relation will be utilised in solving issues and consequent response relevant to professional engineering practise
	PO9	The students will be able to interact with experts with in team members.
	PO10	Importance of Industrial Relations will be used to communicate effectively for solving complex activities.

	PO11	Importance of Industrial Relations can be used effectively for project management and finance.
	PO12	Lifelong learning can be achieved with by knowing the importance of importance of industrial relation.
	PSO2	Students will be able to maintain ethical attitude in industry
CO4	**PO1**	Knowledge of lean manufacturing, its tools will be used in eliminating waste and thus solution can be obtained to engineering problems.
	PO2	Tools of lean manufacturing will be used to analyse problems and will be utilised to attain conclusions.
	PO4	Knowledge of lean manufacturing will be used to solve complex problem.
	PO5	lean manufacturing tools will be used to find and eliminate wastes in industries.
	PO11	Students will select lean manufacturing tools to reduce waste in industries.
	PSO2	Students will be able to maintain ethical attitude in industry
	PO12	Lifelong learning can be achieved with by knowing the importance of lean manufacturing.
CO5	**PO4**	Knowledge of agile manufacturing will be used to solve complex problem.
	PO5	Knowledge of agile manufacturing can be utilised for solving complex activities of manufacturing process used in industries.
	PO9	The students will be able to interact with experts of other disciplines to get more ideas on global issues related to ethics.
	PO11	Information's of various techniques and tools used in agile manufacturing can be used effectively for project management and finance
	PO12	Lifelong learning can be achieved by knowing the importance of agile manufacturing.
	PSO2	Students will be able to maintain ethical attitude in industry
	PO4	Knowledge of agile manufacturing will be used to solve complex problem.
	PO5	Knowledge of agile manufacturing can be utilised for solving complex activities of manufacturing process used in industries.
	PO9	The students will be able to interact with experts of other disciplines to get more ideas on global issues related to ethics.
	PO11	Information's of various techniques and tools used in agile manufacturing can be used effectively for project management and finance
	PO12	Lifelong learning can be achieved by knowing the importance of agile manufacturing.
CO6	**PO1**	Information of enterprise resource planning will be utilised to bring solution to complex engineering problem.

	PO5	Information of enterprise resource planning will be used to solve complex activities
	PO11	Information's of enterprise resource planning can be used effectively for project management and finance
	PO12	Lifelong learning can be achieved by knowing the importance of enterprise resource planning
	PSO2	Students will be able to maintain ethical attitude in industry

9. Curricular gaps (if any)

NIL

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	Ergonomics	Case study (Assignment 1)	PO1, Po2

11. Internal Assessment mark allocation (as per university curriculum)

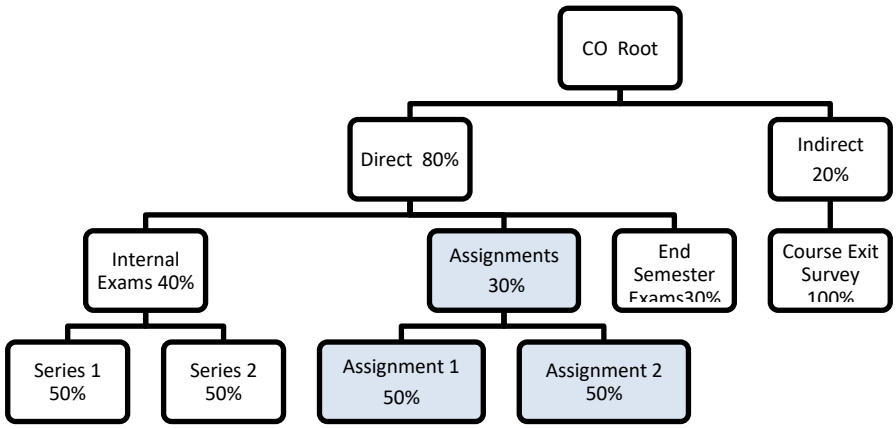
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put' x' if mapping is present)

	Tools		Weightage#	CO1	CO2	CO3	CO4	CO5	CO6
Direct Assessment Tools**	Internal Exam(s) 40%	Series 1	20%	x	x		x		
		Series 2	20%		x	x	x	x	x
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x					
		Assignment 2	15%		x	x	x	x	x
	University Exam		30%	x	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1	Introduction	1	1	Lectur e
2	Objectives of design function	1	5	Tutori al
3	Development of design	1	5	Lectur e
4	Human factors in design	1	5	Lectur e
5	prototype, production and testing	1	2	Remed ial
6	Principles of good product design- tolerance design-	1	1	Lectur e
7	- quality and cost considerations- product life cycle	1	5	Tutori al
8	standardization, simplification, diversification- concurrent engineering-	1	5	Lectur e

9	Economic aspects- C-V-P analysis	1	1	Tutori al
10	Objectives of design function	1	2	Lectur e
11	Development of design	1	1	Remed ial
12	Simple Problems	1	5	Tutori al
13	Human factors in design	1	5	Lectur e
14	prototype, production and testing	1	1	Remed ial
15	Principles of good product design- tolerance design-	1	3	Lectur e
16	Simple Problems	1	2	Tutori al
17	Introduction to materials management – objectives – Types of material handling equipments	2	1	Lectur e
18	principles of material handling – Material selection –	2	5	Tutori al
19	value analysis – make or buy decisions. Purchasing and procedures. Basic inventory management - Inventory - Functions, Costs, Classifications - EOQ Models- Assumptions	2	5	Remed ial
20	Quantity discount model- Q system- P system- Reorder level -	2	2	Lectur e
21	Simple Problems	2	1	Tutori al
22	Concept of JIT manufacturing system.	2	5	Lectur e
23	Introduction to materials management – objectives –	2	5	Lectur e

	Types of material handling equipments			
24	principles of material handling – Material selection –	2	3	Lectur e
25	value analysis – make or buy decisions. Purchasing and procedures. Basic inventory management - Inventory - Functions, Costs, Classifications - EOQ Models- Assumptions	2	2	Remed ial
26	Quantity discount model- Q system- P system- Reorder level -	2	1	Lectur e
27	Industrial relations- Psychological attitudes to work and working conditions	3	5	Tutori al
28	fatigue- Methods of eliminating fatigue- Effect of Communication in Industry	3	5	Lectur e
29	Industrial safety-personal protective devices	3	1	Remed ial
30	causes and effects of industrial disputes	3	1	Lectur e
31	Trade union - Workers participation in management.	3	5	Tutori al
32	Industrial relations- Psychological attitudes to work and working conditions	3	2	Lectur e
33	fatigue- Methods of eliminating fatigue- Effect of Communication in Industry	3	5	Lectur e
34	Industrial safety-personal protective devices	3	1	Remed ial
35	causes and effects of industrial disputes	3	1	Lectur e
36	Collective bargaining-	3	5	Tutori al
37	Trade union - Workers participation in management.	3	5	Lectur e

38	Principles of Lean Manufacturing(LM) – Basic elements of LM– Introduction to LM Tool	4	2	Remed ial
39	Concept of wastes in LM and their narration - stages of 5S and waste elimination	4	1	Lectur e
39	Concept of wastes in LM and their narration - stages of 5S and waste elimination	4	1	Lectur e
40	finition, business need, conceptual frame work, characteristics, and generic features	4	5	Tutori al
41	Principles of Lean Manufacturing(LM) – Basic elements of LM– Introduction to LM Tool	4	5	Lectur e
42	Approaches to enhance ability in manufacturing - Managing people in agile organization	4	1	Lectur e
43	Concept of wastes in LM and their narration - stages of 5S and waste elimination	4	2	Remed ial
44	Conventional Manufacturing versus Lean Manufacturing	4	1	Lectur e
45	finition, business need, conceptual frame work, characteristics, and generic features	4	5	Tutori al
46	Approaches to enhance ability in manufacturing - Managing people in agile organization	4	5	Lectur e
47	Approaches to enhance ability in manufacturing - Managing people in agile organization	4	1	Lectur e
48	ntroduction of enterprise resource planning (ERP)- Concept of	5	3	Lectur e

	Enterprise, ERP Overview -			
49	Integrated information system - Myths about ERP	5	2	Lectur e
50	Evolution of ERP- Benefits of ERP implementation - Success and failure factors of ERP implementation	5	1	Lectur e
51	Small, medium and large enterprise vendor solutions- ERP and related technology: Business intelligence (BI)	5	5	Tutori al
52	ntroduction of enterprise resource planning (ERP)- Concept of Enterprise, ERP Overview -	5	5	Lectur e
52	ntroduction of enterprise resource planning (ERP)- Concept of Enterprise, ERP Overview -	5	5	Lectur e
53	Integrated information system - Myths about ERP	5	1	Lectur e
54	Evolution of ERP- Benefits of ERP implementation - Success and failure factors of ERP implementation	5	3	Lectur e
55	E-Commerce and E-Business, Business Process Reengineering (BPR), Data	5	2	Lectur e
52	ntroduction of enterprise resource planning (ERP)- Concept of Enterprise, ERP Overview -	5	5	Lectur e
53	Integrated information system - Myths about ERP	5	1	Lectur e
54	Evolution of ERP- Benefits of ERP implementation - Success and failure factors of ERP implementation	5	3	Lectur e
56	Data mining, Online Analytical Processing(OLAP), Product lifecycle management(PLC)	5	1	Remed ial

57	Small, medium and large enterprise vendor solutions- ERP and related technology: Business intelligence (BI)	5	1	Lectur e
58	E-Commerce and E-Business, Business Process Reengineering (BPR), Data warehousing,	5	5	Tutori al
59	Data mining, Online Analytical Processing(OLAP), Product lifecycle management(PLC)	5	1	Remed ial
60	Customer relationship management (CRM)- ERP implementation challenges	5	1	Lectur e
61	Emerging trends on ERP	5	5	Tutori al
62	Supply chain management(SCM)	5	5	Lectur e
63	Customer relationship management (CRM)- ERP implementation challenges	5	1	Lectur e
64	Emerging trends on ERP	5	2	Lectur e

15. Question Bank

Module 1				
Sl. No	**Question**	**Marks**	**CO**	**BL**
1	Define industrial engineering. What are the functions of Industrial Engineering	3	CO 1	L 1
2	What are the objectives of design function? How design function is classified. Explain five principles of good product design.	7	CO 1	L 2
3	Explain sequences in product design.	7	CO 1	L 2
4	Explain standardization. List the needs of standardization.	3	CO 1	L 2
5	With neat graph explain various stages of product life cycle.	3	CO 1	L 2
	Define simplification simplification and list the advantages of	3		L

6	simplification.		CO 1	2
7	Define Diversification. List the reasons for diversification	3	L 2	L 2
8	Define tolerances. Explain the type of tolerances.	3	L 2	L 2
9	Define costs. What are the different types of cost associated?	7	L 2	L 2
10.	Define brake even analysis. What are the assumptions in breakeven analysis? What is brake even point (BEP). Show the breakeven point in brake even chart	7	L 2	L 1
11	List the application of breakeven point.	3	L 1	L 2
12	What is cost- volume- profit analysis (CVP). List the objectives of cost volume profit analysis (CVP).	7	L 2	L 2
13	Explain concurrent engineering. Explain the need and benefits of concurrent engineering.	7	L 2	L2
14	Compare sequential engineering v/s concurrent engineering.	7	L2	L 2
15	Explain prototype, testing and production.	7	L 2	L 3
16	Derive equation for break even quantity.	7	L 3	L 3
17	L & T plans to sell an article at a local market. The articles are purchased at Rs 5/- per piece on the condition that all unsold articles shall be returned. The rent for the space is Rs. 2000/-. The articles will be sold at Rs. 9/-per piece. i) Determine the number of articles which must be sold (a) For break-even point, To earn Rs. 400/- as profit, ii) If the company sells 750 articles. Calculate margin of safety and (b) profit	7	L 3	L3
18	The fixed cost for a company is Rs. 5,00,000 and variable cost per unit is Rs. 25. The estimated sales for the period is valued at Rs. 15,00,000. Each unit sells at Rs. 150. Determine: a) Break-even point in rupees. b) Rs. 12,00,000 will be the likely sales turnover for the next period, calculate the estimated contribution and profit.	3	L3	L 2
Module 2				
1	Explain any seven principles of material handling. List any four types of conveyors.	7	CO 2	L2
2	Elaborate Value Analysis. List seven phase of value analysis. Explain any two phase of value analysis. What are the advantages of value analysis.	7	CO2	L2
3	Define material management system. List the functions and objectives of material management system.	3	CO2	L1

4	State the factors for selecting material handling equipment.	3	CO2	L1
5	Explain the functional aspect of make or buy decision.	7	CO2	L2
6	List the noneconomic factors influencing make or buy decision?	3	CO2	L1
7	Discuss inventory. Explain functions of inventory. Explain cost associated with inventory function.	7	CO2	L2
8	Define terms: Demand, order cycle, lead time, reorder level, reorder quantity, safety stock.	3	CO2	L1
9	Explain graph of cost to economic order quantity. And define economic order quantity.	7	CO2	L2
10.	Explain assumptions used in economic order models.	7	CO2	L2
11	Explain Q system (fixed quantity system). What are the characteristics of Q system. Explain advantages and limitation of Fixed Quantity system.	7	CO2	L3
12	Explain P system (Periodic Review system). What are the characteristics of P system. Explain advantages and limitation of Fixed Quantity system.	7	CO2	L3
13	Compare P and Q system.	7	CO2	L3
14	Explain Just in Time Concept.	7	CO2	L3
15	Derive equation for economic order quantity-(inventory model 1)	7	CO2	L3
16	Derive equation for economic order quantity-(inventory model II)	7	CO2	L3
17	ARM industry needs 5400 units per year of a bought-out component which will be used in its main product. The ordering cost is Rs. 250 per order and the carrying cost per unit per year is Rs. 30. Find: a) the economic order quantity (EOQ). b) the number of orders per year c) the time between successive orders. d) the total cost.	7	CO2	L3
18	A company requires 16,000 units of raw material costing Rs.2 per unit. The cost of placing an order is Rs.45 and the carrying costs are 10% per year per unit of the average inventory. Determine (i) EOQ (ii) Number of orders per year (iii) Cycle time (iv) Total variable cost of managing the inventory.	7	CO2	L3
19	State the principle of unit load in material handling.	3	CO2	L1
9	Explain graph of cost to economic order quantity. And define economic order quantity.	7	CO2	L2
	Module 3			
1	List any four factors of industrial fatigue. What are different types of communication in industry?	3	CO3	L1
2	Define industrial safety. List any two objectives of industrial safety.	3	CO3	L1
3	List any five objectives of Trade union. List functions of trade union.	3	CO3	L1
	Explain Industrial Relations. What are the objectives of	3	CO3	L2

4	industrial relations?			
5	Define fatigue. Explain different methods to reduce industrial fatigue. List different effects of fatigue.	3	CO3	L2
6	Explain any seven personal protective devices used in an industry.	7	CO3	L2
7	Define industrial safety. List the objectives of industrial safety.	7	CO3	L1
8	Describe the causes and effects of industrial disputes and how it can be eliminated	7	CO3	L2
9	Explain different measures of industrial safety	7	CO3	L2
10	Discuss any four types of non-respiratory PPE.	7	CO3	L2
11	Explain the types of communication in industry and how it affects productivity.	7	CO3	L2
12	Discuss (i) Workers participation in management (ii) Collective bargaining	7	CO3	L2
13	Discuss personal protective equipment (PPE) and the categories of PPE?	3	CO3	L2
14	List merits and demerits of trade union.	3	CO3	L1
15	List different factors affecting industrial relation	3	CO3	L1
	Module 4			
1	Summarize Lean Manufacturing. List the principles of Lean Manufacturing. Explain any two principles of lean manufacturing.	3	CO4	L2
2	Give the advantages of lean manufacturing.	3	CO4	L1
3.	What are the different tools of lean manufacturing? Explain any four lean manufacturing tools.	3	CO4	L1
4.	Explain Agile Manufacturing	3	CO4	L1
5.	Compare the difference between lean and agile manufacturing.	3	CO4	L2
6.	List and explain different types of waste.	3	CO4	L1
7.	Explain 5 S System.	7	CO4	L2
8.	Explain characteristics of agile manufacturing.	7	CO4	L2
9.	List all the advantages of agile manufacturing?	7	CO4	L1
10.	Compare conventional manufacturing and lean manufacturing.	7	CO4	L2
11.	Explain need of agile manufacturing in business.	7	CO4	L2
12.	Explain conceptual framework of agile manufacturing.	7	CO4	L2
13.	Discuss all principles of lean manufatcuring	7	CO4	L2
14	Describe all types of waste considerd in lean manufacturing.	7	CO4	L2

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15.	Discuss methods to eliminate waste in lean manufacturing	7	CO 4	L2
Module V				
1	Explain the concept of enterprise with reference to ERP system.	7	CO5	L2
2	Describe any three success for implementing ERP system.	7	CO5	L2
3	Describe the key processes of "Customer Relationship Management.	7	CO5	L2
4	Explain ERP technology.	7	CO5	L2
5	Discuss common myths related to ERP system.	7	CO5	L2
6	Explain Business Process Re-engineering. List different failure factors of BPR and also list different phases of BPR.	7	CO5	L2
7	Explain Business Intelligence. List the benefits of Business Intelligence.	7	CO5	L2
8	Explain Data Mining.	7	CO5	L2
9	Explain E business and E commerce.	7	CO5	L2
10	Explain different phases of Business Process Reengineering	7	CO5	L2
11.	Define online analytical processing.	7	CO5	L2
12.	Describe any three failure factors for implementing ERP system.	7	CO5	L2
13.	Compare E commerece and E business	7	CO5	L2
14.	Discuss product cyle management.	7	CO5	L2
15	Describe datawarehousing with figure	7	CO5	L2

Prepared By : Nisha B Nair

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Course Code & Name: MET 307- MACHINE TOOLS AND METROLOGY

1. Prescribed Syllabus

Module	Topic	Hours
1	General purpose machine tools – types and classification of machine tools –types and classification of lathe – methods of holding work and tool –lathe accessories and attachments –lathe operations -tool room lathe – duplicate lathe –capstan and turret lathe –horizontal and vertical-single spindle and multi spindle screw machines - Shaping, Plaining and Slotting machines – Work holding devices-types of operations - surface roughness obtainable indexing - Drilling and boring Machines – -Drill bit nomenclature-cutting forces in drilling – tool and work holding devices-boring tools and reamers.	
2	Milling tool nomenclature - Cutting forces in milling – Calculation of machining time- Indexing head Different indexing methods - Grinding, honing and lapping – types of grinding machines-operations: cutting forces in grinding -Grinding mechanisms – Grinding wheels - surface roughness obtainable in grinding, honing and lapping.	
3	Broaching machines –different machines – cutter for broaching – broaching processes – internal external broaching - Gear cutting – methods in gear production – form cutters –gear generating machines – gear hobbing machines – gear broaching -Bevel gear cutting –worm gear cutting –gear finishing.	
4	Metrology –principles of achieving accuracy -Theory of tolerances and allowances –system of limits and fits – types of fits – interchangeability and selective assembly –standards of measurements- Gauges – classification of gauges –principle of gauge tolerance –wear allowance.	
5	Instruments for checking straightness, flatness and squareness– pneumatic gauging –precision gauging – automatic gauging for inspection-Optical measuring instruments –Comparators – Measurements of surface roughness –- gauging and measurements of screw and gears- Advanced measuring devices – Laser interferometers- Coordinate Measuring Machine (CMM).	

2. Text Books (T)

T1. Chapman W. A. J., Workshop Technology, Viva books (P) Ltd
T2. HMT, Production Technology, Tata McGraw-Hill
T3. Engineering Metrology and Measurements, N.V. Raghavendra, l. Krishnamurthy, oxford university press
T4. Galyer J.F.W., Schotbolt C.R., Metrology for Engineers, ELBS.

3. Reference Books (R)

R1. Acharkan. N., Machine Tool Design Vol. 1 to 4, MIR Publication
R2. Chernov, Machine Tools, MIR Publication.
R3. HajraChoudary, Elements of workshop technology, Vol I & II, Media Publishers.
R4. ASME, Hand book of Industrial Metrology.
R5. Hume K. J., Engineering Metrology, Macdonald &Co. Ltd.
R6. Sharp K.W.B., Practical Engineering Metrology, Sir Isaac Pitman & Sons Ltd.

4. Course Objectives

To develop knowledge of appropriate process parameters to be used for various machining operations.

Understand the fundamentals of modem quality concepts. Be able to apply statistical techniques.

Understand the principles and operation of precision measurement tools and equipment used in modern manufacturing.

5. Course Pre / Co-requisite

MET 205Metallurgy and Material Science and PHT 110 Engineering Physics

6. Course Outcomes

After completion of the course, student will be able to

CO1: Analyze various machining process and calculate relevant quantities such as velocities, forces and powers.

CO2: Analyze of the tool nomenclature with surface roughness obtainable in each machining processes.

CO3: Understand the limitations of various machining process with regard to shape formation and surface texture.

CO4: Demonstrate knowledge of the underlying principles of measurement, as they relate to mechanical measurement, electronic instrumentation, and thermal effects.

CO5: Get an exposure to advanced measuring devices and machine tool metrology.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO 3
CO1	**M**	**H**									**M**	**L**			
CO2	**M**	**H**									**M**	**L**			
CO3	**M**	**L**		**M**	**M**							**M**			
CO4	**H**		**M**								**M**	**M**			**M**
CO5	**M**			**M**	**H**							**H**			

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	PO1	Analyse various machining process and calculate relevant quantities such as velocities, forces and powers by applying the knowledge of mathematics, science and engineering fundamentals. Medium correlation is due to the fact that this involves the basic knowledge using first principles of mathematics, science and engineering.
	PO2	Analyze various machining process reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
	PO11	Demonstrate knowledge and understanding of the various machining process and apply these to one's own work, as a member

		and leader in a team, to manage projects in multidisciplinary environments.
	PO12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in various machining
CO2	PO1	Apply the knowledge of the tool nomenclature with surface roughness obtainable in each machining processes to the solution of complex engineering problems.
	PO2	Identify, formulate, review research literature, and analyse the tool nomenclature with surface roughness obtainable in each machining processes reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
	PO11	Demonstrate knowledge and understanding of the tool nomenclature with surface roughness obtainable in each machining processes and apply these to manage projects in multidisciplinary environments.
	PO12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the tool nomenclature with surface roughness obtainable in each machining processes.
CO3	PO1	Apply the knowledge of various machining process with regard to shape formation and surface texture to the solution of complex engineering problems.
	PO2	Identify, formulate, review research literature, and analyze various machining process with regard to shape formation and surface texture reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
	PO4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions about various machining process with regard to shape formation and surface texture.
	PO5	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations about various machining process with regard to shape formation and surface texture.
	PO12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in various machining process with regard to shape formation and surface texture.
CO4	PO1	Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems underlying principles of measurement, as they relate to mechanical measurement, electronic instrumentation, and thermal effects.
	PO3	Design solutions for complex engineering problems and design system components underlying principles of measurement, as they relate to mechanical measurement, electronic instrumentation, and thermal effects
	PO11	Demonstrate knowledge and understanding of the engineering and management principles underlying principles of measurement, as they relate to mechanical measurement, electronic instrumentation, and thermal effects and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
	PO12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change underlying principles of measurement, as

		they relate to mechanical measurement, electronic instrumentation, and thermal effects.
	PSO3	Apply underlying principles of measurement, as they relate to mechanical measurement, electronic instrumentation, and thermal effects to design and analyse multi-disciplinary systems.
CO5	PO1	Apply the knowledge of advanced measuring devices and machine tool metrology to the solution of complex engineering problems.
	PO4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions regarding advanced measuring devices and machine tool metrology.
	PO5	Use of advanced measuring devices and machine tool metrology.
	PO12	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change in advanced measuring devices and machine tool metrology.

9. Curricular gaps (if any)

NIL

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1.	Machine Tool Lab Visit	Live demo of various machine tools like lathe, shaper, milling machine, grinding machine, drilling machine etc.	PO1, PO12

11. Internal Assessment mark allocation (as per university curriculum)

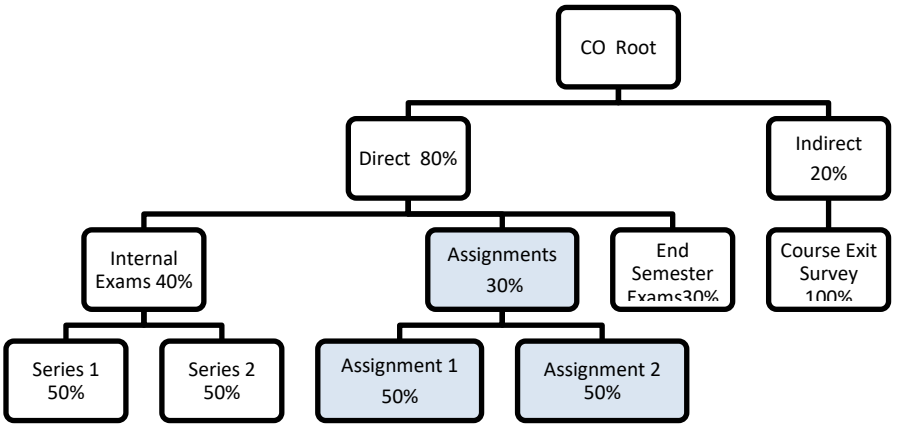
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		Weightage#	CO1	CO2	CO3	CO4	CO5
Direct Assessment Tools**	Internal Exam(s) 40%	Series 1	20%	x	x			
		Series 2	20%			x	x	x
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x	x			
		Assignment 2	15%			x	x	x
	End Semester Exam		30%	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hour	Topic	Module	Reference	Teaching Pedagogy
	Module I			
1.	General purpose machine tools – types and classification of machine tools –Lathe –	1	T1	Lecture
2.	Feed,depth of cut, speed-methods of holding work and tool	1	T1	Lecture
3.	lathe accessories and attachments	1	T1	Lecture
4.	lathe operations and tools used for each operations	1	T1	Tutorial
5.	Brief study of the machine and the nature and type of jobs handled by the following: -	1	T1	Remedial
6.	Tool room lathe – duplicate lathe – capstan and turret lathe –horizontal and vertical	1	T1	Lecture
7.	single spindle and multi spindle screw machines.	1	T1	Lecture
8	Shaping, Plaining and Slotting machines – Types and specifications – quick return motion –hydraulic feed and its advantages - automatic feed speed,feed and depth of cut–Work holding devices-types of operations and examples of work done- surface roughness obtainable indexing	I	T1	Tutorial
9	Drilling and boring Machines – Types and specifications –Brief descriptions about the machines and nature, types of job	1	T1	Lecture
10	-Drill bit nomenclature- cutting forces in drilling – tool and work holding devices-boring tools and reamers.	1	T1	Lecture

	Module 2			
11	Milling machines – types and specifications- Milling operations and types of milling cutters used for each.	2	T1	Lecture
12	Milling tool nomenclature - Cutting forces in milling – Calculation of machining time- Indexing head and its use	2	R1	Tutorial
13	Different indexing methods - Differential indexing	2	T1	Remedial
14	Grinding, honing and lapping – types of grinding machines	2	T1	Lecture
15	operations: cylindrical, surface and center less grinding	2	T1	Lecture
16	internal grinding, tool and cutter grinding - cutting forces in grinding	2	R1	Lecture
17	Grinding mechanisms – Grinding wheels: Specification – types of abrasives, grain size - Types of bond, grade, and structure	2	R1	Lecture
18	Marking system of grinding wheels – Selection of grinding wheels –need of better surface finish; surface roughness obtainable in grinding, honing, lapping and burnishing	2	R1	Lecture
19	Surface roughness comparisons between different conventional metal cutting processes.	2	R1	Tutorial
	Module 3		R1	Lecture
21	Broaching machines –different machines	3	R1	Tutorial
22	cutter for broaching – different broaching processes	3	R1	Lecture
23	internal external broaching.	3	R1	Remedial
24	Gear cutting –methods used in gear production – form cutters	3	R1	Lecture
25	gear generating machines	3	R1	Lecture
26	Gear broaching.	3	R1	Lecture
27	Bevel gear cutting – straight and spiral gears- worm gear cutting	3	R1	Tutorial
28	gear finishing operations.	3	R1	Lecture
	Module 4			Lecture
29	Metrology –principles of achieving accuracy – economic	4	R1	Lecture
30	machining accuracy – precision Vs accuracy - errors- standards of measurements-	4	R1	Lecture

31	Theory of tolerances and allowances	4	R1	Tutorial
32	system of limits and fits	4	T1	Remedial
33	types of fits	4	T1	Lecture
34	interchangeability and selective assembly - Taylor's Principle-	4	R1	Lecture
35	Gauges – classification of gauges- plug, ring, taper angle, slip and snap gauges	4	R1	Tutorial
36	feeler gauges-dial indicator	4	R1	Lecture
37	gauge tolerance	4	R1	Lecture
38	wear allowance-gauge materials.	4		Lecture
	Module 5			
41	Instruments for checking straightness, angle, flatness	5	T1	Lecture
42	squareness of guiding surface, pneumatic gauging –precision gauging –automatic gauging for inspection.	5	T1	Tutorial
43	Optical measuring instruments, baisc principle	5	R1	Lecture
44	interferometer-optical flat –optical tool makers' microscope- autocollimator.	5	R1	Lecture
45	Comparators – mechanical, optical, pneumatic, electric and electronic comparators.	5	R1	Lecture
46	Measurements of surface roughness – elements of roughness – symbols specifying –instruments and for measuring surface roughness-	5	R1	Tutorial
47	Measurements of screw: terminology, measurement of screw thread elements	5	R1	Lecture
48	measurement of gears: terminology, errors in spur gears, measurement of gear elements.	5	R1	Lecture
49	Advanced measuring devices – Laser interferometers- Coordinate Measuring Machine (CMM)	5	R1	Lecture

15. Question Bank

Module 1				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	What is the difference between drilling, boring and reaming?	**5**	**2,3**	**1**
2	What is trepanning? Explain with sketch.	**5**	**3**	**2**
3	What are the use of face plate and angle plate in a lathe?	**5**	**3**	**1**
4	With the help of a neat sketch explain the various parts of a lathe.	**10**	**3**	**2**
5	Explain the working principle of slotter.	**5**	**1**	**2**
6	Explain the various work holding devices in lathe.	**10**	**1,3**	**2**
7	What are the attachments used on a centre lathe and what purpose do they serve?	**10**	**1,3**	**1**
8	Draw a drill signature, name the important angles and explain their each function.	**10**	**2**	**2**
9	Explain the methods of cutting taper in lathe.	**10**	**3**	**2**
10	Discuss the significant machining parameters for shaping machine.	**5**	**2,3**	**1**
Module 2				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	Explain the principle of working of centreless grinding machine.	**5**	**1,3**	**2**
2	What are 'Through Feed', 'In Feed', and 'End Feed' in centreless grinding operations?	**5**	**2,3**	**1**
3	Explain in detail with neat sketches of a) Slot and groove milling, b) profile milling c) thread milling	**10**	**1,3**	**2**
4	With a sketch, show rake angle of milling cutter and chip breaker.	**5**	**2**	**1**
5	What is the difference between grinding wheel dressing and truing?	**5**	**3**	**1**
6	What is the principle of Gear shaping? Explain.	**5**	**3**	**2**
7	How are abrasives selected for grinding operation?	**5**	**2,3**	**1**
8	Why a coolant used in grinding work?	**5**	**1,3**	**1**
9	With the help of a neat sketch explain the various parts of a column & knee milling machine.	**10**	**3**	**2**
10	Differentiate between cylindrical grinding and surface grinding.	**5**	**3**	**2**
Module 3				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	What is the principle of Gear shaping? Explain.	**5**	**2,3**	**1**

2	What is trepanning? Explain with sketch.	**5**	**3**	**2**

3	What are the use of face plate and angle plate in a lathe?	**5**	**3**	**1**
4	With the help of a neat sketch explain the various parts of a lathe.	**10**	**3**	**2**
5	Explain the working principle of slotter.	**5**	**1**	**2**
6	Explain the various work holding devices in lathe.	**10**	**1,3**	**2**
7	What are the attachments used on a centre lathe and what purpose do they serve?	**10**	**1,3**	**1**
8	Draw a drill signature, name the important angles and explain their each function.	**10**	**2**	**2**
9	Explain the methods of cutting taper in lathe.	**10**	**3**	**2**
10	Discuss the significant machining parameters for shaping machine.	**5**	**2,3**	**1**

Module 4

Sl. No.	Question	Marks	CO	BL
1	What are the attachments used on a centre lathe and what purpose do they serve?	**5**	**1,3**	**2**
2	What are 'Through Feed', 'In Feed', and 'End Feed' in centreless grinding operations?	**5**	**2,3**	**1**
3	Explain in detail with neat sketches of a) Slot and groove milling, b) profile milling c) thread milling	**10**	**1,3**	**2**
4	With a sketch, show rake angle of milling cutter and chip breaker.	**5**	**2**	**1**
5	What is the difference between grinding wheel dressing and truing?	**5**	**3**	**1**
6	What is the principle of Gear shaping? Explain.	**5**	**3**	**2**
7	How are abrasives selected for grinding operation?	**5**	**2,3**	**1**
8	Why a coolant used in grinding work?	**5**	**1,3**	**1**
9	With the help of a neat sketch explain the various parts of a column & knee milling machine.	**10**	**3**	**2**
10	Differentiate between cylindrical grinding and surface grinding.	**5**	**3**	**2**

Module 5

Sl. No.	Question	Marks	CO	BL
1	Explain in detail with neat sketches of a) Slot and groove milling, b) profile milling c) thread milling	**5**	**2,3**	**1**
2	What is trepanning? Explain with sketch.	**5**	**3**	**2**
3	What are the use of face plate and angle plate in a lathe?	**5**	**3**	**1**
4	With the help of a neat sketch explain the various parts of a lathe.	**10**	**3**	**2**
5	Explain the working principle of slotter.	**5**	**1**	**2**
6	Explain the various work holding devices in lathe.	**10**	**1,3**	**2**

7	What are the attachments used on a centre lathe and what purpose do they serve?	**10**	**1,3**	**1**
8	Draw a drill signature, name the important angles and explain their each function.	**10**	**2**	**2**
9	Explain the methods of cutting taper in lathe.	**10**	**3**	**2**
10	Discuss the significant machining parameters for shaping machine.	**5**	**2,3**	**1**
11	Explain the principle of working of centreless grinding machine.	**5**	**1,3**	**2**
12	What are 'Through Feed', 'In Feed', and 'End Feed' in centreless grinding operations?	**5**	**2,3**	**1**
13	Explain in detail with neat sketches of a) Slot and groove milling, b) profile milling c) thread milling	**10**	**1,3**	**2**
14	With a sketch, show rake angle of milling cutter and chip breaker.	**5**	**2**	**1**
15	What is the difference between grinding wheel dressing and truing?	**5**	**3**	**1**
16	What is the principle of Gear shaping? Explain.	**5**	**3**	**2**
17	How are abrasives selected for grinding operation?	**5**	**2,3**	**1**
18	Why a coolant used in grinding work?	**5**	**1,3**	**1**
19	With the help of a neat sketch explain the various parts of a column & knee milling machine.	**10**	**3**	**2**
20	Differentiate between cylindrical grinding and surface grinding.	**5**	**3**	**2**

Prepared By: Dr. Manoj Jose Kalathil

Checked By : Dr. Manoj Jose Kalathil

Approved by: Dr. Ramadas T, HoD (ME)

Course Code & Name: HUT300 Industrial Economics and Foreign Trade

1. Prescribed Syllabus

Module	Topic	Hours
1	Module 1 (Basic Concepts and Demand and Supply Analysis) Scarcity and choice - Basic economic problems- PPC – Firms and it's objectives – types of firms – Utility – Law of diminishing marginal utility – Demand and its determinants – law of demand – elasticity of demand – measurement of elasticity and its applications – Supply, law of supply and determinants of supply – Equilibrium – Changes in demand and supply and its effects – Consumer surplus and producer surplus (Concepts) – Taxation and deadweight loss	7
2	Module 2 (Production and cost) Production function – law of variable proportion – economies of scale – internal and external economies – Isoquants, isocost line and producer's equilibrium – Expansion path – Technical progress and its implications – Cobb-Douglas production function - Cost concepts – Social cost: private cost and external cost – Explicit and implicit cost – sunk cost - Short run cost curves - long run cost curves – Revenue (concepts) – Shutdown point – Break-even point.	7
3	Module 3 (Market Structure) Perfect and imperfect competition – monopoly, regulation of monopoly, monopolistic completion (features and equilibrium of a firm) – oligopoly – Kinked demand curve – Collusive oligopoly (meaning) – Non-price competition – Product pricing – Cost plus pricing – Target return pricing – Penetration pricing – Predatory pricing – Going rate pricing – Price skimming.	6
4	Module 4 (Macroeconomic concepts) Circular flow of economic activities – Stock and flow – Final goods and intermediate goods - Gross Domestic Product - National Income – Three sectors of an economy- Methods of measuring national income – Inflation- causes and effects – Measures to control inflation- Monetary and fiscal policies – Business financing- Bonds and shares -Money market and Capital market – Stock market – Demat account and Trading account - SENSEX and NIFTY	7
5	Module 5 (International Trade) Advantages and disadvantages of international trade - Absolute and Comparative advantage theory - Heckscher - Ohlin theory - Balance of payments – Components – Balance of Payments - deficit and devaluation – Trade policy – Free trade versus protection – Tariff and non-tariff barriers.	8

2. Text Books (T)

T1. Rajesh Kumar R., Industrial Economics and Foreign Trade, Jyothis Publishers
T2. Johnson T.T., Industrial Economics and Foreign Trade, Jude Publications Trivandrum

3. Reference Books (R)

R1. Gregory N Mankiw, 'Principles of Micro Economics', Cengage Publications
R2. Gregory N Mankiw, 'Principles of Macro Economics', Cengage Publications
R3. Dwivedi D N, 'Macro Economics', Tata McGraw Hill, New Delhi.
R4. Mithani D M, 'Managerial Economics', Himalaya Publishing House, Mumbai.
R5. Francis Cherunilam, 'International Economics', McGraw Hill, New Delhi.

4. Course Objectives

1. To develop entrepreneurial skills in students
2. To equip students to take industrial decisions related to production and distribution
3. To create an awareness of economic environment in students

5. Course Pre / Co-requisite

Not required

6. Course Outcomes

CO1: Explain the problem of scarcity of resources and consumer behaviour, and to evaluate the impact of government policies on the general economic welfare. (Cognitive knowledge level: Understand)
CO2: Take appropriate decisions regarding volume of output and to evaluate the social cost of production. (Cognitive knowledge level: Apply)
CO3: Determine the functional requirement of a firm under various competitive conditions. (Cognitive knowledge level: Analyse)
CO4: Examine the overall performance of the economy, and the regulation of economic fluctuations and its impact on various sections in the society. (Cognitive knowledge level: Analyse)
CO5: Determine the impact of changes in global economic policies on the business opportunities of a firm. (Cognitive knowledge level: Analyse)

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M										H	M			
CO2	M	M			M	M	H				H	M			
CO3	M	M	M								H	M			
CO4	M	M	M								H	M			
CO5	M	M	M								H	M			

8. Justification for CO-PO-PSO Correlation

CO1	PO1- Understanding economic concepts like scarcity, choice making, demand, supply and taxation and applying this knowledge to the working of a business enterprise.
	PO11- Understanding principles of economics in managing scarce resources, consumer behaviour and government policies, optimise available resources and applying this knowledge to one's own enterprise.
CO 2	PO1- Applying principles of economics while taking production decisions on output keeping in view its scarcity.
	PO2- Applying principles of economics while solving problems related to output decisions and reducing influence on the environment.
	PO5 – Applying mathematical models in making realistic predictions about future and planning production accordingly.
	PO6 – Applying theoretical knowledge into the real business environment and studying the impact of any business activity on society and culture.
	PO7 – Bringing into focus the concept of sustainable environment while running a business enterprise.
	PO11– Demonstrate knowledge of economic principles while running one's own business enterprise and the impact it creates on all stakeholders.
	PSO 2- Analyse and synthesise experimental data to make informed decisions on output volume and evaluate the social cost of production.

CO 3	PO1- Applying knowledge of economics in engineering while analysing requirements of a firm depending on the market structure it operates in.
	PO2- Applying cost benefit analysis to find business solutions appropriate for each market structure.
	PO3 – Applying economic principles in devising business solutions in pricing keeping in view consumer behavior.
	PO11 – Learning how to make business decisions as an entrepreneur while operating under market uncertainty.
CO 4	PO2 - Analysing problems caused by business fluctuations and devising solutions for the same.
	PO3 - Devising solutions for business caused by external factors like trade cycles and finding solutions keeping in mind the consequences on society.
	PO6 - Devising strategies appropriate to each phase of business cycle in a way that, it does not have adverse consequences on the society
	PO11 - Applying knowledge of macroeconomic concepts like inflation and its consequ on one's own enterprise
	PO1- Understanding and applying the impact of foreign trade policies on the operations of a business enterprise

CO 5	PO2- Assessing the impact of foreign trade policies on business environment and substantiating conclusions based on principles of economics
	PO3- Analysing problems and devising solutions keeping in mind the interests of stakeholders
	PO11- Analysing how would an entrepreneur understand and evaluate impact of government policies on trade and devise strategies to overcome its ill effects

9. Curricular gaps (if any)

None

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	NPTEL Course on "Principles of Economics" This course is offered by Dr. Sabuj Kumar Mandal, Associate Professor, Department of Social Sciences and Humanities, IIT Madras. The course is intended for anyone who wants to learn the basic of economics and is of 12 weeks duration.	NPTEL	PO1

11. Internal Assessment mark allocation (as per university curriculum)

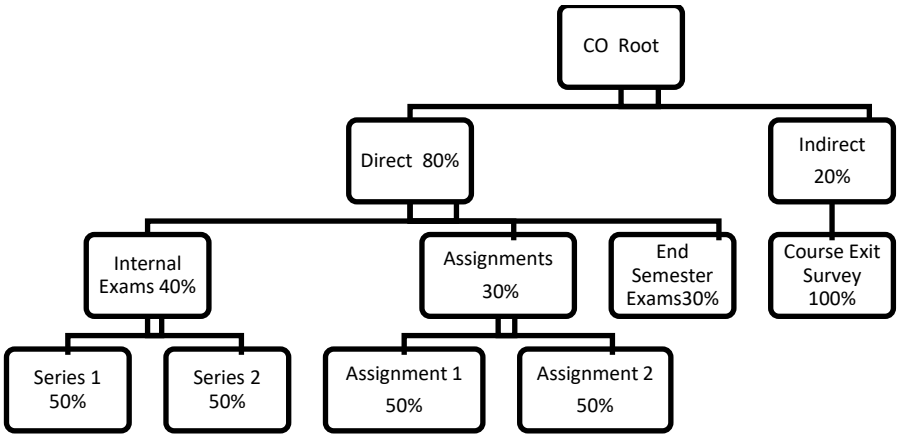
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put' x' if mapping is present)

	Tools		Weightage#	CO1	CO2	CO3	CO4	CO5
Direct Assessment Tools	Internal Exam(s) 40%	Series 1	20%	x	x			
		Series 2	20%			x	x	x
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x	x			
		Assignment 2	15%			x	x	x
	End Semester Exam		30%	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1	Scarcity and choice – Basic economic problems - PPC	Module 1	Robert K Mankiw, Micro Economics	Lecturing and Group Discussion
2	Firms and its objectives – types of firms	Module 1	Mithani D.M. , Managerial Economics	Lecturing (Concepts) and Self Study

3	Utility – Law of diminishing marginal utility – Demand – law of demand	Module 1	Robert K Mankiw, Micro Economics	Discussion and Lecturing
4	Measurement of elasticity and its applications	Module 1	Robert K Mankiw, Micro Economics	Numerical problems to be worked out in class on the board
5	Measurement of elasticity and its applications	Module 1	Robert K Mankiw, Micro Economics	Numerical problems to be worked out in class on the board, Case Study Analysis
6	Supply, law of supply and determinants of supply	Module 1	Robert K Mankiw, Micro Economics	Lecturing (Concept) and Self study
7	Equilibrium – changes in demand and supply and its effects	Module 1	Robert K Mankiw, Micro Economics	Graphical Illustration on the board
8	Equilibrium – changes in demand and supply and its effects	Module 1	Robert K Mankiw, Micro Economics	Graphical Illustration on the board
9	Consumer surplus and producer surplus (Concepts) – Taxation and deadweight loss.	Module 1	Robert K Mankiw, Micro Economics	Lecturing, Illustration on the board,
10	Production function – law of variable proportion	Module 2	Robert K Mankiw, Micro Economics	Lecturing
11	law of variable proportion	Module 2	Robert K Mankiw, Micro Economics	Lecturing
12	Economies of scale – internal and external economies	Module 2	Robert K Mankiw, Micro Economics	Group Discussion and Lecturing,

				Case study Discussion Analysis
13	Producers equilibrium – Expansion path	Module 2	Robert K Mankiw, Micro Economics	Graphical Illustration on board
14	Technical progress and its implications – Cobb Douglas Production function	Module 2	Robert K Mankiw, Micro Economics	Lecturing
15	Cobb Douglas Production function (Numerical Problems)	Module 2	Robert K Mankiw, Micro Economics	Numerical problems to be worked out on the board
16	Cost concepts – social cost: private cost and external cost – Explicit and implicit cost – sunk cost	Module 2	Robert K Mankiw, Micro Economics	Group Discussion
17	Short run cost curves & Long run cost curves	Module 2	Robert K Mankiw, Micro Economics	Plotting graphs using statistical data using board
18	Short run cost curves & Long run cost curves	Module 2	Robert K Mankiw, Micro Economics	Plotting graphs using statistical data using board
19	Revenue (concepts) – shutdown point – Break-even point.	Module 2	Robert K Mankiw, Micro Economics	Lecturing
	First Internal Examination			
20	Equilibrium of a firm, MC – MR approach and TC – TR approach	Module 3	Robert K Mankiw, Micro Economics	Lecturing
21	Perfect competition & Imperfect competition	Module 3	Robert K Mankiw, Micro Economics	Lecturing and Discussion
22	Monopoly – Regulation of monopoly – Monopolistic competition	Module 3	Robert K Mankiw, Micro Economics	Lecturing, Graphical illustration
23	Oligopoly – kinked demand curve	Module 3	Robert K Mankiw, Micro Economics	Lecturing, Graphical illustration, Case Study Analysis

24	Collusive oligopoly (meaning) – Non price competition	Module 3	Robert K Mankiw, Micro Economics	Lecturing, Case Study
25	Cost plus pricing – Target return pricing – Penetration, Predatory pricing – Going rate pricing – price skimming	Module 3	Robert K Mankiw, Micro Economics	Lecturing
26	Circular flow of economic activities	Module 4	Gregory N Mankiw, 'Principles of MacroEconomics', Cengage Publications	Group Discussion and Lecturing
27	Circular flow of economic activities	Module 4	Gregory N Mankiw, 'Principles of MacroEconomics', Cengage Publications	Group Discussion and Lecturing
28	Stock and flow – Final goods and intermediate goods – Gross Domestic Product - National income – Three sectors of an economy	Module 4	Gregory N Mankiw, 'Principles of MacroEconomics', Cengage Publications	Lecturing
29	Methods of measuring national income	Module 4	Gregory N Mankiw, 'Principles of MacroEconomics', Cengage Publications	Lecturing
30	Inflation – Demand pull and cost push – Causes and effects	Module 4	Dwivedi D N, 'Macro Economics', Tata McGraw Hill, New Delhi.	Lecturing and Discussion
31	Measures to control inflation – Monetary and fiscal policies		Dwivedi D N, 'Macro Economics', Tata McGraw Hill, New Delhi.	

32	Business financing – Bonds and shares – Money market and capital market	Module 4	Mithani D.M. , Managerial Economics	Lecturing
33	Stock market – Demat account and Trading account – SENSEX and NIFTY	Module 4	Mithani D.M. , Managerial Economics	Lecturing
	Second Internal Examination			
34	Advantages and disadvantages of international trade	Module 5	International Economics, Francis Cherunilam	Discussion
35	Absolute and comparative advantage theory	Module 5	International Economics, Francis Cherunilam	Lecturing
36	Heckscher – Ohlin theory	Module 5	International Economics, Francis Cherunilam	Lecturing
37	Balance of payments – components	Module 5	International Economics, Francis Cherunilam	Lecturing
38	Balance of payments deficit and devaluation	Module 5	International Economics, Francis Cherunilam	Lecturing
39	Trade policy – Free trade versus protection	Module 5	International Economics, Francis Cherunilam	Lecturing
40	Tariff and non tariff barriers.	Module 5	International Economics, Francis Cherunilam	Lecturing

15. Question Bank

Module 1				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1.	List down the basic economic problems.	**3**	**CO1**	**L1**

2.	Calculate the percentage change in price of a product if the sale is to be increased by 50 percentage and its price elasticity of demand is 2?	**3**	**CO1**	**L1**
3.	Define marginal utility. Explain the same using a schedule and a graph.	**3**	**CO1**	**L1**
4.	Define Law of demand with a demand schedule.	**3**	**CO1**	**L1**
5.	Explain Production Possibility Curve.	**3**	**CO1**	**L2**
6.	Explain the economic significance of opportunity cost?	**3**	**CO1**	**L2**
7.	A consumer purchased 10 units of commodity during the month of June. He purchased 15 units of the same commodity at the same price during the month of July. Give four reasons for the increase in demand.	**3**	**CO1**	**L2**
8.	If a consumer consumes more and more apples, explain the effect on total utility and marginal utility.	**3**	**CO1**	**L3**
9.	Comment on the nature of elasticity from the following data. Ep = 1, Ep = 0, Ep = 2, Ep = 0.85	**3**	**CO1**	**L3**
10.	Draw a total utility curve and marginal utility curve and derive three relations between MU and TU.	**3**	**CO1**	**L3**
11.	Suppose AC>Price>AVC. Will a producer produce or shutdown in the short run? Give reason			
12.	List out the advantages and disadvantages of Joint Stock Company.	**7**	**CO1**	**L1**
13.	Explain the Law of Diminishing Marginal Utility with a diagram.	**7**	**CO1**	**L2**
14.	Distinguish between movements along the demand curve and shift in demand.	**7**	**CO1**	**L2**
15.	Explain market equilibrium with the help of a schedule and diagram.	**7**	**CO1**	**L2**
16.	With the help of diagram explain Deadweight loss.	**7**	**CO1**	**L3**
17.	With the help of Production Possibility Curve, explain the concepts of Opportunity Cost, Under Utilization of resources, and Full employment of resources.	**7**	**CO1**	**L3**

18.	A tea manufacturing company was able to sell 8000 kg of tea when the price of coffee was Rs.70 per kg. Later they were able to sell 9000 kg when the price of coffee became Rs.80 per kg. Calculate the cross elasticity of demand for tea. Are the two commodities substitutes or complements? Give reasons.	**7**	**CO1**	**L3**
19.	A company producing soft drink is selling its product for Rs. 22. It sells 1000 units, and then increases the price to Rs.24. Now sales fall to 900 units. Calculate the price elasticity of soft drink? Is the demand elastic or inelastic? Give reasons?	**7**	**CO1**	**L3**

Module 2

Sl. No.	**Question**	**Marks**	**CO**	**BL**
1.	Define expansion path.	**3**	**CO2**	**L1**
2.	Define Margin of Safety.	**3**	**CO2**	**L1**
3.	Define a Production Function.	**3**	**CO2**	**L1**
4.	Describe factors of production.	**3**	**CO2**	**L1**
5.	Explain the effect of a low Margin of Safety.	**3**	**CO2**	**L2**
6.	Assume the production function $Q = 2L^{½} K^{½}$ i. If L = 100, K = 200, what is the maximum quantity that can be produced? ii. If the firm changes the amount of labour and capital by 10 times what will happen to output?	**3**	**CO2**	**L2**
7.	Distinguish between Fixed Costs and Variable Costs.	**3**	**CO2**	**L2**
8.	Explain break even analysis with a diagram.	**3**	**CO2**	**L2**
9.	In the production function, $Q = 3 L^{1/4}. K^{¾}$ Find the Average and Marginal Product of Labour, when Labour equals 9 and Capital (K) equals 4.	**3**	**CO2**	**L3**
10.	Illustrate Economies and Diseconomies of scale	**3**	**CO2**	**L3**
11.	List down the different types of costs.	**7**	**CO2**	**L1**

12.	Explain the determination of equilibrium price of a firm. Suppose cost of production increases. Determine the effect on supply and equilibrium.	**7**	**CO2**	**L1**
13.	Explain Law of variable proportion with a diagram.	**7**	**CO2**	**L2**
15.	Explain an isoquant curve and the properties of Isoquant curve.	**7**	**CO2**	**L2**
16.	Explain producers' equilibrium using an isoquant and isocost line.	**7**	**CO2**	**L2**
17.	The total sales of a manufacturing firm is Rs 20,000 in this year. Its variable costs are Rs 8000 while its fixed costs are Rs 6000 for that year. Calculate the breakeven point of this firm.	**7**	**CO2**	**L3**
19.	Thejus Associates has the following details. Fixed cost = Rs. 2000000, Variable cost per unit = Rs. 100, Selling Price per unit = Rs. 200, Find the following. a. The break even sales quantity b. The break even sales c. If the actual production quantity is 60000, find Contribution and Margin of safety	**7**	**CO2**	**L3**
20.	Discuss cost-output relationship in short-run and long-run.	**7**	**CO2**	**L3**
21.	Suppose a firm pays Rs.10000 as monthly rent and Rs.10000 as interest payment. Its monthly expenditure on raw materials is Rs.40000 and it get monthly sales revenue of Rs.80000. The price of one unit of output is Rs.40. Estimate i) PV Ratio ii) Break even sales iii) Break-even output iv) Profit earned v) Margin of safety	**7**	**CO2**	**L3**
Module 3				
Sl. No.	Questions			
1.	Define Collusive Oligopoly.	**3**	**CO3**	**L1**
2.	Define Price Skimming.	**3**	**CO3**	**L1**
3.	List down the features of perfect competition?	**3**	**CO3**	**L1**
4.	Define market structure.	**3**	**CO3**	**L1**
5.	Distinguish between collusive and non-collusive oligopoly.	**3**	**CO3**	**L2**

6.	Explain Kinked demand curve.	**3**	**CO3**	**L2**
7.	Explain product differentiation with an example.	**3**	**CO3**	**L2**
8.	Explain predatory pricing.	**3**	**CO3**	**L2**
9.	Explain cost plus and going rate pricing.	**3**	**CO3**	**L2**
10.	List down the different types of Non price competition under Oligopoly.	**7**	**CO3**	**L1**
11.	Distinguish between Monopoly and Oligopoly.	**7**	**CO3**	**L2**
12.	Distinguish between Monopolistic Competition and Perfect Competition.	**7**	**CO3**	**L2**
13.	Distinguish between Monopoly and Monopolistic Competition.	**7**	**CO3**	**L2**
14.	With the help of a diagram, explain equilibrium under Monopolistic Competition.	**7**	**CO3**	**L3**
15.	Explain kinked demand curve model.	**7**	**CO3**	**L3**
16.	With the help of a diagram, explain equilibrium under Perfect Competition.	**7**	**CO3**	**L3**
17.	Explain Pricing and the different methods of Pricing.	**7**	**CO3**	**L3**

Module 4

Sl. No.	**Question**	**Marks**	**CO**	**BL**
1.	Define Stock and Flow Concept.	**3**	**CO4**	**L1**
2.	List down the different sectors in an economy.	**3**	**CO4**	**L1**
3.	Define production boundary.	**3**	**CO4**	**L1**
4.	Define National Income.	**3**	**CO4**	**L1**
5.	Explain the method by which Central Bank controls inflation.	**3**	**CO4**	**L2**
6.	Distinguish between Money Market and Capital Market.	**3**	**CO4**	**L3**
7.	Distinguish between final goods and intermediate goods.	**3**	**CO4**	**L3**
8.	List down the different methods used to control Inflation.	**7**	**CO4**	**L1**
9.	List down the different sources of Business Finance.	**7**	**CO4**	**L1**
10.	Explain the different concepts of National Income.	**7**	**CO4**	**L2**
11.	Explain the different methods of measuring National Income.	**7**	**CO4**	**L2**

12.	From the data given below estimate the NDP, using income method and expenditure method. Items (Rs .Crores) Consumption expenditure 3000 Investment expenditure 2000 Government expenditure 700 Exports 600 Import 300 Intermediate Consumption 2000 Wages and salaries 2000 Rent 500 Interest 500 Profit 1000	**7**	**CO4**	**L3**
13.	Explain Circular flow of income in two sector model and four sector model.	**7**	**CO4**	**L3**
14.	From the data given below estimate Gross National Product, Net National Product and National income. GDP 5000 (in 100 billion) NFIA -50 Indirect tax 70 Subsidies 20 Depreciation 30	**7**	**CO4**	**L3**

Module 5

Sl. No.	**Question**	**Marks**	**CO**	**BL**
1.	Define Free Trade	3	**CO5**	**L1**

2.	Define Devaluation.	3	**CO5**	**L1**
3.	Define Balance of Payments.	3	**CO5**	**L1**
4.	Define devaluation.	3	**CO5**	**L1**
5.	Differentiate between Free Trade and Protection	3	**CO5**	**L2**
6.	Explain Free Trade and its advantages.	3	**CO5**	**L2**
7.	Explain the Hecksher Ohlin Theory of International Trade.	3	**CO5**	**L2**
8.	List down the components of Balance of Payments.	3	**CO5**	**L3**
9.	Point out any three items coming under unilateral transfers account.	3	**CO5**	**L3**
10.	Define international trade? List out the advantages of Foreign trade?	7	**CO5**	**L1**
11.	List down the arguments in favour of free trade?	7	**CO5**	**L1**
12.	Explain tariff barriers and its impact on the economy.	7	**CO5**	**L2**
13.	Explain Absolute advantage theory with the help of an example.	7	**CO5**	**L2**
14.	Explain the Comparative Cost advantage theory with an example.	7	**CO5**	**L2**
15.	Explain the Hecksher Ohlin Theory of International Trade with an example.	7	**CO5**	**L2**
16.	Explain the terms, Liberalization, Privatization and Globalization.	7	**CO5**	**L3**
17.	Evaluate the success or failure of devaluation when the demand for import is more elastic or less elastic.	7	**CO5**	**L3**

Prepared By: ROSE PAUL

Checked By : **DR. JUDE MARTIN MENDEZ**

Approved By : Name and dated signature of Vice Principal Academics

Course Code & Name:	MCN301 - Disaster Management

1. Prescribed Syllabus

Module	Topic	Hours
1	Systems of earth, Lithosphere- composition, rocks, soils; Atmosphere-layers, ozone layer, greenhouse effect, weather, cyclones, atmospheric circulations, Indian Monsoon hydrosphere- Oceans, inland water bodies; biosphere.Definition and meaning of key terms in Disaster Risk Reduction and Management-disaster, hazard, exposure, vulnerability, risk, risk assessment, risk mapping, capacity, resilience, disaster risk reduction, disaster risk management, early warning systems, disaster preparedness, disaster prevention, disaster mitigation, disaster response, damage assessment, crisis counselling, needs assessment.	8
2	Hazard types and hazard mapping; Vulnerability types and their assessment- physical, social, economic and environmental vulnerability. Disaster risk assessment –approaches, procedures	5
3	Disaster risk management -Core elements and phases of Disaster Risk Management Measures for Disaster Risk Reduction – prevention, mitigation, and preparedness. Disaster response- objectives, requirements; response planning; types of responses. Relief, international relief organizations.	5
4	Participatory stakeholder engagement; Disaster communication- importance, methods, barriers, Crisis counselling Capacity Building: Concept – Structural and Non-structural Measures, Capacity Assessment; Strengthening Capacity for Reducing Risk	5
5	Common disaster types in India, Legislations in India on disaster management; National disaster management policy; Institutional arrangements for disaster management in India. The Sendai Framework for Disaster Risk Reduction- targets, priorities for action, guiding principles.	5

2. Text Books (T)

T1. R. Subramanian, Disaster Management, Vikas Publishing House, 2018
T2. M. M. Sulphey, Disaster Management, PHI Learning, 2016
T3. UNDP, Disaster Risk Management Training Manual, 2016
T4. United Nations Office for Disaster Risk Reduction, Sendai Framework for Disaster Risk

3. Reference Books (R)

R1. Andrew, S., "Environmental Modeling with GIS and Remote Sensing", John Willey, 2002
R2. Ariyabandu, M. and Sahni P. "Disaster Risk Reduction in South Asia", Prentice-Hall (India), 2003.
R3. Bell, F.G., "Geological Hazards: Their assessment, avoidance and mitigation", E
R4. Bossler, J.D., "Manual of Geospatial Science and Technology", Taylor and Francis, 2001
R5. David Alexander, "Natural Disasters", Research Press, New Delhi, 1993.

4. Course Objectives

The objective of this course is to introduce the fundamental concepts of hazards and disaster management.

5. Course Pre / Co-requisite

Nil

6. Course Outcomes

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

CO1: Define and use various terminologies in use in disaster management parlance and organize each of these terms in relation to the disaster management cycle (Cognitive knowledge level: Understand).
CO2: Distinguish between different hazard types and vulnerability types and do vulnerability assessment (Cognitive knowledge level: Understand).
CO3: Identify the components and describe the process of risk assessment, and apply appropriate methodologies to assess risk (Cognitive knowledge level: Understand).
CO4: Explain the core elements and phases of Disaster Risk Management and develop possible measures to reduce disaster risks across sector and community (Cognitive knowledge level: Apply)
CO5: Identify factors that determine the nature of disaster response and discuss the various disaster response actions (Cognitive knowledge level: Understand).
CO6: Explain the various legislations and best practices for disaster management and risk reduction at national and international level (Cognitive knowledge level: Understand).

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO 1		M				M				M		M			
CO 2	M	H	M		M	M	H			H		M			
CO 3	M	H	M	M	M	M	H			H		M		M	
CO 4	H	H	H		M	M	H					M		M	
CO 5	H	H			M	M	H					M		M	

8. Justification for CO-PO-PSO Correlation

CO1	PO2: Identifying and understanding terminologies and processes in disaster management help the students to arrive at sustained conclusions on problems.
	PO6: Understanding the processes involved in various disasters and applying various reasoning will enable students to specify the safety and health issues in the respective field of work in the context of a disaster occurred.
	PO10: Communication with engineers and society will help the student to work individually or in a team in the case of a disaster and to take effective measures in disaster prevention, mitigation and preparedness.
	PO12: Lifelong learning and independent decision making help the student to work effectively during a disaster
CO2	PO1: Applying the knowledge of basics of disaster management will help the student to distinguish between the different types of hazards.
	PO2: Understanding the concepts of various disasters will enable students to suggest measures taken to mitigate and contain common episodes of disasters for the safety and health of society.
	PO3: Selecting the processes that meet specified needs with public safety, environmental considerations will help the student to prepare vulnerability assessment efficiently.
	PO5 Selecting appropriate techniques in disaster management will help the student to determine the disaster management cycle and assessment.
	PO7: Understanding the concept of disaster management will help the student to understand the sustainable solutions in the case of a disaster.

	PO10: Idea about vulnerability and its assessment involved in natural and anthropogenic disasters will enable the students to act proactive in the case of disaster.
	PO12: Improving the technological knowledge will help the student to distinguish between different hazard types.
CO3	PO1: Applying the knowledge of basics of disaster management will help the student to apply suitable methodologies for assessing the risk.
	PO2: Understanding the concepts of various disasters will enable students to describe the process of risk assessment
	PO3: Selecting the processes that meet specified needs with public safety, environmental considerations will help the student to do the risk assessment
	PO4: Research based knowledge and information make the student capable of doing the risk assessment effectively.
	PO5: Applying suitable techniques will help the student to select suitable methodologies of risk assessment.
	PO6: Potential knowledge and concepts of disaster management learnt will help the students to make effective planning for disaster management for the benefit of safety and health of society.
	PO7 Understanding the impacts of solutions in societal and environmental contexts will help the student to do the risk assessment.
	P10: Knowledge and concepts of disaster management will help the student to work individually or in a team in the case of a disaster.
	PO12: Knowledge and concepts of disaster management will enable the students to act proactive in the case of disaster.
	PSO2 modelling and analysing the real time problems make the student capable of selecting suitable methodologies of risk assessment.
CO4	PO1: Applying the knowledge in science and engineering will help the student for find the solution of risk associated with the disaster.
	PO2: Identifying, analysing and formulating the complex engineering problems will help the student to reach conclusions and preventive measures to reduce disaster risk.
	PO3: Development of solutions will help the student to arrive at conclusions considering the public health and safety. Environmental considerations in the occurrence of a disaster.
	PO5 Create, select and apply appropriate techniques will help the student to reduce the risk associated with a disaster
	PO6 Applying reasoning and other engineering techniques will help the student to develop possible measures to reduce disaster risk
	PO7: Understanding the impact of disaster will help the student to find solutions

	in societal and environmental contexts and thereby achieving sustainable development.
	PO12: Knowledge and concepts of disaster management will enable the students to explain the core elements and phases in disaster risk management.
	PSO2: modelling and analysing the real time problems make the student capable to develop different measures to reduce risk associated with disaster.
CO5	PO1: Applying the knowledge in science and engineering will help the student to identify the nature of disaster and discuss various disaster responses.
	PO2: Identifying, analysing and formulating the complex engineering problems will help the student to select the response actions related to disaster
	PO5: Create, select and apply appropriate techniques will help the student to reduce the risk associated with a disaster.
	PO6: Applying reasoning and other engineering techniques will help the student to identify the factors determining the nature of disaster responses.
	PO7: Understanding the impacts of solutions in societal and environmental contexts will help students to effectively do the disaster responses.
	PO12: Knowledge and concepts of disaster management will enable the students to act proactive in the case of disaster
	PSO2: Modelling and analysing the real time problems make the student capable to determine the nature of disaster responses
CO6	PO1: Applying the knowledge in science and engineering will help the student to know the best practices in disaster management and reducing the risk.
	PO6: Applying reasoning and other engineering techniques will help the student to select best practices of disaster management
	PO7: Understanding the impact of engineering solutions will help the student to take effective measures of disaster management.
	PO8: Understanding the professional ethics and responsibilities will help the student to be proactive during a disaster.
	PO12: Understanding the concepts of disaster management will help the student to identify the factors for the best practices in disaster management.
	PSO2: Modelling and analysing the real time problems make the student capable of reducing the risk in national and international levels.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	Case studies	Case studies on disasters	PO6,PO9,PO12

11. Internal Assessment mark allocation (as per university curriculum)

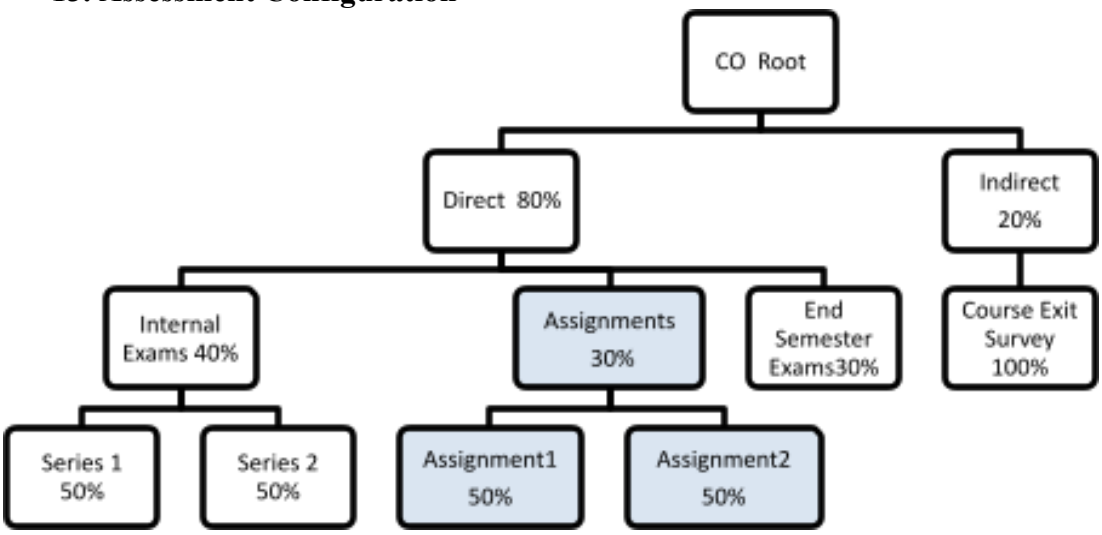
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s) / Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		Weightage	CO1	CO2	CO3	CO4	CO5	CO6
Direct Assessment Tools**	Internal Exam(s) 40%	Series 1	20%	x	x	x			
		Series 2	20%				x	x	x
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment1	15%	x	x	x			
		Assignment2	15%				x	x	x
	End Semester Exam		30%	x	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1	Lithosphere-composition, Atmosphere-layers,ozone layer,greenhouse effect,	1	T1	Lecture
2	Weather, cyclones, atmospheric circulations	1	T1	Lecture
3	Indian Monsoon,hydrosphere-Oceans, inland water bodies, biosphere	1	T1	Lecture
4	Definition and meaning of key terms in Disaster Risk Reduction and Management- disaster, hazard, exposure, vulnerability, risk, risk assessment	1	T1	Lecture
5	Risk mapping, capacity, resilience, disaster risk reduction	1	T1	Lecture
6	Disaster risk management, early warning systems, disaster preparedness	1	T1	Lecture
7	Disaster prevention, disaster mitigation, disaster response	1	T1	Lecture
8	Damage assessment, crisis counselling, needs assessment.	1	T1	Lecture
9	Hazard types and hazard mapping;	2	T2	Lecture

10	Vulnerability types and their assessment-physical,social	2	T2	Lecture
11	Economic and environmental vulnerability	2	T2	Lecture
11	Disaster risk assessment	2	T2	Lecture
12	Disaster approaches, procedures	2	T2	Lecture
13	Disaster risk management -Core elements and phases of Disaster Risk Management	3	T2	Lecture
14	Measures for Disaster Risk Reduction – prevention, mitigation, and preparedness.	3	T2	Case study
15	Disaster response- objectives, requirements;	3	T2	Lecture
16	Response planning; types of responses.	3	T2	Lecture
17	Relief; international relief organizations.	3	T2	Lecture
18	Participatory stakeholder engagement;	4	T3	Lecture
19	Disaster communication- importance, methods, barriers;	4	T3	Lecture
20	Crisis counselling	4	T3	Lecture
21	Capacity Building: Concept – Structural and Non-structural Measures, Capacity Assessment	4	T3	Lecture
22	Strengthening Capacity for Reducing Risk	4	T3	Lecture
23	Common disaster types in India	5	T3	Lecture
24	Legislations in India on disaster management	5	T3	Lecture
25	National disaster management policy	5	T3	Lecture
26	Institutional arrangements for disaster management in India.	5	T3	Lecture
27	The Sendai Framework for Disaster Risk Reduction- targets, priorities for action, guiding principles	5	T3	Lecture

15. Question Bank

Module 1				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	Explain about ozone layer depletion and greenhouse effect.	**3**	**CO1**	**L2**
2	Explain the following terms in the context of disaster management Exposure, Resilience, Disaster risk management, early warning systems, damage assessment, crisis counselling, needs assessment.	**14**	**CO1**	**L1**
3	Explain different atmospheric layers.	**3**	**CO1**	**L1**
4	Explain the two types of cyclones and their formations	**14**	**CO1**	**L1**
5	Define lithosphere	**3**	**CO1**	**L1**
6	Explain the different types of rocks and soils present in lithosphere	**14**	**CO1**	**L2**
7	Explain about different composition of lithosphere.	**3**	**CO1**	**L1**
8	Explain the terms hydrosphere and biosphere	**3**	**CO1**	**L1**
9	Discuss about disaster risk reduction and management steps.	**14**	**CO1**	**L2**
10	Differentiate between disaster and hazard.	**3**	**CO1**	**L1**
11	Differentiate between capacity and resilience	**3**	**CO1**	**L1**
12	Enumerate the different ways to deal with risk	**3**	**CO1**	**L1**
13	With the help of a neat diagram, explain the disaster management cycle	**14**	**CO1**	**L2**
14	Explain the core elements in disaster resilience.	**3**	**CO1**	**L2**
15	Differentiate between crisis and emergency.	**3**	**CO1**	**L2**
16	Explain the mechanism by which stratospheric ozone protects	**3**	**CO1**	**L2**

	earth from harmful UV rays.			
17	Explain the relevance and adverse effects of greenhouse gases.	**3**	**CO1**	**L2**
18	Discuss the two types of monsoon in Indian subcontinent.	**3**	**CO1**	**L2**
19	Categorize the various layers of atmosphere based on their distance from earth and explain the features of each layer with a neat diagram.	**8**	**CO1**	**L2**
20	Define the following terms: a) Disaster b) Hazard c)Risk	**6**	**CO1**	**L2**
21	State and explain crisis counselling. Identify the necessity of crisis counselling.	**8**	**CO1**	**L2**
22	Identify the reasons for the depletion of Ozone layer . Suggest two initiatives which can be implemented at home to prevent this.	**6**	**CO1**	**L2**
23	Differentiate between acceptable risk and residual risk.	**3**	**CO1**	**L2**
24	State the composition of lithosphere?	**3**	**CO1**	**L1**
25	Illustrate with diagram the layers of earth's atmosphere.	**8**	**CO1**	**L1**
26	State and explain the classification of rocks.	**6**	**CO1**	**L1**
27	State and explain the features of the hydrosphere and biosphere in detail.	**8**	**CO1**	**L1**
28	Explain the terms resilience, recovery and early warning systems with respect to disaster risk management.	**6**	**CO1**	**L2**
29	Define the term "biosphere" and describe the three main components that constitute it.	**3**	**CO1**	**L1**
30	What are disasters? What are their causes?	**3**	**CO1**	**L1**
31	Briefly explain Indian Monsoon and factors affecting Indian Monsoon?	**10**	**CO1**	**L2**
32	Explain greenhouse effect and global warming?	**4**	**CO1**	**L1**

33	Explain the following terms in the context of disaster management (a) Disaster Risk Management (b) Crisis Counselling (c) Exposure (d) Early Warning Systems (e) Damage Assessment (f) Resilience (g) Needs Assessment	**14**	**CO1**	**L1**
34	Describe the role of the ozone layer in the Earth's atmosphere and its significance for life on the planet.	**3**	**CO1**	**L2**
35	Explain the greenhouse effect and its impact on global climate. Provide examples of greenhouse gases.	**3**	**CO1**	**L2**
36	Classify the layers of Earth's atmosphere based on their distance from the surface and explain the distinctive features of each layer.	**10**	**CO1**	**L1**
37	Differentiate between disaster preparedness and disaster response.	**4**	**CO1**	**L2**
38	Differentiate between igneous, sedimentary, and metamorphic rocks. Provide examples of each.	**14**	**CO1**	**L2**
Module 2				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	Explain different categories of hazards with examples.	**3**	**CO2**	**L1**
2	Explain vulnerability and its types	**14**	**CO2**	**L1**
3	Enlist the data required for hazard mapping	**3**	**CO2**	**L1**
4	Discuss the cartographic representation of hazards.	**14**	**CO2**	**L2**
5	Explain hazard mapping using GIS method	**3**	**CO2**	**L2**
6	List the strategies for disaster risk management before, during, and after a disaster	**3**	**CO2**	**L1**

7	Explain the applications of hazard maps.	**3**	**CO2**	**L2**
8	Define participatory hazard mapping and explain its methodology.	**14**	**CO2**	**L1**
9	Explain about the two risk assessment methods.	**14**	**CO3**	**L1**
10	Enumerate the contemporary approaches to risk assessments	**3**	**CO3**	**L1**
11	Enumerate the methods of measuring physical vulnerabilities and socio economic vulnerabilities	**14**	**CO2**	**L1**

12	Explain the different approaches in vulnerability assessment	**14**	**CO2**	**L2**
13	Explain the data needed for vulnerability assessment and their usefulness.	**3**	**CO2**	**L1**
14	State the major data requirements of hazard mapping and the 3 sources for obtaining these data.	**3**	**CO2**	**L2**
15	State the principle of qualitative risk assessment and the method of expressing risk qualitatively.	**3**	**CO3**	**L2**
16	Define hazard mapping. Explain the two approaches of hazard mapping.	**8**	**CO2**	**L2**
17	In Kerala for the past 5 years. the average number of road accidents is 44076 per year and 1 death occurs in every 10 accidents. Considering the population as 3.33 crores, assess the risk of being killed in driving an automobile in terms of societal and individual risk.	**6**	**CO2**	**L3**
18	Explain the four different types of vulnerability. List any four socioeconomic indicators of human capital as livelihood asset.	**8**	**CO2**	**L2**
19	Outline the two major physical vulnerability assessment approaches.	**6**	**CO2**	**L2**
20	Explain physical vulnerability and ecological vulnerability.	**3**	**CO2**	**L2**
21	Define disaster deficit index.	**3**	**CO2**	**L1**

22	Explain the applications of hazard maps.	**8**	**CO2**	**L2**
23	Explain the methods of representing vulnerability.	**6**	**CO2**	**L1**
24	Explain the method of expressing population risk.	**5**	**CO2**	**L2**
25	List the components of risk assessment. Explain the contemporary approaches to risk assessment.	**9**	**CO3**	**L2**
26	Define the term "hazard" and provide examples of natural and human-made hazards.	**3**	**CO2**	**L1**
27	Define vulnerability in the context of disasters.	**3**	**CO2**	**L1**
28	Explain the types of vulnerabilities and approaches to assess them.	**10**	**CO2**	**L1**
29	Explain the application of hazard maps.	**4**	**CO2**	**L2**
30	Describe in detail the approaches and procedures involved in disaster risk assessment.	**14**	**CO3**	**L2**
31	Explain the significance of hazard mapping in disaster risk management.	**3**	**CO2**	**L2**
32	Define Natural Hazards and provide examples.	**3**	**CO2**	**L1**
33	Explain the types of vulnerabilities and approaches to assess them.	**10**	**CO2**	**L2**
34	Outline the two major physical Vulnerability assessment approaches.	**4**	**CO2**	**L1**
35	List the components of risk assessment Explain the contemporary approaches to risk assessment.	**10**	**CO3**	**L2**
36	Explain the application of hazard maps.	**4**	**CO2**	**L2**

Module 3

Sl. No.	Question	Marks	CO	BL
1	Define disaster risk management.	**3**	**CO4**	**L1**

2	With the help of a block diagram, explain disaster risk management.	**3**	**CO4**	**L1**
3	Define disaster risk reduction	**3**	**CO4**	**L1**
4	Explain the disaster risk reduction measures in detail.	**3**	**CO4**	**L2**
5	Define disaster prevention	**3**	**CO4**	**L1**
6	Define disaster mitigation	**3**	**CO4**	**L1**
7	Define disaster preparedness	**3**	**CO4**	**L1**
8	Explain the objectives of disaster response	**3**	**CO5**	**L2**
9	Explain disaster response	**3**	**CO5**	**L1**
10	Explain the two types of disaster prevention	**3**	**CO4**	**L1**
11	What are the primary objectives of disaster mitigation	**3**	**CO4**	**L2**
12	Explain the two types of disaster mitigation	**3**	**CO4**	**L1**
13	What are the mitigation functions provided by the ecosystem	**3**	**CO4**	**L3**
14	List out the components of a disaster preparedness strategy.	**3**	**CO4**	**L1**
15	Explain the different types of disaster preparedness.	**3**	**CO4**	**L1**
16	What are the factors that determine the nature of disaster response.	**3**	**CO5**	**L2**
17	Explain the requirement for an effective response.	**3**	**CO5**	**L2**
18	Explain the rationale for disaster response.	**4**	**CO5**	**L2**
19	Explain any five disaster response activities in detail.	**10**	**CO5**	**L1**
20	Define relief and explain different relief activities.	**3**	**CO5**	**L1**
21	With the help of a neat diagram explain PCM linked to relief.	**3**	**CO5**	**L2**
22	State the different types of disaster response	**3**	**CO5**	**L1**
23	List six international relief organizations	**3**	**CO5**	**L1**

24	Explain the core elements of disaster risk management.	**10**	**CO4**	**L2**
25	State the requirements for effective disaster response.	**4**	**CO5**	**L1**
26	Define the term ‘disaster risk reduction’. Explain the measures for disaster risk reduction.	**8**	**CO4**	**L1**
27	Define ‘relief’ in the context of disaster management. Identify the principles guiding relief.	**6**	**CO5**	**L2**
28	Explain psychosocial support related with disaster response.	**3**	**CO5**	**L1**
29	List any six public health services required in responding to disasters.	**3**	**CO5**	**L2**
30	State and explain the types of disaster mitigation measures.	**4**	**CO4**	**L1**
31	Identify the factors that determine the nature of disaster response and explain	**10**	**CO5**	**L2**

32	State and explain the types of disaster preparedness.	**6**	**CO4**	**L1**
33	Identify the standard operating procedures to be followed during a disaster stage and explain.	**8**	**CO5**	**L1**
34	Define the term ‘disaster preparedness.	**3**	**CO4**	**L1**
35	Define ‘relief’ in the context of disaster management.	**3**	**CO5**	**L1**
36	Explain the factors that decide the nature of disaster response.	**8**	**CO5**	**L2**
37	Explain disaster relief and international relief organizations.	**6**	**CO5**	**L1**
38	Explain the core elements of disaster risk management.	**7**	**CO4**	**L1**
39	Explain the different disaster response actions.	**7**	**CO5**	**L1**
40	Discuss the role of international relief organizations in disaster response and recovery.	**7**	**CO5**	**L2**

41	Describe different types of disaster responses.	**7**	**CO5**	**L2**
42	State and explain the types of disaster mitigation measures.	**7**	**CO4**	**L1**
43	Define the term ‘disaster risk reduction’.	**3**	**CO4**	**L1**
44	List the strategies for disaster risk management ‘before’, ‘during’ and ‘after’ a disaster	**3**	**CO4**	**L3**

Module 4

Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	Define the terms, stakeholder participation and stakeholder engagement.	**3**	**CO5**	**L1**
2	Explain the stakeholder analysis by grid method	**3**	**CO5**	**L3**
3	Explain the stakeholder analysis by salience method	**3**	**CO5**	**L3**
4	Explain the three types of stakeholders.	**3**	**CO5**	**L1**
5	Explain the basic steps of participatory stakeholder engagement.	**3**	**CO5**	**L1**
6	Enlist the potential benefits of increased stakeholder participation.	**3**	**CO5**	**L2**
7	Enlist the impacts of the absence of stakeholder participation.	**3**	**CO5**	**L2**
8	Explain about the different methods for participatory stake holder engagement.	**3**	**CO5**	**L2**
9	With the help of a neat diagram, explain the levels of stakeholder participation.	**3**	**CO5**	**L1**
10	Briefly explain the importance of communication in disaster risk reduction.	**8**	**CO5**	**L1**
11	What are the steps for an effective communication during a disaster.	**6**	**CO5**	**L1**
12	Enlist the barriers to effective communications.	**7**	**CO5**	**L1**
13	Distinguish between risk communication and crisis communication	**3**	**CO5**	**L2**

14	List the structural and nonstructural measures in capacity building	**3**	**CO5**	**L3**
15	Describe the effective ways of promoting stakeholder participation in disaster risk reduction. State its benefits.	**8**	**CO5**	**L3**
16	Explain the basic steps in participatory stakeholder engagement.	**6**	**CO5**	**L2**
17	Explain capacity building , relevance of capacity assessment and the different methods of assessing capacity in disaster risk management.	**10**	**CO5**	**L2**
18	State the barriers to effective communication in disaster management.	**4**	**CO5**	**L1**
19	Explain pyramid scheme related with participatory stakeholder engagement.	**3**	**CO5**	**L1**
20	How are stakeholders in disaster management identified?	**4**	**CO5**	**L1**
21	What are the steps to effective disaster communication? What are the barriers to communication?	**7**	**CO5**	**L2**
22	Briefly explain the levels of stakeholder participation in the context of disaster risk reduction?	**3**	**CO5**	**L2**
23	Define the terms counselling and crisis counselling.	**3**	**CO5**	**L1**
24	State and explain the basic principles of participatory rural appraisal tools.	**5**	**CO5**	**L2**
25	Explain the characteristics of effective crisis counsellors. State the advantages of crisis counselling.	**9**	**CO5**	**L1**
26	State and explain the steps for effective communication.	**8**	**CO5**	**L1**
27	Identify the barriers to effective communication.	**6**	**CO5**	**L1**
28	What are the advantages and drawbacks of involving stakeholders in disaster management?	**8**	**CO5**	**L2**
29	Explain capacity building in the context of disaster management.	**6**	**CO5**	**L2**

30	What is the process for identifying stakeholders in disaster management?	**5**	**CO5**	**L1**
31	How can one ensure effective disaster communication by outlining the necessary steps, and what obstacles or barriers to communication should be considered in this context?	**9**	**CO5**	**L2**
32	What distinguishes crisis counselling from regular counselling?	**3**	**CO5**	**L2**
33	Explain the importance of communication in disaster management.	**3**	**CO5**	**L1**
34	Why is crisis counselling important in the aftermath of a disaster, and how does it differ from regular counselling?	**3**	**CO5**	**L2**
35	Define the concept of capacity building in the context of disaster risk reduction.	**3**	**CO5**	**L2**
36	Explain the core elements of disaster risk management.	**7**	**CO5**	**L1**
37	Discuss the role of international relief organizations in disaster response and recovery.	**7**	**CO5**	**L2**

38	Describe different types of disaster responses.	**7**	**CO5**	**L1**
39	State and explain the types of disaster mitigation measures.	**7**	**CO5**	**L1**

Module 5

Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	State the legislations in India on disaster management	**3**	**CO6**	**L1**
2	Explain the interrelation of National Disaster Management Policy with other national policies.	**3**	**CO6**	**L1**
3	Explain the common disaster types in India.	**10**	**CO6**	**L2**
4	State the objectives and main elements of national disaster	**4**	**CO6**	**L1**

	management policy.			
5	State the targets, priorities and guiding principles of Sendai Framework for disaster risk reduction.	**8**	**CO6**	**L1**
6	Explain the institutional arrangement for disaster management in India	**6**	**CO6**	**L1**
7	Define man-made disasters and list examples from our country.	**3**	**CO6**	**L2**
8	Explain the role of National Institute of Disaster Management in our country.	**3**	**CO6**	**L2**
9	List the global targets of Sendai framework and explain.	**7**	**CO6**	**L1**
10	Explain the role, composition and responsibilities of National Disaster Management Authority.	**7**	**CO6**	**L1**
11	List the guiding principles of Sendai framework and explain.	**10**	**CO6**	**L1**
12	State the composition and role of National Executive Committee related with the National Policy on Disaster Management.	**4**	**CO6**	**L1**
13	What role do local governments play in implementing disaster management legislation in India?	**3**	**CO6**	**L1**
14	What are Tsunamis? How are they caused?	**3**	**CO6**	**L3**
15	Discuss the priorities for action identified in the Sendai Framework. How can these priorities be tailored to address the specific needs and challenges faced by India?	**9**	**CO6**	**L3**
16	What role do local governments play in implementing disaster management legislation in India.	**5**	**CO6**	**L2**
17	Discuss the key features and objectives of the National Disaster Management Policy in India. How does it guide the country in managing and reducing disaster risks?	**7**	**CO6**	**L3**

18	What are the most common types of disasters faced by India.	**7**	**CO6**	**L1**
19	What are the objectives of the National Disaster Management Policy?	**3**	**CO6**	**L1**
20	State the legislations in India on disaster management.	**3**	**CO6**	**L1**
21	What are the typical types of disasters that frequently occur in India?	**10**	**CO6**	**L2**

22	Explain the institutional arrangement for disaster management in India.	**4**	**CO6**	**L1**
23	Explain the guiding principles target and priorities for action according to the Sendai Framework for disaster risk reduction.	**14**	**CO6**	**L1**
24	Explain the salient features of the National Policy on Disaster Management in India	**8**	**CO6**	**L2**
25	Explain the guiding principles and priorities of action according to the Sendai framework for Disaster Risk Reduction.	**8**	**CO6**	**L2**
26	Explain the earthquake zonation of India	**3**	**CO6**	**L3**

Prepared By: Kuriakose V Thundiyil

Checked By: Dr. Bindumol T V

Approved By: Kanaka Xavier, VP Academics

Course Code & Name: MEL 331 MACHINE TOOLS LAB-II

1. Prescribed Syllabus

Sl. No.	EXPERIMENTS
1	Experiment on Grinding machine
2	Experiment on Measuring Instruments
3	Experiment on limit, fits, and tolreance
4	Experiments on Repeatability and Reproducibility
5	Experiments on linear measurements
6	Experiments on Straightness error measurement
7	Experiment on Angle Measurement
8	Experiment on Roundness Measuremen
9	Experiment on Screw thread Measurements
10	Experiment on Bore Measurements
11	Experiment on Gear Parameters
12	Experiment on Gear Parameters using tool maker's microscopy
13	Experiment on Gear Parameters surface measurement
14	Experiment on squareness measurement
15	Experiment on flatness measurement
16	Experiment on vibration measurement
17	Experiment on Rotation measuremnt
18	Experiment on CNC Machines
19	Experiment on Analysis of automobile exhaust gas and flue gas.

2. Text Books (T)

Nil

3. Reference Books (R)

R1. Yoram Koren, Numerical Control of Machine Tools, McGraw-Hill.
R2. Shotbolt C.R. and Gayler J.F.W, Metrology for Engineers, 5th edition, ELBS, London.
R3. Sharp K.W.B. and Hume, Practical Engineering Metrology, Sir Isaac Pitman and sons Ltd, London.
R4. Collett, C.V. and Hope, A.D, Engineering Measurements, Second edition, ELBS/Longman

4. Course Objectives

1. To learn the measurement of bores by internal micrometers, bore indicators, indirect methods etc.

2. To learn the measurement of the Angle and taper by Bevel protractor, Sine bars, indirect methods etc.

3. Allow to study the various limits, fits and tolerances adopted in the production drawings.

4. To learn to measure straightness, flatness, roundness, profile, screw threads and gear teeth.

5. To learn, to prepare programs for CNC machines and measurements in CMM. 7. Course Pre / Co-requisite

5. Course Pre / Co-requisite

MET 307 Machine Tools and Metrology

6. Course Outcomes

After completion of the course, student will be able to

CO1: Apply the procedures to measure length, angles, width, depth, bore diameters, internal and external tapers, tool angles, and surface roughness by using different instruments and by different indirect methods.

CO2: Determine limits and fits and allocate tolerances for machine components

CO3: CNC programming and to use coordinate measuring machine to record measurements of complex profiles with high sensitivity.

CO4: Use effective methods of measuring straightness, Squareness, flatness, roundness, profile, screw threads and gear teeth.

CO5: Securing knowledge of manufacturing components within the tolerance limit and surface roughness according to given drawings using various machine tools.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO 3
CO1	**H**												**M**		
CO2			**H**											**H**	
CO3				**H**										**H**	
CO4		**H**													
CO5					**H**										

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	**PO1**	High correlation is that the knowledge on the procedure to operate different instruments helps the student to measure length, angles, width, depth, bore diameters, internal and external tapers, tool angles, and surface roughness and solves the engineering problems.

	PSO1	Understanding of the mechanism and principles of measuring devices will help the students to carry out measurements accurately
CO2	**PO3**	High correlation is that for designing of components principles of limits and fits is essential. By applying the principles of limits fits and tolerances designing various system components will be possible
	PSO2	Understanding the principles of Limits, fits and tolerances and applying them in the process of design and manufacturing of mechanical components is possible so high correlation
CO3	**PO4**	High correlation is that by using research based knowledge in CNC programming and to use coordinate measuring machine to record measurements of complex profiles and with high sensitivity , the students will be able to analyse, interpret and synthesis the data that they obtained from the experiment and will make conclusions from the results.
	PSO2	After gaining knowledge in CNC part programming, students can work on CNC machines which is one of the modern technology used in most of the industries for machining operation so high correlation.
CO4	**PO2**	By using effective methods of measuring straightness, Squareness, flatness, roundness, profile, screw threads and gear teeth. High correlation is that parameters of engineering components like gear, tools, thread, etc. can be found out by using the knowledge and methods that the students gained from the lab.
CO5	**PO5**	High correlation is that the student will be able to use modern equipments available for measuring surface roughness, tool angles, gear parameters using roughness tester, tool makers microscope, profile projector thereby securing knowledge of manufacturing components within the tolerance limit and surface roughness.

9. Curricular gaps (if any)

NIL

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1			

11. Assessment Pattern (as per university curriculum)

Continuous Internal evaluation - 75 marks

End Semester Examination - 75 marks
Total - 50 marks

Evaluation criteria (as per syllabus)

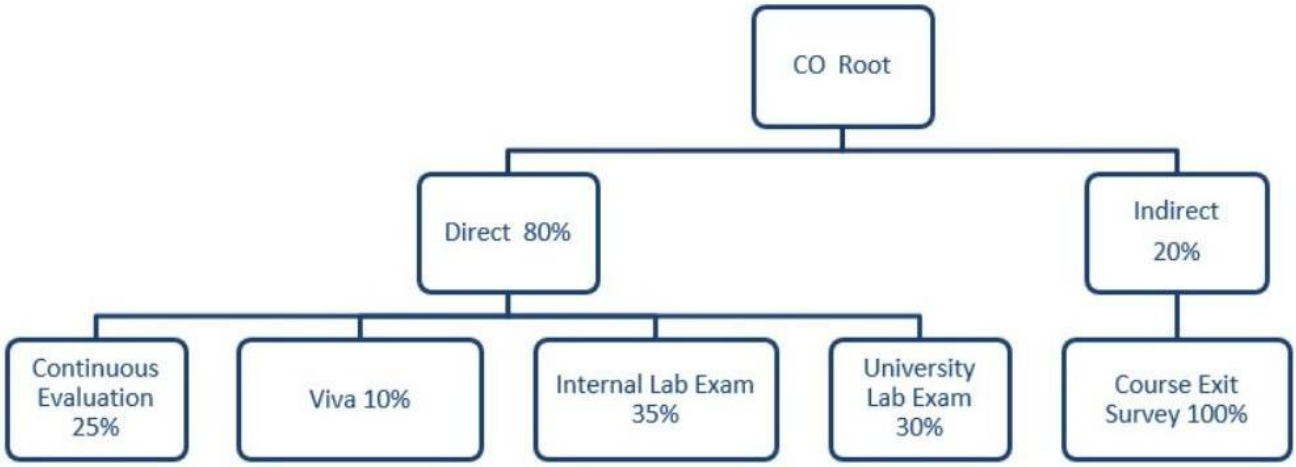
Sl. No.	Nature of Evaluation**	Evaluation Pattern**	Topics of Evaluation**	Duration**	Weightage of marks**
1.	**Continuous Internal evaluation (75 marks)**				
a.	Attendance	90%-100% - 15 marks 85% -90% - 13.5 marks 75% -85 % - 12 marks			20%
b.	Continuous Evaluation	Each experiment carries 10 marks for performance (record) and 10 marks for viva. Total no. of experiments : 12 Total – 120 marks will be converted to 20 while calculating internals	Each experiment	2.5 hours	40%
	Viva Voce	Each experiments carries 10 marks for viva. Total no. of experiments : 12 Total – 120 marks will be converted to 10 while calculating internals	Each experiment	2.5 hours	40%
c.	Internal Test	Preliminary Work – 10 marks Conducting Experiment – 10 marks Performance and Result – 5 marks Viva – 5 marks Total – 30 marks	All Experiments	2.5 hours	40%
2.	**End Semester Examination (75 marks)**				
a.	End semester Examination	(a) Preliminary work : 15 Marks (b) Implementing the work/ Conducting the experiment : 10 Marks (c) Performance, result and inference (usage of equipment's and troubleshooting) : 25 Marks (d) Viva voce : 20 marks (e) Record : 5 Marks	All Experiments	2.5 hours	50%

12. **Assessment – CO Mapping** (Put' x' if mapping is present)

	Tools**	Weightage#	CO1	CO2	CO3	CO4	CO5
Direct Assessment	Continuous Evaluation Experiment wise CO mapping	30%	x	x	x	x	x
	Viva – Voce Experiment wise CO mapping	10%	x	x	x	x	x

Tools	Internal Test	10%	x	x	x	x	x
	End Semester Exam – 50%	**50%**	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey	100%	x	x	x	x	x

13. Assessment Configuration



14.Course Plan

Weeks	Experiments	Relevance to COs
1	Experiment in grinding machines	CO1,CO5
2	Experiment on Vernier Calliper	CO1.CO2
3	Rotation Measurement test	CO5
4	Angular measurement	CO1
5	Roundness measurement of rod	CO4
6	Measurement of profile error and gear parameters using profile projectors	CO4
7	Calibration of LVDT	CO1,CO5
8	Vibration measurement	CO5
9	Screw thread measurement	CO4
10	Bore measurement	CO1
11	Programming and experiment on CNC Lathe	CO3
12	Programming and experiment on CNC Milling machine	CO3
Total No. Of Hours	36	

Prepared By : Nisha B Nairl, (Subject Faculty)

Checked By : Dr. Manoj Jose Kalathil (Subject group coordinator)

Approved By : Dr. Ramadas T (HOD - ME)

Course Code & Name: MEL333 Thermal Engineering Lab 1

1. Prescribed Syllabus

Sl No	Experiments
1	Determination of flash and fire points of petroleum fuels and oils
2	Determination of viscosity of lubricating oils and fuels and its variation with temperature
3	Determination of calorific value of solid and liquid fuels- Bomb Calorimeter
4	Determination of calorific value of gaseous fuels –Gas Calorimeter
5	Familiarisation of various systems and subsystems of petrol engine / MPFI engine
6	Familiarisation of various systems and parts of Diesel engine / Turbocharged engine
7	Performance test on petrol engines / MPFI engine
8	Performance test on Diesel engines / Turbocharged engine
9	Heat Balance test on petrol/Diesel engines
10	Determination volumetric efficiency and Air-fuel ratio of IC engines
11	Cooling curve of IC engines
12	Valve timing diagram of IC engines
13	Economic speed test on IC engines
14	Retardation test on IC engines
15	Morse test on petrol engine
16	Experiment to find flame temperature of premixed flames at different equivalence ratios and temperature of diffusion flames at different fuel flow rates.
17	Analysis of automobile exhaust gas and flue gas using exhaust gas analyser.
18	Performance test on reciprocating compressor
19	Performance test on rotary compressor/blower

2. Text Books (T)

T1. J.B.Heywood, I.C engine fundamentals, McGraw-Hill, 2017
T2. V. Ganesan, Fundamentals of IC engines, Tata McGraw-Hill, 2017

3. Reference Books (R)

R1. Stephen R Turns, An Introduction to Combustion: Concepts and Applications, McGraw-Hill, 2017

4. Course Objectives

The course is intended to impart basic understanding on the working of internal combustion engines. This includes various performance tests on internal combustion engines as well as makes the students familiar with the evaluation of fuel properties such as viscosity, flash and fire points, calorific value etc. which are key to any performance test.

5. Course Pre / Co-requisite

Should have undergone a course on Thermal Engineering with emphasis on IC engines

6. Course Outcomes

After the completion of the course the student will be able to

CO1: Measure thermo-physical properties of solid, liquid and gaseous fuels
CO2: Identify various systems and subsystems of Diesel and petrol engines
CO3: Analyse the performance characteristics of internal combustion engines
CO4: Investigate the emission characteristics of exhaust gases from IC Engines
CO5: Interpret the performance characteristics of air compressors / blowers

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	H		M	H			M		H	M		M	H		
CO2	H		M	H			M		H	M		M			H
CO3	H		M	H			M		H	M		M			H
CO4	H		M	H			M		H	M		M			H
CO5	H		M	H			M		H	M		M			H

8. Justification for CO-PO-PSO Correlation

CO1	PO1	Conducting experiments to measure thermo-physical properties of solid, liquid and gaseous fuels contributes to skills in solving engineering problems. High correlation is due to the fact that this involves in-depth knowledge of mathematics, science and engineering fundamentals to solve complex engineering problems.
	PO3	Formulating methods to measure thermo-physical properties of solid, liquid and gaseous fuels will help the students to design solutions for complex engineering problems. Medium correlation is due to the fact that this involves standard knowledge of design and development.
	PO4	Using research methods to measure thermo-physical properties of solid, liquid and gaseous fuels contributes to skills in conducting investigations of complex problems. High correlation is due to the fact that this involves in-depth knowledge of design of experients.
	PO7	Conducting experiments to measure thermo-physical properties of solid, liquid and gaseous fuels will help the students to understand the impact of environment

		and sustainability. Medium correlation is due to the fact that this involves standard knowledge of sustainable development.
	PO9	Conducting experiments as a team to measure thermo-physical properties of solid, liquid and gaseous fuels will help the students to work as a member of a team. High correlation is due to the fact that effective individual work is required in a team.
	PO10	Communication during the conduct of experiment will help the students to communicate effectively in a team and write effective reports and inferences.
	PO12	Conducting experiments to measure thermo-physical properties of solid, liquid and gaseous fuels will help the students to understand the broadest context of technological change.
	PSO1	Conduct of detailed investigations on solid, liquid and gaseous fuels and the evaluation of its thermo-physical properties helps in developing sustainable solutions to thermal engineering problems. High correlation is due to the fact that this involves lifelong learning of engineering solutions.
CO2	**PO1**	Conducting experiments to identify various systems and subsystems of Diesel and petrol engines contributes to skills in solving engineering problems. High correlation is due to the fact that this involves in-depth knowledge of mathematics, science and engineering fundamentals to solve complex engineering problems.
	PO3	Formulating methods to identify various systems and subsystems of Diesel and petrol engines will help the students to design solutions for complex engineering problems. Medium correlation is due to the fact that this involves standard knowledge of design and development.
	PO4	Using research methods to identify various systems and subsystems of Diesel and petrol engines contributes to skills in conducting investigations of complex problems. High correlation is due to the fact that this involves in-depth knowledge of design of experients.
	PO7	Conducting experiments to identify various systems and subsystems of Diesel and petrol engines will help the students to understand the impact of environment and sustainability. Medium correlation is due to the fact that this involves standard knowledge of sustainable development.
	PO9	Conducting experiments as a team to identify various systems and subsystems of Diesel and petrol engines will help the students to work as a member of a team. High correlation is due to the fact that effective individual work is required in a team.
	PO10	Communication during the conduct of experiment will help the students to communicate effectively in a team and write effective reports and inferences.
	PO12	Conducting experiments to identify various systems and subsystems of Diesel and petrol engines will help the students to understand the broadest context of technological change.
	PSO3	Conduct of detailed investigations on various systems and subsystems of Diesel and petrol engines helps in developing sustainable solutions to thermal engineering problems. High correlation is due to the fact that this involves the principles of mathematics, science and engineering.
CO3	**PO1**	Conducting experiments to analyse the performance characteristics of internal combustion engines contributes to skills in solving engineering problems. High correlation is due to the fact that this involves in-depth knowledge of

		mathematics, science and engineering fundamentals to solve complex engineering problems.
	PO3	Formulating methods to analyse the performance characteristics of internal combustion engines will help the students to design solutions for complex engineering problems. Medium correlation is due to the fact that this involves standard knowledge of design and development.
	PO4	Using research methods to analyse the performance characteristics of internal combustion engines contributes to skills in conducting investigations of complex problems. High correlation is due to the fact that this involves in-depth knowledge of design of experients.
	PO7	Conducting experiments to analyse the performance characteristics of internal combustion engines will help the students to understand the impact of environment and sustainability. Medium correlation is due to the fact that this involves standard knowledge of sustainable development.
	PO9	Conducting experiments as a team to analyse the performance characteristics of internal combustion engines will help the students to work as a member of a team. High correlation is due to the fact that effective individual work is required in a team.
	PO10	Communication during the conduct of experiment will help the students to communicate effectively in a team and write effective reports and inferences.
	PO12	Conducting experiments to analyse the performance characteristics of internal combustion engines will help the students to understand the broadest context of technological change.
	PSO3	Conduct of detailed investigations on the performance characteristics of internal combustion engines helps in developing sustainable solutions to thermal engineering problems. High correlation is due to the fact that this involves the principles of mathematics, science and engineering.
CO4	**PO1**	Conducting experiments to investigate the emission characteristics of exhaust gases from IC Engines contributes to skills in solving engineering problems. High correlation is due to the fact that this involves in-depth knowledge of mathematics, science and engineering fundamentals to solve complex engineering problems.
	PO3	Formulating methods to investigate the emission characteristics of exhaust gases from IC Engines will help the students to design solutions for complex engineering problems. Medium correlation is due to the fact that this involves standard knowledge of design and development.
	PO4	Using research methods to investigate the emission characteristics of exhaust gases from IC Engines contributes to skills in conducting investigations of complex problems. High correlation is due to the fact that this involves in-depth knowledge of design of experients.
	PO7	Conducting experiments to investigate the emission characteristics of exhaust gases from IC Engines will help the students to understand the impact of environment and sustainability. Medium correlation is due to the fact that this involves standard knowledge of sustainable development.
	PO9	Conducting experiments as a team to investigate the emission characteristics of exhaust gases from IC Engines will help the students to work as a member of a team. High correlation is due to the fact that effective individual work is required in a team.

	PO10	Communication during the conduct of experiment will help the students to communicate effectively in a team and write effective reports and inferences.
	PO12	Conducting experiments to measure investigate the emission characteristics of exhaust gases from IC Engines will help the students to understand the broadest context of technological change.
	PSO3	Conduct of detailed investigations on investigate the emission characteristics of exhaust gases from IC Engines helps in developing sustainable solutions to thermal engineering problems. High correlation is due to the fact that this involves the principles of mathematics, science and engineering.
CO5	**PO1**	Conducting experiments to interpret the performance characteristics of air compressors / blowers contributes to skills in solving engineering problems. High correlation is due to the fact that this involves in-depth knowledge of mathematics, science and engineering fundamentals to solve complex engineering problems.
	PO3	Formulating methods to interpret the performance characteristics of air compressors / blowers will help the students to design solutions for complex engineering problems. Medium correlation is due to the fact that this involves standard knowledge of design and development.
	PO4	Using research methods to interpret the performance characteristics of air compressors / blowers contributes to skills in conducting investigations of complex problems. High correlation is due to the fact that this involves in-depth knowledge of design of experients.
	PO7	Conducting experiments to interpret the performance characteristics of air compressors / blowers will help the students to understand the impact of environment and sustainability. Medium correlation is due to the fact that this involves standard knowledge of sustainable development.
	PO9	Conducting experiments as a team to interpret the performance characteristics of air compressors / blowers will help the students to work as a member of a team. High correlation is due to the fact that effective individual work is required in a team.
	PO10	Communication during the conduct of experiment will help the students to communicate effectively in a team and write effective reports and inferences.
	PO12	Conducting experiments to interpret the performance characteristics of air compressors / blowers will help the students to understand the broadest context of technological change.
	PSO3	Conduct of detailed investigations on the performance characteristics of air compressors / blowers helps in developing sustainable solutions to thermal engineering problems. High correlation is due to the fact that this involves the principles of mathematics, science and engineering.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs

11. Assessment Pattern (as per university curriculum)

(Provide details as mentioned in syllabus)

Continuous Internal evaluation - 75 marks

End Semester Examination - 75 marks

Total -150 marks

Evaluation criteria (as per syllabus)

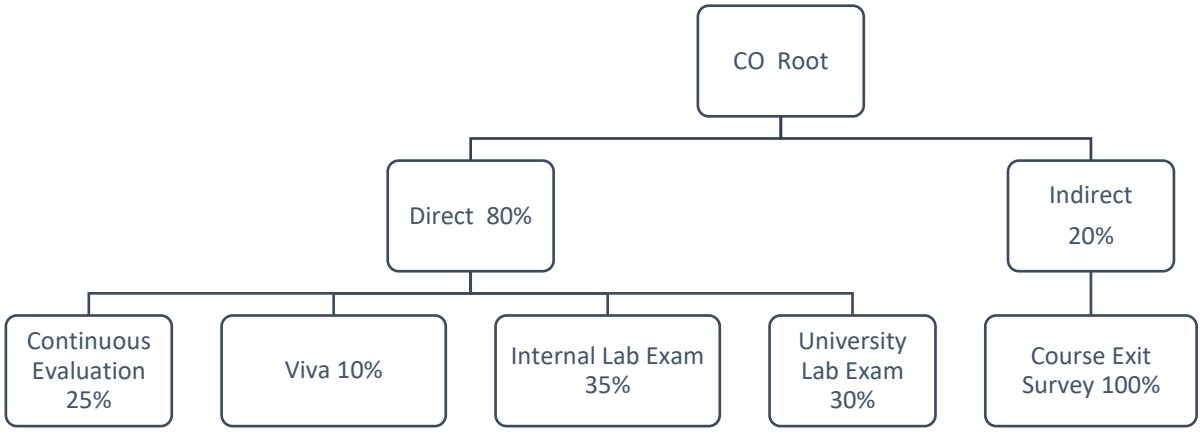
Sl. No	Nature of Evaluation	Evaluation Pattern	Topics of Evaluation	Duration	Weightage of marks
1.	**Continuous Internal evaluation (75 marks)**				
a.	Attendance	90%-100% - 15 marks 85% -90% - 13.5 marks 75% -85 % - 12 marks 70% - 75% - 10.5 marks 65% - 70% - 9 marks 60% - 65% - 7.5 marks	NA	NA	20%
b.	Continuous Assessment	20 marks for performance (Records) Total no. of experiments: 10 Total – 200 marks will be converted to 20 while calculating internals	Each experiment	2.5 hours	26.67%
c.	Viva Voce	10 marks for viva. Total no. of experiments: 10 Total – 100 marks will be converted to 10 while calculating internals	Each experiment	2.5 hours	13.33%
d.	Internal Test	Preliminary Work – 10 marks Conducting Experiment – 10 marks Performance and Result – 5 marks Viva – 5 marks Total – 30 marks	All Experiments	2.5 hours	40%
2.	**End Semester Examination (75 marks)**				
a.	End semester Examination	(a) Preliminary work: 15 Marks (b) Implementing the work/ Conducting the experiment: 10 Marks (c) Performance, result and inference (usage of equipment's and troubleshooting): 25 Marks (d) Viva voce: 20 marks (e) Record: 5 Marks	All Experiments	3 hours	100%

12. Assessment – CO Mapping (Put' x' if mapping is present)

	Tools	Weightage	CO1	CO2	CO3	CO4	CO5
Direct Assessment Tools	Continuous Evaluation Experiment wise CO mapping	25%	x	x	x	x	x

80%	Viva – Voce Experiment wise CO mapping	10%	x	x	x	x	x
	Internal Lab Exam	35%	x	x	x	x	x
	End Semester Exam – 50%	**50%**	x	x	x	x	x
Indirect Assessment Tool 20%	Course Exit Survey	100%	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Weeks (W)	Experiments	Relevance to COs
1	Familiarisation of various systems and subsystems of petrol and diesel engine	**CO2**
2	Load Test on Petrol Engine	**CO3, CO4**
3	Load Test on Diesel Engine	**CO3, CO4**
4	Performance Test on Centrifugal Blower Test Rig	**CO5**
5	Performance Test on Air Compressor Test Rig	**CO5**
6	Retardation Test on Diesel Engine	**CO3, CO4**
7	Valve Timing Diagram of 4-Stroke Diesel Engine	**CO2**
8	Heat Balance Test on Diesel Engine	**CO3, CO4**
9	Morse Test on Petrol Engine	**CO3, CO4**
10	Flash and Fire Point Test using Cleveland Apparatus	**CO1**
10	Flash and Fire Point Test using Pensky Marten's	**CO1**
11	Determination of viscosity using Saybolt Viscometer	**CO1**

12	Determination of viscosity using Redwood Viscometer	**CO1**
Total No. of Hours	36	

Prepared By : Prof. Jobin Jose, (Subject Faculty)

Checked By : Prof. Asha K.R (Subject group coordinator)

Approved By : Dr. Ramadas T (HOD - ME)

Semester: 6

Curriculum

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MET302	HEAT & MASS TRANSFER	3-1-0	4	4
B	MET304	DYNAMICS OF MACHINERY & MACHINE DESIGN	3-1-0	4	4
C	MET306	ADVANCED MANUFACTURING ENGINEERING	3-1-0	4	4
D	MET 312	NON-DESTRUCTIVE TESTING	2-1-0	3	3
E	HUT310	MANAGEMENT FOR ENGINEERS	3-0-0	3	3
F	MET308	COMPREHENSIVE COURSE WORK	1-0-0	1	1
S	MEL332	COMPUTER AIDED DESIGN & ANALYSIS LAB	0-0-3	3	2
T	MEL334	THERMAL ENGINEERING LAB-II	0-0-3	3	2
R/M/H	VAC	Remedial/Minor/Honours course	3-1-0	4*	4
TOTAL				25/29	23/27

Course Code & Name: MET302 Heat and Mass Transfer

1. Prescribed Syllabus

Module	Topic	Hours
1	CONDUCTION HEAT TRANSFER Introduction to heat transfer- thermodynamics and heat transfer- typical heat transfer situations- modes of heat transfer- mechanism of heat transfer- basic laws of heat transfer- thermal conductivity-effect of temperature on thermal conductivity- combined heat transfer mechanism-real life situations of combined heat transfer. Differential equations of heat conduction-boundary conditions and initial conditions, one dimensional steady state situations – plane wall, cylinder, sphere -concept of thermal resistance, critical radius, conduction with heat generation- Two-dimensional steady state situations, transient conduction, Lumped capacitance model, concept of Heisler chart and Schmidt Plot- Conduction shape factor-Numerical methods of analysis-thermal analysis of rectangular fins	12
2	Fundamentals, order of magnitude analysis of momentum and energy equations; hydrodynamic and thermal boundary Layers-Relation between fluid friction and heat transfer-Concepts of fluid mechanics, Differential equation of heat convection, Laminar flow heat transfer in circular pipe – constant heat flux and constant wall temperature, thermal entrance region, Turbulent flow heat transfer in circular pipe, pipes of other cross sections, Heat transfer in laminar flow and turbulent flow over a flat plate, Reynolds analogy, Flow across a cylinder and sphere- Natural convection- basics- free convection heat transfer on a vertical flat plate-empirical relations for free convection heat transfer.	10
3	HEAT EXCHANGERS Condensation heat transfer phenomena- the condensation Number-Boiling heat transfer Phenomena- Simplified relations for boiling heat transfer-Introduction to heat exchangers- types of heat exchangers-the overall heat transfer coefficient-Fouling factor-LMTD analysis of heat exchangers- effectiveness-NTU method-Analysis of variable properties-compact heat exchangers-heat exchanger design considerations.	7
4	RADIATION HEAT TRANSFER Physical mechanism of radiation heat transfer-Radiation properties-; Black body radiation Planck‟s law, Wein‟s displacement law, Stefan Boltzmann law, Kirchoff‟s law; Gray body Radiation shape factors-heat exchange between non -black bodies-Infinite parallel planes-Radiation combined with conduction and convection.	7
5	MASS TRANSFER Introduction to mass transfer- Molecular diffusion in fluids- Steady state molecular diffusion in fluids under stagnant and laminar flow conditions - Fick‟s law of diffusion-Types of solid diffusion- mass	9

	transfer coefficients in laminar and turbulent flows- Introduction to mass transfer coefficient- Equimolar counter-diffusion- Correlation for convective mass transfer coefficient- Correlation of mass transfer coefficients for single cylinder- Theories of mass transfer- Overall mass transfer coefficients.	

2. Text Books (T)

T1. Sachdeva R.C., Fundamentals of Engineering Heat and Mass Transfer, New Age Science Limited, 2009
T2. R.K.Rajput. Heat and mass transfer, S.Chand &Co., 2015 T3 Nag P.K., Heat and Mass Transfer, McGrawHill, 2011
T4 Kothandaraman C.P., Fundamentals of Heat and Mass Transfer, New Age International, New Delhi,2006

3. Reference Books (R)

R1 . Holman J.P, "Heat transfer", Mc Graw-Hill, 10th. Ed.,2009.
R2. Yunus A. Cengel, "Heat and Mass Transfer: Fundamentals and Applications" McGraw-Hill Higher Education; 6th edition, 2019.
R3. Frank P. Incropera and David P. Dewitt, Heat and Mass Transfer, John Wiley and sons, 2011

4. Course Objectives

- To introduce the various modes of heat transfer and to develop methodologies for solving a wide variety of practical heat transfer problems
- To provide useful information concerning the performance and design of simple heat transfer systems
- Conceive the energy balance in any thermal practical situation involving heat transfer Mechanisms.
- To introduce mass transfer.

5. Course Pre / Co-requisite

MET203 Mechanics of Fluids, MET202 Engineering Thermodynamics

6. Course Outcomes

After completion of the course the students will be able to:
CO1: Apply principles of heat and mass transfer to engineering problems
CO2: Analyse and obtain solutions to problems involving various modes of heat transfer CO3: Design heat transfer systems such as heat exchangers, fins, radiation shields etc.
CO4: Define laminar and turbulent boundary layers and ability to formulate energy equation in flow systems.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	H	H	M									L			H
CO2	H	H	H									M			H
CO3	H	H	H									M			H
CO4	H	H	H									M			H
CO5	H	H	M									L			H

8. Justification for CO-PO-PSO Correlation

CO1	**PO1:** High correlation is that it involves applying the knowledge in mathematics and Engineering fundamentals to solve simple problems involving the modes of heat and mass transfer. **PO2:** High relation is due to the fact that the Students can understand and analyse complex Engineering problems related to the modes of heat transfer and can reach substantiated conclusions using first principles of mathematics and Engineering. **PO3:** Medium mapping is due to that Students will be only able to apply basic principles of mathematics, science and engineering to design equipments involving the modes of heat and mass transfer. **PO12:** Low correlation is due to that has less lifelong learning ability in various modes of heat and mass transfer in the context of technological change. **PSO3:** High mapping is due to that by applying principles of mathematics, science and engineering the students will be able to understand and solve problems in heat and mass transfer
CO2	**PO1:** High correlation is due to fact that it involves applying the knowledge in mathematics and Engineering fundamentals to solve simple problems involving the various modes of heat transfer such as conduction, convection and radiation **PO2:** High mapping is due to the fact it helps the Students to understand and analyse complex Engineering problems related to the modes of heat transfer and can reach substantiated conclusions using first principles of mathematics and Engineering. **PO3:** High correlation is that Students will be able to apply basic principles of mathematics, science and engineering to design equipments working based on the modes of heat transfer. **PO12:** Medium correlation is that may have lifelong learning ability to the students in various modes of heat transfer in the context of technological change. **PSO3:** High correlation is that the Students will be able to apply principles of mathematics, science and engineering to explain and design of heat transfer process system.
CO3	**PO1:** High correlation is that it involves applying the knowledge in mathematics and Engineering fundamentals to solve simple problems related to various heat transfer systems such as heat exchangers, fins, radiation shields etc **PO2:** High correlation is due to the fact it helps the Students to understand and analyse complex Engineering problems involving the various heat transfer systems such as heat exchangers, fins, radiation shields etc and can reach substantiated conclusions using first principles of mathematics and Engineering. **PO3:** High correlation is due that Students will be able to apply basic principles of mathematics, science and engineering to design various heat transfer systems such as heat exchangers, fins, radiation shields etc **PO12:** Medium correlation is that may give lifelong learning ability to the students in to designing of various heat transfer systems such as heat exchangers, fins, radiation shields

	etc in the context of technological change. **PSO3:** High correlation is due to that by applying principles of mathematics, science and engineering the students will be able to design and analyse simple heat exchangers and fins and radiation shields and evaluate their performances.
CO4	**PO1:** High correlation is due to that it involves applying the knowledge in mathematics and Engineering fundamentals to define laminar and turbulent boundary layers and ability to formulate energy equation in the heat flow systems **PO2:** High correlation is due to the fact it helps the Students to understand and analyse complex Engineering problems involving laminar and turbulent boundary layers and can reach substantiated conclusions using first principles of mathematics and Engineering. **PO3:** High correlation is due to that Students will be able to apply basic principles of mathematics, science and engineering to formulate energy equation and design the heat flow systems **PO12:** Medium mapping is due that; it may give lifelong learning ability to the students in to designing of the heat flow systems in the context of technological change. **PSO3:** High correlation is that by applying principles of mathematics, science and engineering the students will be able to design and analyse the energy equation in the flow systems.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs

11. Internal Assessment mark allocation (as per university curriculum)

(Provide details as mentioned in syllabus)

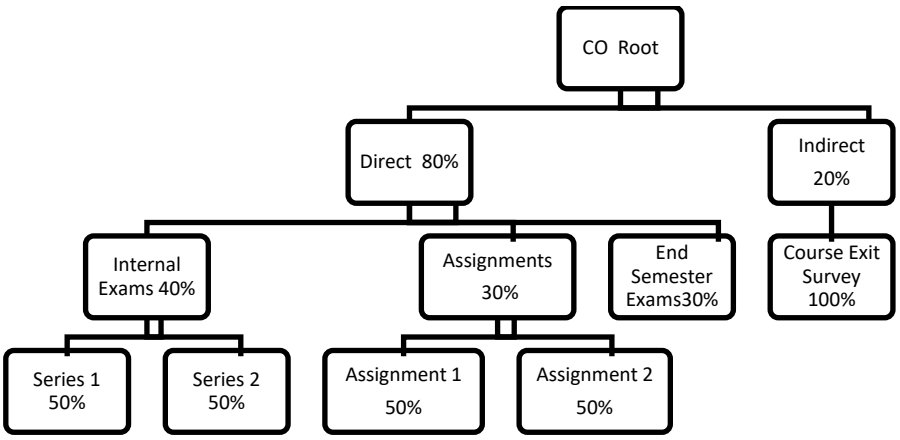
Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. Assessment – CO Mapping (Put‘ x’ if mapping is present)

	Tools		Weightage#	CO1	CO2	CO3	CO4
	Internal Exam(s)	Series 1	20%	x	x		

Direct Assessment Tools	40%	Series 2	20%			x	x
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x	x		
		Assignment 2	15%			x	x
	End Semester Exam		30%	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1	Introduction to heat transfer- thermodynamics and heat transfer typical heat transfer situations-	1	T1,T2,T3,T4	Lecture
2	modes of heat transfer- mechanism of heat transfer- basic laws of heat transfer	1	T1,T2,T3,T4	Lecture
3	Thermal conductivity-effect of temperature on thermal conductivity combined heat transfer mechanism-	1	T1,T2,T3,T4	Lecture
4	Differential equations of heat conduction-boundary conditions and initial conditions	1	T1,T2,T3,T4	Lecture
5	one dimensional steady state situations – plane wall	1	T1,T2,T3,T4	Lecture
6	Cylinder, sphere -concept of thermal resistance, critical radius	1	T1,T2,T3,T4	Lecture

7	Conduction with heat generation	1	T1,T2,T3,T4	Lecture
8	Two-dimensional steady state situations, transient conduction	1	T1,T2,T3,T4	Lecture
9	Lumped capacitance model, concept of Heisler chart and Schmidt Plot	1	T1,T2,T3,T4	Lecture
10	Conduction shape factor	1	T1,T2,T3,T4	Lecture
11	Numerical methods of analysis	1	T1,T2,T3,T4	Lecture
12	Thermal analysis of rectangular fins	1	T1,T2,T3,T4	Lecture
13	Fundamentals, order of magnitude analysis of momentum and energy equations	2	T1,T2,T3,T4	Lecture
14	Hydrodynamic and thermal boundary Layers	2	T1,T2,T3,T4	Lecture
15	Relation between fluid friction and heat transfer-Concepts of fluid mechanics	2	T1,T2,T3,T4	Lecture
16	Differential equation of heat convection, Laminar flow heat transfer in circular pipe – constant heat flux and constant wall temperature, thermal entrance region	2	T1,T2,T3,T4	Lecture
17	Turbulent flow heat transfer in circular pipe, pipes of other cross sections	2	T1,T2,T3,T4	Lecture
18	Heat transfer in laminar flow and turbulent flow over a flat plate,	2	T1,T2,T3,T4	Lecture
19	Reynolds analogy, Flow across a cylinder and sphere	2	T1,T2,T3,T4	Lecture
20	Natural convection- basics- free convection heat transfer on a vertical flat plate	2	T1,T2,T3,T4	Lecture
21	Empirical relations for free convection heat transfer.	2	T1,T2,T3,T4	Lecture
22	Condensation heat transfer phenomena- the condensation Number- Boiling heat transfer Phenomena	3	T1,T2,T3,T4	Lecture
23	Simplified relations for boiling	3	T1,T2,T3,T4	Lecture
24	Introduction to heat exchangers-types of heat exchangers-the overall heat transfer coefficient-Fouling factor	3	T1,T2,T3,T4	Lecture
25	LMTD analysis of heat exchangers-effectiveness	3	T1,T2,T3,T4	Lecture
26	NTU method-	3	T1,T2,T3,T4	Lecture
27	Analysis of variable properties	3	T1,T2,T3,T4	Lecture

28	Compact heat exchangers-heat exchanger design considerations	3	T1,T2,T3,T4	Lecture
29	Physical mechanism of radiation heat transfer-Radiation properties	4	T1,T2,T3,T4	Lecture
30	Black body radiation Planck‟s law, Wein‟s displacement law	4	T1,T2,T3,T4	Lecture
31	Stefan Boltzmann law, Kirchoff‟s law	4	T1,T2,T3,T4	Lecture
32	Gray body Radiation shape factors	4	T1,T2,T3,T4	Lecture
33	Heat exchange between non -black bodies-Infinite parallel planes-	4	T1,T2,T3,T4	Lecture
34	Introduction to mass transfer-Molecular diffusion in fluids	5	T1,T2,T3,T4	Lecture
35	Steady state molecular diffusion in fluids under stagnant and laminar flow conditions	5	T1,T2,T3,T4	Lecture
36	Fick‟s law of diffusion-Types of solid diffusion	5	T1,T2,T3,T4	Lecture
37	Mass transfer coefficients in laminar and turbulent flows	5	T1,T2,T3,T4	Lecture
38	Equimolar counter-diffusion-Correlation for convective mass transfer coefficien	5	T1,T2,T3,T4	Lecture
39	Correlation of mass transfer coefficients for single cylinder	5	T1,T2,T3,T4	Lecture
40	Theories of mass transfer	5	T1,T2,T3,T4	Lecture
41	Overall mass transfer coefficients	5	T1,T2,T3,T4	Lecture

15. Question Bank

Sl. No.	Question	Marks	CO	BL
	Module 1			
1	Write the general heat conduction equation in cylindrical coordinates.	3	CO1	L1
2	Explain the significance of critical radius of insulation.	3	CO1	L1
3	State Fourier law of conduction.	3	CO1	L1
4	How does transient heat transfer differ from steady heat transfer?	3	CO1	L1
5	Explain the terms: Efficiency and effectiveness of a fin.	3	CO1	L1
6	Discuss about the application of Heisler chart and Schmidt plot in heat transfer analysis.	3	CO1	L1
7	What are the assumptions considered in the formulation of Fourier law?	3	CO1	L1
8	Explain critical thickness of insulation	3	CO1	L1

9	What are the mechanisms of heat transfer? How are they distinguished from each other?	3	CO1	L1
10	List out the applications of heat transfer in engineering.	3	CO1	L1
12	Explain the term thermal diffusivity and its significance	3	CO1	L2
14	Write down the steady state heat conduction equation in Cylindrical coordinates without heat generation.	3	CO1	L1
15	Explain conduction mechanism of heat transfer	3	CO1	L1
16	Explain convection mechanism of heat transfer	3	CO1	L2
17	List out the 6 assumptions in Fourier's law	3	CO1	L1
18	What do you mean by critical radius of insulation over a cylindrical surface?	3	CO1	L2
19	Define Biot number. Give its formula and explain the terms. What is its relevance?	3	CO1	L1
20	Derive the general heat conduction equation in Cartesian coordinates. Reduce the equation for the following cases. I. Steady state conduction. II. Steady state, one dimensional heat transfer III. Steady state, one dimensional and without internal heat generation.	14	CO1	L2
21	Derive the general heat conduction equation in Cylindrical coordinates for an isotropic material	14	CO1	L2
22	A furnace wall consists of 200 mm layer of refractory brick and 6mm layer of steel plate and 100 mm layer of insulating fire brick The inner surface of the wall is at 11000C and the room temperature is 400C. An accurate energy balance over the furnace shows that the heat loss from the wall is 400W/m2. It is known that there is a thin layer of air between the layers of refractory bricks and steel plate . The thermal conductivities for the 3 layers are 1.52 W/mK, 45W/mK and 0.138W/mK respectively. Then Find	14	CO1	L3

	1. How many millimetres of the air layer is the insulation brick equivalent 2. What is the temperature of outer surface of the steel plate			
23	A storage tank fabricated from 20mm thick pyrex glass (K=1.4 W/mK) consists of a cylindrical section (length 2m and inner diameter 1m) and two hemispherical end sections. The tank is exposed to ambient air at 25^0C and having convective coefficient 50W/m^2K. The tank is used to store heated oil which keeps the inner surface of tank at 125^0C. Determine the electric power that needs to be supplied to the heater submerged in the oil so that the prescribed conditions can be maintained.	10	CO1	L1
24	A hollow sphere (k = 65 W/mK) of 120 mm inner diameter and 350 mm outer diameter is covered 10 mm layer of insulation (k =10 W/mK). The inside and outside temperatures are 500°C and 50°C respectively. Calculate the rate of heat flow through this sphere.	10	CO1	L2
25	Derive the general heat conduction equation in Cartesian coordinates	10	CO1	L3
26	What is heat flux? How is it related to the heat transfer rate?	5	CO1	L3
27	Explain the term thermal conductivity. List out the factors that affect the thermal conductivity.	3	CO1	L3
28	Consider a large 3 cm-thick stainless steel plate in which heat is generated uniformly at a rate of 5 x 106 W/m^3. Assuming the plate is losing heat from both sides, determine the heat flux on the surface of the plate during steady operation.	10	CO1	L3
29	Consider a large 5 cm thick brass plate (k =111 W/m. °C) in which heat is generated uniformly at a rate of 2 x 105 W/m^3. One side of the plate is insulated while the other side is exposed to an environment at 25°C with a heat transfer coefficient of 44 W/m^2 °C. Explain where in the plate the highest and the lowest temperatures will occur, and determine their values.	10	CO1	L3
30	A chemical reaction takes place in a cylinder (k= 0.6 W/m K) of inner radius 15mm and outer radius 45mm. The inner surface is at 580^0Cand it is insulated. Assuming the reaction rate of 0.55 MW/m^3 in the reactor volume, find the temperature at the outer surface of the reactor.	10	CO1	L3
31	A furnace wall consists of 120mm wide refractory brick and 120mm wide insulating fire brick separated by an air gap. The outside wall is covered with a 12mm thickness of plaster. The inner surface of the wall is at 1090^0C and the room temperature is 20^0C. The heat transfer coefficient from the outside wall surface to the air in the room is 18W/m^{20}C and the resistance to the heat flow of the air gap is 0.16k/w. If the thermal conductivities of the refractory brick, insulating fire brick and plaster are 1.6W/mK, 0.3W/mK and 0.14W/mK respectively, then calculate 1. Rate at which heat is lost per m^2 of wall surface.	14	CO1	L3

	2. Each interface temperature 3. Temperature of the outside surface of the wall.			
32	Steel balls 12 mm in diameter are annealed by heating to1150 K and then slowly cooling to 400 K in an air environment for which temperature $T\infty$ = 325 K and heat transfer coefficient, h =20 W/m2 K. Assume the properties of the steel to be the following. Thermal conductivity is 40W/mK, density is 7800 kg/m3, and specific heat is 600 J/kg K, estimate the time required for the cooling process.	10	CO1	L3
33	A rectangular aluminium fin of thermal conductivity 200 W/mK, 3mm thick and 7.5 cm long protrudes out from a wall. The fin base is maintained at a temperature of 300ºC and the ambient temperature is 50ºC with heat transfer coefficient 10W/m2K. The tip of the fin is insulated. Calculate the heat transfer from the fin per unit depth of material.	5	CO1	L3
34	An aluminium alloy fin (k = 200 W/mK) of 1 m width, 3.5 mm thick, and 2.5 cm long protrudes from a wall. The base is at 420°C, the ambient air temperature is 30°C and the heat transfer coefficient is 11 W/m2.K. Find the rate of heat loss and fin efficiency, if the fin tip is insulated.	10	CO1	L3
35	Derive equations of temperature distribution and heat dissipation for an infinitely long fin.	10	CO1	L3
36	A large plane wall of thickness L = 0.2 m, thermal conductivity k =1.2 W/m °C, and surface area A = 15 m2. The two sides of the wall are maintained at constant temperatures of T1 = 120°C and T2 = 50°C, respectively. Determine (a) the variation of temperature within the wall and the value of temperature at x = 0.1 m and (b) the rate of heat conduction through the wall under steady conditions.	10	CO1	L3
37	What is the criterion for treating a heat transfer problem as a lumped heat system	4	CO1	L1
38	An aluminium alloy fin (k= 200 W/m.K) with an insulated tip is 2 mm thick, 20mm wide and 10 cm long protrudes from a wall. The base is at 240 º C and ambient temperature is 30 º C. The heat transfer coefficient may be taken as 11 W/m2 K. Find the heat loss and fin efficiency.	10	CO1	L3
39	Differentiate between effectiveness and efficiency of a fin.	4	CO1	L1
	Module 2			
1	State the governing law of convection.	3	CO1	L1
2	What is meant by hydrodynamic boundry layer and thermal boundry layer?	3	CO4	L1
3	Discuss the significance Nusselt number and Prandtl number in convection	3	CO1	L1
4	Explain displacement thickness and momentum thickness.	3	CO1	L1
5	State Newton's law of cooling.	3	CO1	L1

6	Explain hydrodynamic boundry layer	3	CO1	L1
7	Discuss the significance Raleigh's number and Grashoff number in convection	3	CO1	L1
8	What are the characteristics of a boundary layer?	3	CO1	L1
9	Write the significance of Nusselt number.	3	CO1	L1
10	Explain Thermal boundry layer	3	CO1	L1
11	Explain the physical significance of a. Prandtl Number b. Nusselt Number	3	CO2	L1
12	Discuss the formation of thermal boundary layer formation over a flat plate.	3	CO4	L2
13	Explain thermal boundary layer thickness.	3	CO4	L2
14	List out the types of convection.	3	CO2	L1
15	Explain the physical significance of a. Reynolds Number b. Rayleigh Number	3	CO2	L2
16	Discuss the formation of hydrodynamic boundary layer formation over a flat plate.	3	CO4	L1
17	Explain hydrodynamic boundary layer thickness	3	CO4	L2
18	What is the physical significance of Prandtl number	3	CO4	L2
19	Give a briefing on the mechanism of natural convection with reference to the forces that come into play in it, with special reference to the non dimensional numbers that is involved in the determination of natural convection heat transfer coefficient.	3	CO2	L1
20	Draw the pool boiling curve of water at 1 atm and mark the major regimes.	4	CO2	L1
21	How does the heat transfer coefficient differ from thermal conductivity?	4	CO2	L1
22	Air at 40^0C flows over a flat plate 0.8m long and at a velocity of 50m/s. The plate surface is maintained at 300^0C. Determine the heat transferred from the entire plate length to air taking in to consideration both laminar and turbulent portion of the boundary layer. Also calculate the percentage error if the boundary layer is assumed to be turbulent nature from the very leading edge of the plate.	10	CO1, CO4	L1
23	Air at 20°C and atmospheric pressure flows over a flat plate at a velocity of 3 m/s. If the plate is 1 m wide and at 80^0C, calculate the following at x = 300 mm. I. Hydrodynamic boundary layer thickness II. Thermal boundary layer thickness III. Local friction coefficient IV. Average heat transfer coefficient V. Heat transfer rate	10	CO1	L3
24	By dimensional analysis, establish the functional relationship between the relevant non-dimensional numbers in the case of forced convection heat transfer.	10	CO1	L3
25	Derive an equation for free convection by the use of dimensional analysis $Nu=C(Pr)^n * (Gr)^m$	10	CO1	L3

26	Water at 30^0C, 20m/s flows through a straight tube of 60mm diameter. The tube surface is maintained at 70^0C and outlet temperature of water is 50^0C. Determine: I. Heat transfer coefficient from the tube surface to the water. II. Heat transferred. Tube length.	5	CO1	L3
27	Explain displacement thickness and momentum thickness.	3	CO1	L1
28	Air at 30^0C is flowing across a tube with a velocity of 25 m/s. The tube should be either a cylinder of dia. 5cm or a square with a side of 5cm. Compare the rate of heat transfer in each case if the tube surface temperature is 130^0C.	10	CO2	L3
29	State Newton's law of cooling.	3	CO1	L1
	A thin 100cm long and 10cm wide horizontal plate is maintained at a uniform temperature of 150^0C by constant heating, in a large tank full of water at 75^0C. Estimate the rate of heat to be supplied to the plate to maintain constant plate temperature as heat is dissipated from either side of the plate.	10	CO1	L2
30	Air at an atmospheric pressure and temperature of 200^0C flows over a plate with a velocity of 5m/sec. The plate is 15 mm wide and is maintained at a temperature of 120^0C. Calculate i. Boundary layer thickness ii. Thermal boundary layer thickness iii. Local friction coefficient iv. Local convective heat transfer coefficient v. Average convective heat transfer coefficient vi. Rate of heat transfer At a distance of 0.5 m from the leading edge. Assume the flow is on one side of the plate.	14	CO3	L3
31	A steam pipe of 10cm outside diameter runs horizontally in a room at 23^0C. Take the outside surface temperature of pipe as 165^0C. Determine the heat loss per meter length of the pipe.	8	CO2	L3
32		8	CO2	L3
33	Air at 40^0C flows over a tube with a velocity of 30 m/sec. The tube surface temperature is 120^0C. Calculate the heat transfer coefficient and rate of heat transfer per meter length for the following cases. i. Tube is a circular cylinder of diameter 6 cm. , ii. Tube is a square of side 6 cm.			
34	Water at 30^0C, 20 m/sec flows through a straight tube of 60 mm diameter. The tube surface is maintained at 70^0C and outlet temperature of water is 50^0C. Calculate i. The heat transfer coefficient from the tube surface to the water. ii. Heat transferred iii. Tube length.	14	CO2	L3
35	Air at 30 ^{o}C and 1 atm flows over a heated plate with a velocity of 2 m/s. The plate is at a uniform temperature of 90 ^{o}C. Calculate the heat transfer rate per unit width from the first 0.4 m of the plate. Also calculate the critical length, assuming a critical Reynolds Number of 5,00,000.	10	CO2	L3
36	Water at 20 ^{o}C enters a 2 cm diameter tube with a velocity of 1.5	10	CO2	L3

	m/s. The tube is maintained at 100 °C. Find the tube length required to heat the water to a temperature of 60 °C.			
	Module 3			
1	Distinguish between fin efficiency and fin effectiveness.	3	CO3	L1
2	Explain the terms fouling factor and LMTD correction factor.	3	CO3	L1
3	What are the main factors to be considered for a heat exchanger design?	3	CO3	L1
4	Classify types of heat exchangers	3	CO3	L1
5	What is meant by condensation heat transfer? How it differs from drop wise heat transfer?	3	CO3	L1
6	Explain Fouling of heat exchangers	3	CO3	L1
7	Distinguish between NTU method and LMTD method in analysis	3	CO3	L1
8	What are the applications of heat exchangers?	3	CO3	L1
9	Describe parallel flow heat exchanger	3	CO3	L1
10	Describe counter flow heat exchanger	3	CO3	L1
11	A counter flow single pass heat exchanger is used to cool the engine oil from 150^0C to 55^0C with water available at 23^0C as the cooling medium. The specific heat of oil is 2125 J/kgK. The flow rate of cooling water through the inner tube of 0.4m diameter is 2.2 kg/s. The flow rate of oil through the outer tube of 0.75m diameter is 2.4 kg/s. If the value of the overall heat transfer coefficient is 240 W/m^{2}K, calculate the length of the heat exchanger to meet its cooling requirement.	10	CO3	L1
12	Derive an expression for Log Mean Temperature Difference in the case of a counter flow heat exchanger.	10	CO3	L2
13	In a double pipe heat exchanger hot water flows at a rate of 14 kg/s and gets cooled from 370K to 340K. At the same time 14 kg/s of cooling water at 303K enters the heat exchanger. The flow conditions are such that overall heat transfer coefficient remains constant at 2270 W/m^{2}K. Determine the effectiveness and the heat transfer area required, assuming two streams are in parallel flow. Assume the specific heat for the both the streams = 4.2 kJ/kg K.	10	CO3	L2
14	A parallel flow heat exchanger is used to cool 4.2 kg/min of hot liquid of specific heat 3.5 kJ/kgK at 130^0C. Cooling water of specific heat 4.18 kJ/kgK is used for cooling purpose at a temperature of 15^0C. The mass flow rate of cooling water is 17 kg/min. Determine the following. I. Outlet temperature of liquid and water II. Effectiveness of heat exchanger	10	CO3	L3
15	Derive an expression for the effectiveness of a counter flow heat exchanger	10	CO3	L3
16	Derive an expression for the effectiveness of a parallel flow heat exchanger as a function of Number of Transfer Unit and Capacity Ratio.	10	CO3	L3
17	Hot fluid enters on the shell side of a 2 - 4 heat exchanger (2 shell pass & 4 tube pass) at 75^0C and leaves at 39^0C while the cold	10	CO3	L3

	fluid enters at 15^0C and leaves at 33^0C on the tube side. Calculate the correction factor for this heat exchanger.			
18	Water enters a Cross flow heat exchanger (both fluids unmixed) at 5^0C and flows at the rate of 4600 kg/hr. to cool 4000 kg/hr. of air that is initially at 40^0C. Calculate the exit temperatures of air and water if the surface area of the heat exchanger is 25 m^2.	10	CO3	L3
	Module 4			
1	Distinguish radiation from other modes of heat transfer.	3	CO3	L1
2	describe the laws governing radiation heat transfer	3	CO3	L1
3	Derive an equation for view factor of two arbitrarily oriented surfaces	3	CO3	L1
4	State and Explain Stefan-Boltzmann law	3	CO3	L1
5	State and explain Wein's displacement law and Kirchoff's law.	3	CO3	L1
6	Define Irradiation and Radiosity for a grey body	3	CO3	L1
7	Explain about radiation shape factor.	3	CO3	L1
8	What are the properties of blackbody?	3	CO3	L1
9	List out the laws in radiation	3	CO3	L1
10	Expalin on view factor	3	CO3	L1
11	Two large plates, one at 800K and other at 600K have emissivities 0.5 and 0.8 respectively. A radiation shield having an emissivity 0.1 on one side and emissivity 0.05 on the other side is placed between the plates. Calculate the heat transfer by radiation per square meter with and without the radiation shield.	6	CO3	L3
12	Two concentric cylinders of 300mm and 400mm diameter are kept at 400^0C and 300^0C respectively. Determine the radiation heat transfer for the following cases. 1. L=0.5m 2. L=Infinity	10	CO3	L3
13	Distinguish radiation from other modes of heat transfer. Also describe the laws governing radiation heat transfer	10	CO3	L1
14	With proper figure, derive an equation for view factor of two arbitrarily oriented surfaces and arrive at the reciprocity relation.	8	CO3	L1
15	Calculate the net radiant heat exchange per m^2 area for two large parallel plates at temperature of 427^0C and 27^0C respectively. The emissivities of hot and cold plates are 0.9 and 0.6 respectively. Also determine the percentage of reduction in the heat transfer if a polished aluminium shield of emissivity 0.4 is paced between them.	10	CO3	L3
16	Emissivity's of two large parallel plates maintained at 8000C and 3000C are 0.3 and 0.5 respectively. Find the net radiant heat exchange per unit area for these plates. Find the percentage reduction in heat transfer when a polished aluminum radiation shield of emissivity 0.05 is placed between them.	10	CO3	L3
17	A long steel rod 2cm dia. is to be heated from 425^0C to 550^0C. It is placed concentrically in a long cylindrical furnace which has an inside dia. of 15cm. The inner surface of the furnace is at a temperature of 1000^0C and has an emissivity of 0.85. If the emissivity of the rod is	10	CO3	L3

	0.6 find the time required for the heating operation. Take density of steel, ρ = 7845 kg/m3 and specific heat, cp = 0.67 kJ/ kg.K.			
	Module 5			
1	State Fick's law of diffusion.	3	CO1	L1
2	What are the different modes of mass transfer, give examples for each	3	CO1	L1
3	Explain different modes of mass transfer.	3	CO1	L1
4	Define Mass flux and Molar flux	3	CO1	L1
6	Define and explain the physical significance of Schmidt number and Sherwood number	3	CO1	L1
7	Explain the analogy between heat and mass transfer	3	CO1	L1
8	Explain equimolar counter difusion	3	CO1	L1
9	Give two examples of mass transfer in day-to-day life.	3	CO1	L1
10	Explain Ficks law of diffusion with suitable assumptions	3	CO1	L1
11	Explain the phenomenon of equimolar counter diffusion with an example	8	CO1	L2
12	Derive the general mass transfer equation in Cartesian coordinates	10	CO1	L2
13	Air at 35^0C flows over a wet flat plate 50cm long with a velocity of 30 m/s. Calculate the mass transfer coefficient of water vapour in air at the end of the plate	10	CO1	L3
14	Calculate the diffusion rate of water from the bottom of a test tube 10mm in diameter and 15cm long into dry atmosphere air at 25^0C. Take diffusion coefficient as 0.255×10^{-4} m^2/s and partial pressure at the bottom of the test tube corresponding to saturation temperature of 25^0C as 0.03166×10^5 N/m^2	10	CO1	L3
15	Air at 20^0C and atmospheric pressure containing small quantities of iodine flows with a velocity of 4 m/s inside a 4cm inner diameter tube. Determine the mass transfer coefficient. Take diffusion coefficient as 0.75×10^{-5} m^2/s	6	CO1	L3

Prepared By: J V C Maliackal (Course Faculty)

Checked By : Prof. Asha K R (Subject Group Coordinator)

Approved By : Dr. Ramadas T (HOD)

Course Code & Name: MET304 DYNAMICS AND DESIGN OF MACHINERY

1. Prescribed Syllabus

Module	Topic	Hours
1	Dynamic force analysis- D' Alembert's principle –four bar mechanism- engine force analysis (reciprocating engines)- piston side thrust- connecting rod force-piston effort- dynamic force analysis considering mass of the connecting rod-analytical method. Flywheels-turning moment diagrams for four stroke internal combustion engine and multi cylinder engines-coefficient of fluctuation of speed-coefficient of fluctuation of energy design of flywheels.	**9**
2	Introduction- free vibration of single degree undamped systems- natural frequency-energy method- Newton's second law (free body diagram)- damped systems- logarithmic decrement. Forced vibration-single degree of freedom systems-harmonic excitation-vibration isolation transmissibility-whirling of shafts.	**8**
3	Introduction to two degree of freedom systems- natural frequencies and mode shapes. Introduction to design-definition, steps in the design process, materials and their properties- elastic and plastic behaviour of metals, ductile and brittle behaviour, shear, bending and torsional stresses, combined stresses, stress concentration factor.	**8**
4	Shock and impact loads- fatigue loading- Gerber, Goodman and Soderberg criteria, endurance limit stress, factors affecting endurance limit, factor of safety. Deign of riveted joints- material for rivets, modes of failure, efficiency of joint, design of boiler and tank joints, structural joints.	**12**
5	Design of welded joints-welding symbols, stresses in fillet and butt welds, Butt joint in tension, fillet weld in tension, fillet joint under torsion, fillet weld under bending, eccentrically loaded welds. Springs- classification, spring materials, stresses and deflection of helical springs, axial loading, curvature effect, resilience, static and fatigue loading, surge in spring, critical frequency, concentric springs, end construction.	**10**

2. Text Books (T)

T1. Ballaney, P. L. Theory of machines and mechanisms. Khanna Publishers, 2010.
T2. Rattan S S, Theory of Machines, Tata McGraw-Hill Education, 2005.
T3. Bhandari V B, Design of Machine Elements, Tata McGraw-Hill Education, 2010.

Design Data Books (permitted for reference in the university examination)
1. Mahadevan, K., and K. Balaveera Reddy. Design Data Handbook; Mechanical Engineers in SI and Metric Units. CBS Publishers & Distributors, New Delhi, 2018.
2. NarayanaIyengar B.R & Lingaiah K, Machine Design Data Handbook, Tata McGraw Hill/Suma Publications, 1984
3. PSG Design Data, DPV Printers, Coimbatore, 2012

3. Reference Books (R)

R1. Charles E Wilson and J Peter Sadler, Kinematics and Dynamics of Machinery, Tata
McGraw-Hill Education, 2008.

R2. Amithabha Ghosh and Asok Kumar Malik, Theory of Mechanisms and Machines, EastWest Press, 2011
R3. Robert L Norton, Design of Machinery, Tata Mc Graw-Hill, 2005
R4. P C Sharma and D K Aggarwal, Machine Design, S K Kataria & Sons

4. Course Objectives

This course focuses on important topics of dynamics of machinery and design of machine elements. It covers the topics namely force of four bar mechanisms, design of flywheels, welded joints, riveted joints and spring. Design of machine elements due to impact, shock and fatigue loading are covered in the syllabus. Analysis of free and forced vibration of single degree of freedom systems and a brief introduction about free vibration of two degree of freedom systems is also included.

5. Course Pre / Co-requisite

Engineering Mechanics (EST 100)

6. Course Outcomes

The students will be able to
CO1: **Do** engine force analysis and to draw turning moment diagrams
CO2: **Analyse** free and forced vibrations of single degree of freedom systems
CO3: **Determine** the natural frequencies of a two degree of freedom vibrating system and to calculate the stresses in a structural member due to combined loading.
CO4: **Design** machine elements subjected to fatigue loading and riveted joints.
CO5: **Design** welded joint and close coiled helical compression spring

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2	PSO 3
CO 1	H	H	M									M	M	M	H
CO 2	H	H	H									M	M	M	H
CO 3	H	H	M									M	M	M	H
CO 4	H	H	M									M	M	M	H
CO 5	H	H	M									M	M	M	H

8. Justification for CO-PO-PSO Correlation

CO1	PO1	Advanced mathematical techniques are used to solve mechanical engineering problems related to engine force analysis. High correlation is due to the fact that the deep knowledge of mathematics and science is used to solve the complex engineering problems.
	PO2	Dynamic force analysis problems are converted to suitable static force problems and solved. High correlation is due to the fact that deep knowledge about engineering systems, variables, and parameters are used to solve the problems.

	PO3	Conceptual design into a detailed design within the existing constraints (of the resources).Medium correlation is due to the fact that standard knowledge is to design solutions for complex engineering problems.
	PO12	Engine force analysis and turning moment diagrams relate to life-long learning. Medium correlation is due to the need for continuous improvement in understanding and applying engineering principles in response to technological changes in the field.
	PSO1	A fundamental knowledge in Dynamics of Machinery will be helpful in analyzing force in Mechanical systems. Medium correlation is due to the fact that practical problems can be solved using the standard knowledge of principles of scientific management.
	PSO2	Problem solving using dynamic force related equations and theorems. Medium correlation is due to the fact that the acquired standard knowledge will be useful to solving problems on mechanical design area.
	PSO3	Engine force analysis and drawing turning moment diagrams highly correlate with applying principles of mathematics, science, and engineering to design and analyze multi-disciplinary systems, as both require deep knowledge and specialized engineering skills to solve complex problems.
CO2	PO1	Analyzing vibration systems to solve engineering problems. High correlation is due to the fact that it involves in depth application of mathematical knowledge to solve complex engineering problems.
	PO2	Identify vibrations systems, variables, and parameters to solve the problems. High correlation is due to the fact that desired in depth understanding and conclusions consistent with objectives and limitations of the analysis is derived.
	PO3	Apply formal idea generation tools to develop multidegree freedom system. High correlation is due to the fact that in depth design knowledge is applied for calculating solutions for system components.
	PO12	Analyzing free and forced vibrations of single degree of freedom systems promotes life-long learning by fostering independent problem-solving skills and adaptability in response to technological advancements, demonstrating a medium correlation with continuous professional development
	PSO1	The acquired knowledge in the area of vibration will be helpful in analyzing problems in systems subjected to forced and free vibrations. Medium correlation is due to the fact that standard knowledge acquired can be used to solve practical problems.
	PSO2	Understanding real life vibrations system and its components. Medium correlation is due to the fact that the acquired supervisory design knowledge will be helpful in solving real life problems.
	PSO3	Analyzing vibrations in single degree of freedom systems has a high correlation with applying mathematical, scientific, and engineering principles to design and analyze multi-disciplinary systems, as it involves a comprehensive understanding of these fields to solve complex engineering problems.
CO3	PO1	Apply vibrating systems concepts to solve engineering problems. High correlation is due to the fact that it involves in depth application of mathematical knowledge to solve complex engineering problems.
	PO2	Identify existing design considerations for solving the problem, including forming justified approximations and assumptions. High correlation is due

		to the fact that in depth knowledge acquired can be used to develop design solutions.
	PO3	Recognize that need analysis is key to good problem definition. Apply formal idea generation tools to develop multiple engineering design solutions. Medium correlation is due to the fact that standard design solutions for complex engineering problems are obtained.
	PO12	Determining natural frequencies and calculating stresses in structural members requires a solid grasp of mechanical principles and problem-solving skills. Medium correlation is due to the necessity for continuous learning and adaptation to technological advancements in structural analysis and design.
CO3	PSO1	The knowledge gained in the area of vibration will be helpful to solve design related problems of mechanical systems. Medium correlation is due to the fact standard knowledge of concurrent technologies can be used to solve practical problems.
	PSO2	The knowledge gained will be extremely helpful in designing members of structural systems. Medium correlation is due to the fact that standard knowledge acquired can be used to manage engineering projects as a team.
	PSO3	Determining natural frequencies and calculating stresses in structural members involve deep knowledge of mathematics and engineering principles. High correlation is due to the need for specialized skills to design and analyze multi-disciplinary vibrating systems and structural load scenarios.
CO4	PO1	Analyze the fatigue loading on machine members. High correlation is due to the fact that in depth knowledge of science and engineering fundamentals can be used to solve complex engineering problems.
	PO2	Formulate necessary design equations for different machine members. High correlation is due to the fact that complex engineering problems can be analysed and formulated using the deep knowledge acquired.
	PO3	Design of riveted joints and failure analysis of machine member design. High correlation is due to the fact that design solutions for complex engineering problems can be derived using the deep knowledge acquired.
	PO12	Designing machine elements for fatigue loading and riveted joints involves understanding and applying engineering principles to solve complex problems, highlighting a medium correlation with life-long learning as it requires ongoing adaptation to technological advancements.
	PSO1	An acquired knowledge in this area will be helpful in solving problems associated with machine elements which are subjected to fatigue loading. Medium correlation is due to the fact supervisory knowledge of concurrent technologies can be used to solve practical problems.
	PSO2	These additional constraints will be helpful in designing systems used for riveted joints. Medium correlation is due to the fact that standard knowledge acquired can be used to manage engineering projects as a team.
	PSO3	Designing machine elements subjected to fatigue loading and riveted joints highly correlates with applying principles of mathematics, science, and engineering to design and analyze multi-disciplinary systems due to the complex, specialized engineering knowledge required
CO5	PO1	Apply welded joint and spring design knowledge. High correlation is due to the fact that deep knowledge of engineering fundamentals can be used to solve complex engineering problems.

PO2	Formulate necessary design equations for different machine members. High correlation is due to the fact that complex engineering problems can be analysed and formulated using the deep knowledge acquired.
PO3	Design of welded joint and failure analysis of machine member design. High correlation is due to the fact that design solutions for complex engineering problems can be derived using the in depth knowledge acquired. .
PO12	Designing welded joints and helical compression springs requires a solid grasp of mechanical principles and materials science. Medium correlation with life-long learning is due to the need for continual updates on technological advancements and new engineering techniques..
PSO1	A clear knowledge in the area will be helpful in designing compression springs. Medium correlation is due to the fact that standard knowledge of concurrent technologies can be used to solve practical problems.
PSO2	The acquired knowledge will be helpful in in designing and analyzing welded joints. Medium correlation is due to the fact that standard knowledge acquired can be used to manage engineering projects as a team.
PSO3	Designing welded joints and close coiled helical compression springs requires a deep understanding of engineering principles, mathematics, and science, thus exhibiting a high correlation with the ability to design and analyze multi-disciplinary systems.

9. Curricular gaps (if any)

The concepts explained in this Syllabus is conventional methods only.

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	Static force analysis techniques	Conduct Seminars	PO1

11. Internal Assessment mark allocation (as per university curriculum)

(Provide details as mentioned in syllabus)

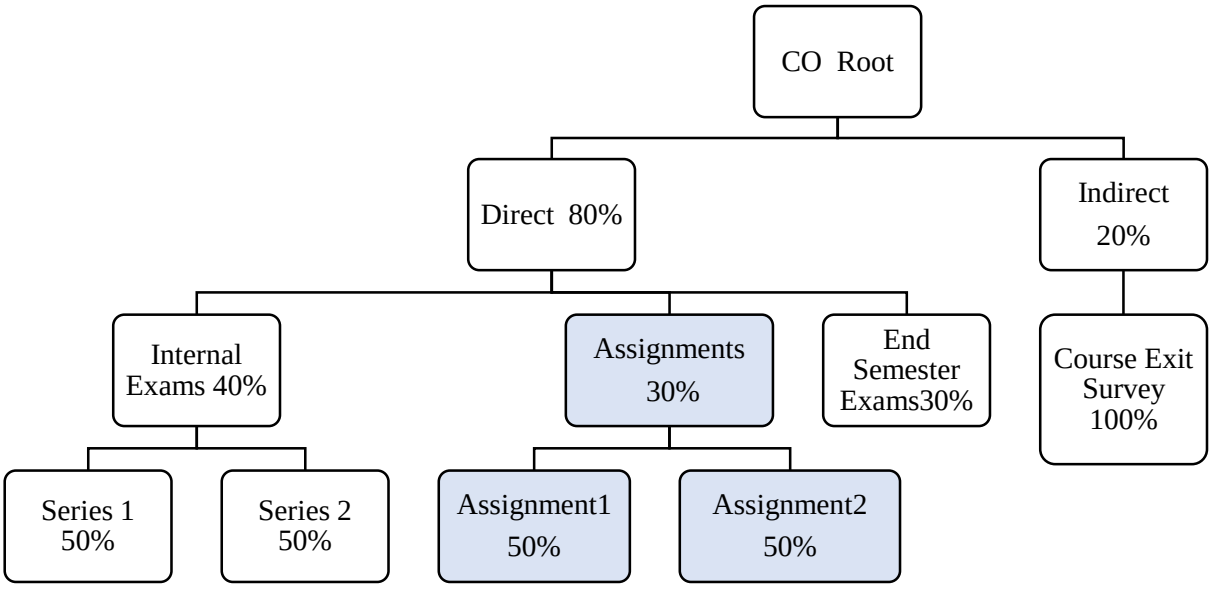
Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		**Weightage#**	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Direct Assessment Tools**	Internal Exam(s) 40%	Series 1	50%	x	x	x		
		Series 2	50%			x	x	x
	Assignment (s) 30%	1	50%	x	x			
		2	50%			x	x	x

	End Semester Exam - 30%	100%	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey	100%	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Sl.no	Topic Name	Module	Reference	Teaching Pedagogy
1	Dynamic force analysis- De Alembert's principle	1	R1, R2	Lecture
2	Dynamic force analysis- Four bar mechanism	1	R1, R2	Lecture
3	Dynamic force analysis- Four bar	1	R1, R2	Lecture
4	Engine force analysis (reciprocating engines)-	1	R1, R2	Tutorial
5	Engine force analysis (reciprocating engines)-	1	R1, R2	Lecture
6	piston side thrustconnecting rod force-piston effort-dynamic force analysis considering mass of the connecting rod-	1	R1, R2	Lecture
7	piston side thrustconnecting rod force-piston effort-dynamic force analysis considering mass of the connecting rod-	1	R1, R2	Lecture
8	Flywheels, turning moment diagrams	1	R1, R2	Lecture
9	Four stroke internal combustion engines	1	R1, R2	Lecture
10	multi cylinder engines	1	R1, R2	Lecture

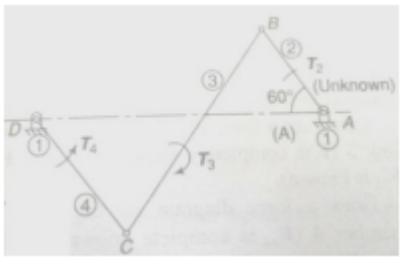
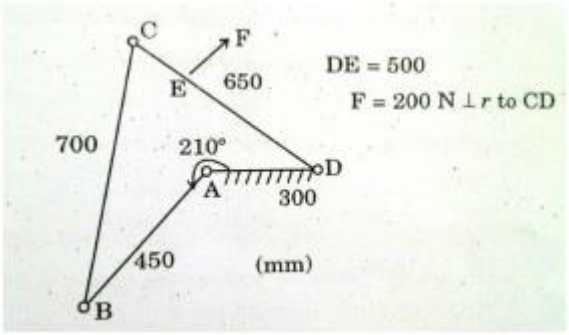
11	Coefficient of fluctuation of speed	1	R1, R2	Lecture
12	coefficient of fluctuation of energy-design of flywheels	1	R1, R2	Lecture
13	free vibration of single degree undamped systems	2	R1, R2	Lecture
14	natural frequency-energy method	2	R1, R2	Lecture
15	Newtonâ€™s second law (free body diagram)-damped systems- logarithmic decrement.	2	R1, R2	Lecture
16	Forced vibration-single degree of freedom systems	2	R1, R2	Tutorial
17	harmonic excitation-vibration isolation	2	R1, R2	Lecture
18	transmissibility-whirling of shafts.	2	R1, R2	Lecture
19	Introduction to two degree of freedom systems	3	R1, R2	Lecture
20	natural frequencies and mode shapes.	3	R1, R2	Lecture
21	natural frequencies and mode shapes.	3	R1, R2	Lecture
22	Introduction to design-definition, steps in design process	3	R3, R4	Tutorial
23	materials and their properties- elastic and plastic behaviour of metals	3	R3, R4	Lecture
24	ductile and brittle behaviour	3	R3, R4	Lecture
25	Shear, bending and torsional stresses	3	R3, R4	Lecture
26	combined stresses	3	R3, R4	Lecture
27	combined stresses	3	R3, R4	Lecture
28	combined stresses- Numericals	3	R3, R4	Tutorial
29	Shock and Impact loads, fatigue loading- Gerber, Goodman and Soderberg criteria,	4	R3, R4	Lecture
30	endurance limit stress, factors affecting endurance limit, factor of safety.	4	R3, R4	Lecture
31	Deign of riveted joints- material for rivets, modes of failure	4	R3, R4	Lecture
32	efficiency of joint, design of boiler and tank joints,	4	R3, R4	Lecture
33	joints.	4	R3, R4	Lecture
34	welding symbols	5	R3, R4	Tutorial
35	stresses in fillet and butt welds, butt joint in tension	5	R3, R4	Lecture
36	fillet weld in tension,	5	R3, R4	Lecture
37	Fillet joint under torsion, fillet weld under bending,	5	R3, R4	Lecture
38	eccentrically loaded welds	5	R3, R4	Lecture

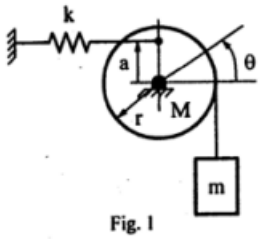
39	Springs- classification, spring materials, stresses and deflection of helical spring	5	R3, R4	Lecture
40	axial loading, curvature effect	5	R3, R4	Tutorial
41	resilience, static and fatigue loading	5	R3, R4	Lecture
42	Surge in spring, critical frequency	5	R3, R4	Lecture
43	concentric springs	5	R3, R4	Lecture
44	end construction.	5	R3, R4	Lecture

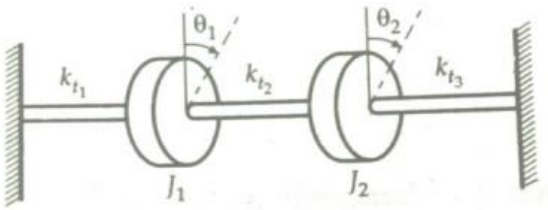
15. Question Bank

Module 1				
Q. No	**Question**	**Marks**	**CO**	**BL**
1	Explain the principle of virtual work applied in a slider crank mechanism.	**3**	**CO1**	**L1**
2	Explain equivalent offset inertia force in plane motions.	**3**	**CO1**	**L1**
3	**Explain a dynamically equivalent system. What are the conditions it should satisfy?**	**3**	**CO1**	**L2**
4	Find the magnitude and direction of inertia force acting on links AB, BC, CD, in the four bar mechanism shown in Fig: 1 AB= 500 mm, BC= 660 mm, CD= 560 mm, AD= 1000 mm (horizontal), ωAB = 10.5 rad/sec (CCW), angular retardation αAB= 26 rad/sec2 , < DAB= 600	**7**	**CO1**	**L3**
5	Mass of link AB, MAB = 3.54 kg, MBC = MCD = 3.54 kg /m length. Centre of gravity link AB lies at 200 mm from A and has a moment of inertia of 88500 kg mm2. For link 3 & 4 Centre of gravity is at its mid-point.	**7**	**CO1**	**L3**
6	Explain static and dynamic balancing.	**4**	**CO1**	**L2**
7	Derive an expression for maximum swaying couple.	**4**	**CO1**	**L2**
8	With a neat sketch briefly describe the working of cradle type balancing machine.	**4**	**CO1**	**L1**
9	Explain hammer blow and variation of tractive force.	**4**	**CO1**	**L1**
10	The following data refers to a two cylinder uncoupled locomotive engine: Rotating mass per cylinder = 280 kgm, Reciprocating mass per cylinder= 300 kg, Distance between wheels= 1400mm, Distance between cylinder centers= 600 mm, Angular velocity of balancing mass= 15.43 rad/sec, Crank radius= 300 mm, Radius of centre of balancing mass= 620 mm, Angle between cylinder cranks= 90 deg, Dead load on each wheel= 3.5 tonne Find: a) Balancing mass required	**12**	**CO1**	**L3**

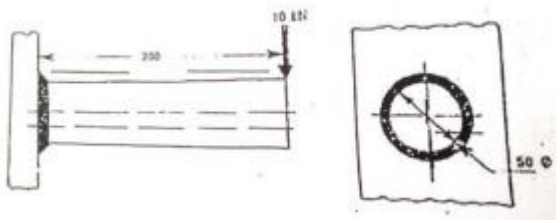
	in the planes of driving wheels if whole of the revolving and 2/3 rd of the reciprocating mass are to be balanced b) Swaying couple , c) Tractive force , d) Maximum and minimum pressure on the rails			
11	Derive the expression for coefficient of fluctuation of energy.	**7**	**CO1**	**L3**
12	Explain the turning moment diagram of a single cylinder four stroke engine with a neat sketch.	**4**	**CO1**	**L2**
13	Determine the energy released by the flywheel having a mass of 2 kN and radius of gyration of 1.2 m when the speed decreases from 460 rpm to 435 rpm.	**9**	**CO1**	**L3**
14	Explain and derive an expression for a) Piston effort b) Force along the connecting rod c) Thrust on the sides of the cylinder d) Crank effort e) Thrust on the bearings.	**12**	**CO1**	**L2**
15	Find the equivalent offset inertia distance at which the inertia force are acting on the links AB, BC, and CD of the mechanism shown in Fig 1. With a neat sketch represent equivalent offset inertia forces acting on each link	**8**	**CO1**	**L3**
16	A flywheel fitted to a steam engine has a mass of 800 kg. Its radius of gyration is 360 mm. The starting torque of the engine is 580 Nm and may be assumed constant. Find the kinetic energy of the flywheel after 12 seconds.	**10**	**CO1**	**L3**
17	In a four-bar mechanism ABCD the crank AB 5 cm long makes 60° with fixed link AD. Link Be = 7 cm, CD = 9 cm and AD = 10 cm. A force of 8 N at 73.5° acts on BC at a distance of 4 cm from B. Determine the reactive torque on link AB	**12**	**CO1**	**L4**
18	Explain the static equilibrium conditions of two forces, three forces, two forces and a torque member.	**6**	**CO1**	**L2**
19	In a four-bar mechanism ABCD the crank AB = 5 cm long makes 60° with fixed link AD. Link BC = 7 cm, CD = 9 cm and AD = 10 cm. A force of 8 N at 73.5° acts on BC at a distance of 4 cm from B. Determine the reactive torque to be applied on link AB so that the system is in static equilibrium.	**12**	**CO1**	**L4**
20	Explain with an example the static force analysis of a slider crank mechanism in which friction is considered for sliding and revolute pairs.	**6**	**CO1**	**L2**
21	In a four- link mechanism shown in the figure below, torque T3 and T4 have magnitudes of 30 Nm and 20 Nm respectively. The link lengths are AD= 800mm, AB= 300mm, BC=700mm and CD= 400mm. For the	**12**	**CO1**	**L4**

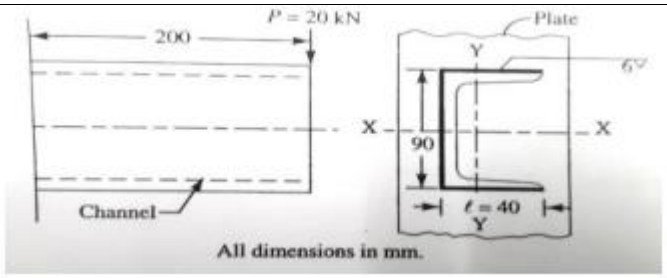
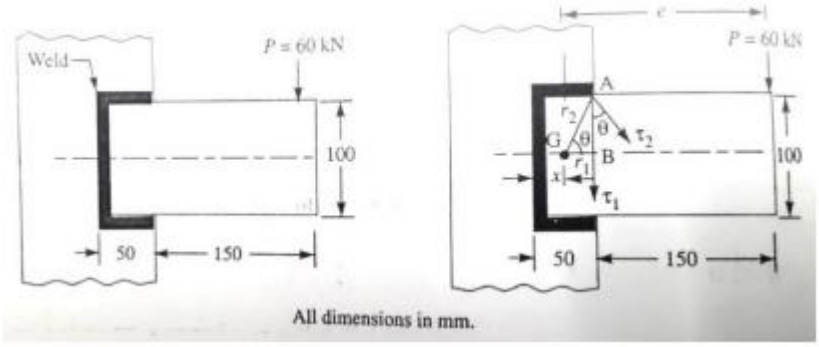
	static equilibrium of the mechanism, determine the required input torque T2 			
22	Find the torque required to be applied to link AB of the linkage shown in figure to maintain static equilibrium. The force F is perpendicular to link CD acting at E. The dimensions of the links are in mm 	**12**	**CO1**	**L3**
	MODULE –II			
1	Difference between vibration absorbers and vibration isolators.	**3**	**CO2**	**L1**
2	Explain co-ordinate coupling.	**3**	**CO2**	**L1**
3	Explain the working of unturned dry friction damper with a neat diagram.	**5**	**CO2**	**L2**
4	Derive an expression for displacement transmissibility of a spring mass damper system subjected to a force.	**6**	**CO2**	**L2**
5	Explain two types of frequency measuring instruments	**3**	**CO2**	**L2**
6	A machine weighing 1600 kg is mounted on a spring having stiffness of 10800 N/cm. A piston within the machine weighing 25 N has a reciprocating motion with a stroke of 7.5 cm and a speed of 6000 rpm. Assume the motion to be simple harmonic. Determine: a) Amplitude of vibration of machine. b) Transmissibility and force transmitted to the ground. Take ξ= 0.2 a) A single cylinder vertical petrol engine of total mass 320 kg is mounted upon a steel chassis and causes a vertical static deflection of 2 mm. The reciprocating parts of the engine have a mass of 24kg and move through a vertical stroke of 150mm. with simple	**12**	**CO2**	**L4**

	harmonic motion. A dashpot attached to the system offers a resistance of 490 N at a velocity of 0.3 m/sec. Determine: The speed of the driving shaft at resonance, The amplitude of steady state vibration when the driving shaft of the engine rotates at 480 rpm.			
7	A centrifugal pump rotating at 600 r.p,m. is driven by an electric motor running at 1500 r.p.m through a single stage reduction gearing. The moment of inertia of the pump impeller and the motor are 150 Kg-m 2 and 450 Kg-m 2 respectively. The lengths of the pump shaft and the motor shafts are 500 mm and 300 mm, and their diameters are 100 mm and 60 mm respectively. Neglecting the inertia of the gears, find the frequency of torsional oscillations of the system, and draw the mode shape. Take G = 82 GPa.	**12**	**CO2**	**L4**
8	The rotor of a turbo charger weighing 90 N is keyed to the centre of 25 mm diameter steel shaft 40 cm between bearings. Determine: Critical speed of shaft, The amplitude of vibration of rotor at a speed of 3200 rpm, if the eccentricity is 0.015 mm, Dynamic force transmitted to the bearing at this speed. Take density of shaft material as 8 gm/cm3 , E= 200 GPa,	**12**	**CO2**	**L3**
9	Derive an expression for energy dissipated per cycle in single degree of freedom system with viscous damping.	**8**	**CO2**	**L3**
10	Find the expression of frequency of free vibration of the system shown in figure 1. Assume the chord passing over the frictionless pulley is inextensible  Fig. 1	**12**	**CO2**	**L3**
11	A vibrating system is defined by the following parameters: m= 3 kg, k= 100 N/m, C=3 Nsec/m Determine: a) damping factor, b) the natural frequency of damped vibration, c) Logarithmic decrement, d) the ratio of two consecutive amplitudes and e) The number of cycles after which the original amplitude is reduced to 20 percent.	**12**	**CO2**	**L3**
12	Derive an expression for logarithmic decrement.	**3**	**CO 2**	**L1**
13	What do you mean by Over damped system? Plot displacement VS time graph of such system.	**3**	**CO 2**	**L1**

MODULE - III				
1	Explain in detail the design consideration in design of machine elements	5	CO3	L1
2	Briefly describe a) theories of failure b) Creep	5	CO3	L1
3	Discuss the various factors affecting which govern the selection of material for machine component.	4	CO3	L2
4	Explain the weighted point method for material selection and state its limitations.	5	CO3	L1
5	What are the ergonomic conditions in machine design?	3	CO3	L1
6	Explain Fits and tolerances	3	CO3	L2
7	Briefly describe standards and code in design.	3	CO3	L2
8	Explain the term a) modulus of elasticity b) Explain ductile and brittle material using a stress-strain diagram.	3	CO3	L2
9	Explain a) combine stress b) stress concentration factor	3	CO3	L2
10	Describe critical speed of shaft.	6	CO3	L2
11	Find the natural frequencies for the torsional system shown in figure below: Given J1= J0, J2 = 2J0 and kt1= kt2 = kt3 = kt 	8	CO3	L3
12	A mild steel shaft of 50 mm diameter is subjected to a bending moment of 2000Nm and a torque T. If the yield point of the steel in tension is 200 MPa., find the maximum principle stress; the maximum shear stress of yielding.	8	CO3	L3
13	A cylinder shaft made of steel of yield strength 700Mpa is subjected to static loads consisting of bending moment 10kNm and a torsional moment 30 kNm. Determine the diameter of the shaft using maximum shear stress theory and maximum strain energy theory, assuming a factor of safety of 2. Take E=210 GPa and Poisson's ratio = 0.25.	10	CO3	L3
14	Explain the following theories of failure a) Maximum normal stress theory, b) Maximum shear stress theory and c) Distortion theory	6	CO3	L3

15	A rod of 50mm diameter is subjected to compressive load of 20 kN together with a twisting moment of 1.5kNm. It is made of C40 steel (σyt = 328.6 MPa). Determine the factor of safety according to a) maximum normal stress theory and b) Maximum shear stress theory.	**10**	**CO3**	**L3**
16	A bolt is subjected to tensile load of 18kN and a shear load of 12 kN. The material has a yield stress of 328.6 MPa. Taking factor of safety as 2.5, determine the core diameter of bolt according to the following theories of failure a) Rankine's theory, b)Shear stress theory, c)Shear energy theory and c) Saint Venant's theory (Possion ratio = 0.298).	**12**	**CO3**	**L3**
17	A machine member is subjected to the following stress σ x = 150 MPa, τ=24 MPa. Find the equivalent stress as per the following theories of failure, a) Shear stress theory, b) Normal stress theory and c) Von-Mises theory.	**12**	**CO3**	**L3**
18	Find the diameter of a rod subjected to a bending moment of 3 kNm and a twisting moment of 1.8 kNm according to the following theories of failure, taking normal yield stress as 420 MPa and factor of safety as 3. a) Normal stress theory and b) Shear stress theory.	**12**	**CO3**	**L3**
19	A M.S shaft having yield stress as 232 MPa is subjected to the following stresses σ x =120 MPa and σ y =-60 MPa and τ = 36 MPa. Find the factor of safety using: a) Rankine's theory, b) Guest's theory of failure and c) Von-Mises theory of failure.	**12**	**CO3**	**L3**
MODULE - IV				
1	Write a note on fatigue failure and its prediction.	**5**	**CO4**	**L2**
2	Factors affecting endurance limit.	**3**	**CO4**	**L1**
3	A cantilever beam shown in figure below is subjected to load varying from P to 3P. Determine the value of P if the material of beam has ultimate strength of 620.8 MPa., yield strength of 400 MPa and endurance strength of 345.2 MPa. The stress concentration factor may be taken as 1.4. Analyze the member at the change of cross section A-A. Use factor of safety =3.	**10**	**CO4**	**L3**
4	What are riveted joins? What are its advantages and disadvantages of riveted joints over welded joins? Explain. Also explain the type of rivet heads.	**7**	**CO4**	**L2**

5	Design a triple riveted zigzag lap joint to connect two plates each 12mm thick. Draw a neat sketch of the joint.	**12**	**CO4**	**L2**
6	Design a triple riveted double covered butt joint with unequal cover plates to connect two plates of 20mm thickness. Use permissible values of tensile, compressive and shear stress are 90 N/mm2 , 150 N/mm2 and 60 N/mm2 respectively.	**12**	**CO4**	**L4**
7	A double riveted double cover butt joint in plates 20mm thick is made with 25mm diameter rivets at 100 mm pitch. The permissible stresses are: Tensile =120 MPa, Shear stress 100 MPa, crushing stress =150 Mpa. Find the efficiency of joint, taking the strength of the rivet in double shear as twice than that of single shear.	**12**	**CO4**	**L4**
8	Design a double riveted butt joint with two cover plates for the longitudinal seam of a boiler shell 1.5m in diameter is subjected to a steam pressure of 0.95 N/mm2 . Assume joint efficiency as 75%, allowable tensile stress in the plate 90MPa, compressive stress 140Mpa and shear stress in the river 56 MPa.	**12**	**CO4**	**L4**
9	Explain Soderberg criteria	**3**	**CO4**	**L1**
10	What do you mean by Factor of safety? Explain.	**3**	**CO4**	**L1**
11	Explain Goodman criteria	**3**	**CO4**	**L1**
12	Define notch sensitivity factor. Obtain an equation for it.	**3**	**CO4**	**L1**
	MODULE - V			
1	What are the different types of welded joints?	**6**	**CO5**	**L1**
2	A circular shaft, 50mm in diameter is welded to a support by means of a fillet weld as shown in the figure. Determine the size of the weld if the permissible shear stress in the weld is limited to 100 N/m^2 . 	**10**	**CO5**	**L3**
3	Find the maximum shear stress induced in the weld of 6 mm size when a channel, as shown in figure below, is welded to a plate and loaded with 20kN force at a distance of 200mm.	**12**	**CO5**	**L3**

				
4	A rectangular steel plate is welded as a cantilever to a vertical column and supported a single concentrated load P, as shown in figure below. Determine the weld size if shear stress is not exceed 140 MPa. 	**12**	**CO5**	**L3**
5	A helical compression spring of a cam-mechanism is subjected to an initial pre load of 50 N. The maximum operating force during the load cycle is 150N. The wire diameter is 3 mm while the mean coil diameter is 18mm. The spring is made of oil hardened and tempered valve spring wire of grade–SW (Sut =1430N/mm2). Determine the factor of safety used in the design on the basis of fluctuating stress.	**12**	**CO5**	**L4**
6	Design a helical spring for a safety valve. The valve must blow off at a pressure of 1.2 MPa and should lift by 3mm for 5% increase in pressure. The valve diameter is 60mm. The maximum allowable shear stress is 400 MN/m2 and the modulus of rigidity is 82.7 Gpa. Assume the spring index as 8.	**12**	**CO5**	**L4**
7	The load on a steel helical compression spring varies from 500 N to 1200 N. The spring index is 6 and the desired factor of safety is 1.3. Determine the required wire size by taking yield shear stress as 600 MN/m2 and the endurance shear stress as 300 MN/m2 .	**12**	**CO5**	**L3**
8	A semi elliptical laminated spring is to carry a load of 600N and consists of 8 leaves 46mm wide, two of the leaves being of full length. The spring is to be made 1000mm between the eyes and is held at the centre by a 60 mm wide band. Assume that the spring is initially stressed so as to induce an equal stress of 500 N/mm2 when fully loaded. Design the spring giving a) thickness of leaves b) eye diameter c) length of leaves d) maximum deflection and radius to which the leaves should be initially bent.	**12**	**CO5**	**L4**

9	A helical compressed spring made of oil tempered carbon steel, is subjected to a load which varies from 400 N to 1000 N. The spring index is 6 and the design factor of safety is 1.25. The yield stress in shear is 770 MPa and endurance stress in shear is 350 Mpa, find: (a) size of the spring wire, (b) Diameter, (c) Number of turns of the spring and (d) Free length of the spring. The compression of the spring at the maximum load is 30mm. The modulus of rigidity of the material may be taken as 80 kN/mm2 .	**12**	**CO5**	**L4**
10	Design a helical compression spring for a maximum load of 1000 N for a deflection of 25 mm using the value of spring index as 5. The maximum permissible shear stress for spring wire is 420 MPa and modulus of rigidity is 84 kN/mm2 .	**12**	**CO5**	**L4**
11	The load on a steel helical compression spring varies from 500 N to 1200 N. The spring index is 6 and the desired factor of safety is 1.3. Determine the required wire size by taking yield shear stress as 600 MN/m2 and the endurance shear stress as 300 MN/m2 .	**12**	**CO5**	**L3**
12	An automotive single plate clutch, with two pairs of friction surfaces, transmits 300 Nm torque at 1500rpm. The inner and outer diameters of the friction disk are 170 and 270mm respectively. The coefficient of friction is 0.35. The normal force on the friction surfaces is exerted by nine helical compression springs, so that the clutch is disengaged when the external force further compressed the springs. The spring index is 5 and the number of active coils is 6. The springs are made of patented and cold-drawn steel wires of grade 2. (G=81370 N/mm^2). The permissible shear stress for the spring is 30% off the ultimate tensile strength. Design the spring and specify their dimensions.	**12**	**CO5**	**L5**
13	A concentric spring consists of two helical compression springs having the same free length. The composite spring subjected to a maximum force of 2000 N. The wire diameter and mean coil diameter of inner spring are 8mm and 64mm respectively. Also, the wire diameter and mean coil diameter of the outer spring are 10 and 90 mm respectively. The number of active coils in inner and outer springs is 12 and 8 respectively. Assume same material for two springs and the modulus of rigidity of spring material is 81370 N/mm2 . Calculate a) The force transmitted by each spring, b) The maximum deflection of the spring and c) The maximum torsional shear stress induced in each spring.	**12**	**CO5**	**L4**
14	A helical compression spring of the exhaust valve mechanism is initially compressed with a preload of 375 N. When the spring is further compressed and the valve is fully opened, the torsional shear stress in the spring wire should not exceed 750 N/mm2 . Due to space limitations, the outer diameter of the spring should not exceed 42 mm.	**12**	**CO5**	**L4**

	The spring is to be designed for minimum weight. Calculate the wire diameter and the mean coil diameter of the spring.			
15	Write a short note on surge in spring	**3**	**CO5**	**L1**
16	Differentiate between welded and riveted joints	**3**	**CO5**	**L1**

Prepared By : Jibin Jose, Course Faculty

Checked By : Nisha B Nair, Subject Group Coordinator

Approved by : Dr. Ramadas T, HoD (ME)

Course Code & Name: MET306 Advanced Manufacturing Engineering

1. Prescribed Syllabus

Module	Topic	Hours
1	Powder Metallurgy- Powder Production- Powder characteristics- Mixing – Compaction: -techniques- sintering- Theory metal cutting - Orthogonal and oblique cutting- chip formation- Merchant's Theory- Friction force - cutting tool materials -Thermal aspects of machining -Tool wear and wear mechanisms - Economics of machining- Machinability- Cutting fluids.	10
2	Programmable Logic Controllers (PLC) – CNC: systems - contouring systems: principle of operation -DDA integrator: -Principle of operation, exponential deceleration –liner, circular and complete interpolator - NC part programming - Computer aided part programming – machining centers, feedback devices.	9
3	Non-Traditional machining processes: - EDM, USM, ECM, LBM, EBM, PAM, IBM, AJM, AWJM.	9
4	High velocity forming of metals - Sheet metal forming - explosive forming – Electro hydraulic forming - Electro Magnetic Forming.	8
5	Micromachining: Diamond turn mechanism, Advanced finishing processes: - Abrasive Flow Machining, Magnetic Abrasive Finishing. - Magnetorheological Finishing, Magnetorheological Abrasive Flow Finishing, Magnetic Float Polishing, Elastic Emission Machining. – Material addition processes: - stereo-lithography, selective laser sintering, fused deposition modeling, laminated object manufacturing, laser engineered net-shaping, laser welding, LIGA process.	9

2. Text Books (T)

T1. Yoram Koren, Computer control of manufacturing systems, TMH
T2. Jain V.K., Introduction to Micromachining, Narosa publishers.
T3. Davies K and Austin E.R, Developments in high-speed metal forming, the machinery publishing Co, 1970, SBN -853332053
T4. S Jose and Ahammad Vazim K A, Advanced Manufacturing Engineering, Pentagon Educational Services

3. Reference Books (R)

R1. ASTME, High velocity forming of metals, PHI, 1968.
R2. Ibrahim Zeid, R Sivasubrahmanian CAD/CAM: Theory & Practice Tata McGraw Hill Education Private Limited, Delhi.
R3. P. Groover, E.M. Zimmers, Jr."CAD/CAM"; Computer Aided Design and Manufacturing, Prentice Hall of India, 1987
R4. PetruzellaFrank.D. - Programmable logic controllers

R5. Jain V.K., Advanced Machining Processes
R6. Armarego and Brown, The Machining of Metals, Prentice – Hall.
R7. Paul. H. Black, Theory of Metal Cutting, McGraw Hill.
R8. ASM hand book Volume 16, Machining, ASM international, 1989
R9. Lal G.K., Introduction to Machining Science, New Age Publishers.

4. Course Objectives

- Understand the capabilities, limitations of conventional manufacturing & machining process and what the need of advanced manufacturing processes is.
- Understand, how to formulate tool path and program CNC machines.
- Understand, how PLC operate and control automated equipment and systems.
- Understand the need of atomic level surface roughness and machining process.
- Understand the need of high velocity forming of metals

5. Course Pre / Co-requisite

MET 205 Metallurgy and material science and MET204 Manufacturing Processes

6. Course Outcomes

After the successful completion of the course, the students will be able to
CO1: Conversant with the advanced machining process and to appreciate the effect of process parameters on the surface integrity aspects during the advanced machining process.
CO2: Develop CNC programming, select appropriate tooling and fixtures.
CO3: Categorize the various non-traditional material removal process based on energy sources and mechanism employed.
CO4: Analyze the processes and evaluate the role of each process parameter during micro machining of various advanced material removal processes.
CO5: Explain the processes used in additive manufacturing for a range of materials and applications.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	H				M							M	H		
CO2	M		M		H								H		
CO3	M				M							M	H		
CO4	M	H			M								H		
CO5	M			H	M						M		H		

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	PO1	Conversant with various advanced machining processes and the effect of process parameters on the surface integrity aspects contributes to skills in solving engineering problems. High correlation is due the fact that this involves in-depth knowledge of mathematics, science and engineering fundamentals to solve engineering problems.
	PO5	Selecting and applying the appropriate techniques for modelling advanced machining processes will help the students to select appropriate modern tools for various engineering activities. Medium correlation is due to the fact that this involves standard and moderate knowledge of modern tools.
	PO12	Continuous learning about the various advanced machining processes and the effect of process parameters on the surface integrity aspects will help the students for engaging in independent and lifelong learning in the broadest context of technological knowledge. Medium correlation is due to the fact that this involves standard and moderate technical knowledge.
	PSO1	Knowledge about the concurrent technologies used in different advanced machining processes contributes to solving the practical problems using the principles of sustainable development. High correlation is due the fact that this involves in-depth knowledge on concurrent technologies.
CO2	PO1	Developing CNC programs and selecting appropriate tooling and fixtures contributes to skills in solving engineering problems. Medium correlation is due to the fact that this involves standard knowledge of mathematics, science and engineering fundamentals in developing CNC programs.
	PO3	Designing and developing CNC programs and selecting appropriate tools and fixtures will helps the students to design solutions for complex engineering problems that meet the specified needs with appropriate consideration for public safety and environmental considerations. Medium correlation is due to the fact that this involves standard and moderate knowledge on CNC programming.
	PO5	Selecting appropriate tools and fixtures to develop CNC programs will help the students to select appropriate modern tools for various engineering activities. High correlation is due the fact that this involves in-depth knowledge of the various tools used for CNC programming.
	PSO1	Knowledge about the concurrent technologies used to develop CNC programming contributes to solving the practical problems using the principles of sustainable development. High correlation is due the fact that this involves in-depth knowledge of concurrent technologies.
CO3	PO1	Categorizing the various non-traditional material removal process based on energy will help the students to apply the knowledge to solve complex engineering problems in the field of non-traditional material removal processes. Medium correlation is due to the fact that this involves standard knowledge of mathematics, science and engineering fundamentals.
	PO5	Selecting appropriate tools to categorize the various non-traditional material removal process based on energy sources will help the students to select appropriate modern tools for various engineering activities. Medium correlation is due to the fact that this involves standard knowledge of the various techniques and tools.

	PO12	Knowledge about categorizing the various non-traditional material removal process contributes towards lifelong learning in the broadest context of technological knowledge. Medium correlation is due to the fact that this involves standard technical knowledge.
	PSO1	Concurrent technologies used for categorizing the various non-traditional material removal process based on energy sources contributes to solving the practical problems using the principles of sustainable development. High correlation is due to the fact that this involves in-depth knowledge of concurrent technologies.
CO4	**PO1**	Knowledge about the processes and evaluation of each process parameter during micro machining of various advanced material removal processes will helps the students to apply the knowledge to solve complex engineering problems. Medium correlation is due to the fact that this involves standard knowledge of mathematics, science and engineering fundamentals.
	PO2	Analyzing the various processes during micro machining of various advanced material removal processes will helps the students to analyze complex engineering problems and to reach substantiated conclusions using first principles of mathematics and Engineering. High correlation is due the fact that this involves in-depth knowledge to formulate and analyze complex engineering problems.
	PO5	Creating, selecting and applying appropriate techniques and tools for the evaluation of each process parameter during micro machining of various advanced material removal processes will helps the students to select appropriate modern tools for various engineering activities. Medium correlation is due to the fact that this involves standard and basic knowledge of modern tools.
	PSO1	Concurrent technologies used for the evaluation of each process parameter during micro machining of various advanced material removal processes contributes to solving the practical problems using the principles of sustainable development. High correlation is due to the fact that this involves in-depth knowledge of concurrent technologies.
CO5	**PO1**	Knowledge about the processes used in additive manufacturing for a range of materials will help the students to apply the knowledge to solve complex engineering problems. Medium correlation is due to the fact that this involves standard knowledge of mathematics, science and engineering fundamentals to solve engineering problems.
	PO4	Investigating the various processes used in additive manufacturing for a range of materials and applications will helps the students to use research-based knowledge and research methods, analysis and interpretation of data and synthesis of the information to provide valid conclusions. High correlation is due to the fact that this involves in-depth research based knowledge and research methods.
	PO5	Gaining supervisory knowledge about the processes used in additive manufacturing for a range of materials and applications will helps the students to select appropriate modern tools for various engineering activities. Medium correlation is due to the fact that this involves standard knowledge modern tools.
	PO11	Selecting the appropriate tools to model the different processes used in additive manufacturing will help the students to manage projects as a member or leader in team in multidisciplinary environments. Medium correlation is

		due to the fact that this involves standard engineering and management principles.
	PSO1	Concurrent technologies used for the evaluation of the different processes used in additive manufacturing for a range of materials contributes to solving the practical problems using the principles of sustainable development. High correlation is due to the fact that this involves in-depth knowledge of concurrent technologies.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	Hands on workshop and Expert Lecture	CNC Programming	PO1, PO5, PO9, PSO3

11. Internal Assessment mark allocation (as per university curriculum)

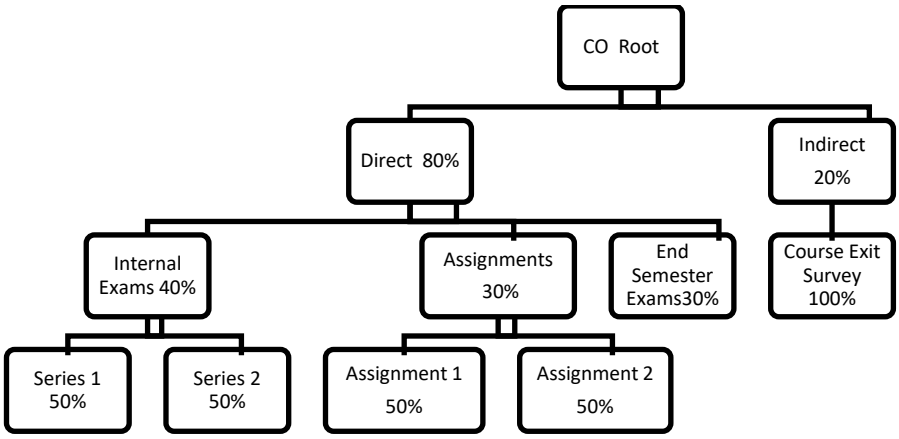
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		Weightage#	CO1	CO2	CO3	CO4	CO5
Direct Assessment Tools	Internal Exam(s) 40%	Series 1	20%	x	x	x		
		Series 2	20%			x	x	x
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x	x			
		Assignment 2	15%			x	x	x
	End Semester Exam		30%	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1	Powder Metallurgy	1	T4, R5	Lecture
2	Powder Production	1	T4, R5	Lecture
3	Powder characteristics- Mixing and Compaction: - techniques-	1	T4, R5	Lecture
4	sintering	1	T4, R5	Lecture
5	Theory metal cutting - Orthogonal and oblique cutting	1	T4, R7	Lecture
6	chip formation	1	T4, R7	Lecture
7	Friction force	1	T4, R7	Tutorial
8	cutting tool materials	1	T4, R7	Lecture
9	Thermal aspects of machining	1	T4, R7	Lecture
10	Tool wear and wear mechanisms - Economics of machining- Machinability- Cutting fluids	1	T4, R7	Tutorial
11	Programmable Logic Controllers (PLC)	2	T4, R4	Expert Lecture
12	contouring systems: principle of operation	2	T4, R3	Lecture
13	CNC: systems	2	T4, R3	Lecture
14	DDA integrator: -Principle of operation	2	T4, R3	Lecture
15	exponential deceleration	2	T4, R3	Lecture
16	linear, circular and complete interpolator -	2	T4, R3	Lecture

17	NC part programming	2	T4, R3	Tutorial
18	Computer aided part programming	2	T4, R3	Tutorial
19	machining centres	2	T4, R3	Lecture
20	Non-Traditional machining processes	3	T4, R5	Lecture
21	USM	3	T4, R5	Lecture
22	EDM	3	T4, R5	Tutorial
23	ECM	3	T4, R5	Lecture
24	LBM	3	T4, R5	Tutorial
25	EBM	3	T4, R5	Lecture
26	PAM	3	T4, R5	Lecture
27	IBM	3	T4, R5	Lecture
28	AJM	3	T4, R5	Lecture
29	comparison of conventional and high velocity forming methods	4	T3, R1	Lecture
30	High velocity forming of metals	4	T3, R1	Tutorial
31	Stress waves and deformation in solids	4	T3, R1	Lecture
32	types of elastic body waves relation	4	T3, R1	Lecture
33	Sheet metal forming	4	T3, R1	Lecture
34	properties of explosively formed parts	4	T3, R1	Lecture
35	Electro hydraulic forming	4	T3, R1	Tutorial
36	comparison with explosive forming	4	T3, R1	Lecture
37	Micromachining: Diamond turn mechanism	5	T2, T4	Lecture
38	Advanced finishing processes:	5	T2, T4	Lecture
39	Abrasive Flow Machining, Magnetic Abrasive Finishing	5	T2, T4	Lecture
40	Magnetic Float Polishing, Elastic Emission Machining	5	T2, T4	Lecture
41	Magnetorheological Finishing, Magnetorheological Abrasive Flow Finishing	5	T2, T4	Tutorial
42	Material addition processes:	5	T2, T4	Lecture
43	stereo-lithography, selective laser sintering	5	T2, T4	Lecture
44	fused deposition modeling	5	T2, T4	Tutorial
45	laminated object manufacturing, laser engineered net-shaping, Laser welding, LIGA	5	T2, T4	Lecture

15. Question Bank

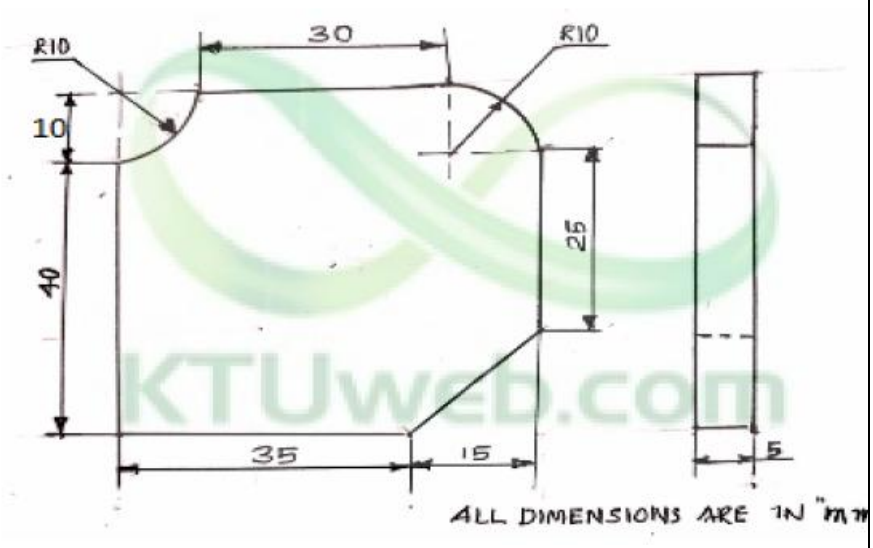
Module 1				
Sl. No	**Question**	**Marks**	**CO**	**BL**
1	Explain powder metallurgy process	**3**	**CO1**	**L1**
2	What are the advantages of Powder metallurgy?	**3**	**CO1**	**L1**
3	Explain the functions of cutting fluids in metal cutting	**3**	**CO1**	**L2**
4	Describe the HIP technique in powder metallurgy	**3**	**CO1**	**L2**
5	Differentiate the impregnation and infiltration process in Powder metallurgy	**3**	**CO1**	**L1**
6	Compare traditional and non-traditional machining process	**3**	**CO1**	**L1**
7	Differentiate orthogonal and oblique cutting in machining	**3**	**CO1**	**L2**
8	Describe the need for powder metallurgy process	**3**	**CO1**	**L2**
9	List few components which cannot be manufactured by powder metallurgy	**3**	**CO1**	**L1**
10	Can you use powder metallurgy for job production and batch production? Justify your answer	**3**	**CO1**	**L1**
11	Define flank wear and crater wear.	**3**	**CO1**	**L1**
12	Differentiate between conventional and non-conventional manufacturing processes.	**3**	**CO1**	**L2**
13	Write the expression for Taylor's tool life equation. Define the terms	**3**	**CO1**	**L1**
14	Explain why continuous chips are not desirable.	**3**	**CO1**	**L1**
15	Justify the usage of coolants while machining cast iron.	**3**	**CO1**	**L1**
16	List the various functions of cutting fluids.	**3**	**CO1**	**L1**
17	Define built up edges. Explain the need and purpose of chip breaking.	**3**	**CO1**	**L1**
18	List and explain any three characteristics of fine powder.	**3**	**CO1**	**L1**
19	With neat sketches explain the methods used to produce metallic powders in powder metallurgy	**7**	**CO1**	**L2**
20	Explain different steps involved in powder metallurgy	**7**	**CO1**	**L2**

21	What are the different methods of atomization for making metal powders in Powder metallurgy?	**7**	**CO1**	**L2**
22	Explain the different stages of sintering process in Powder metallurgy with a neat sketch	**7**	**CO1**	**L2**
23	Differentiate the impregnation and infiltration process in Powder metallurgy	**7**	**CO1**	**L2**
24	In an orthogonal cutting process, the following data has been observed: Uncut chip thickness= 0.127 mm, width of cut= 6.35 mm, cutting speed= 2 m/s, rake angle= 10 degree, cutting force, Fc= 567 N, thrust force, Ft= 227 N, chip thickness= 0.228 mm. Determine the following: shear angle, friction angle, shear stress along shear plane, power for cutting operation, chip velocity and chip shear strain.	**7**	**CO1**	**L3**
25	Explain the three mechanisms of mixing and blending	**7**	**CO1**	**L2**
26	Explain the different wear mechanisms in metal cutting.	**7**	**CO1**	**L2**
27	Name the various methods of powder production and explain the types of powders used.	**7**	**CO1**	**L2**
28	Discuss the development of various cutting tool materials in use today.	**7**	**CO1**	**L2**
29	Sketch a two-dimensional cutting operation and define rake and relief angles with the help of this.	**7**	**CO1**	**L2**
30	Explain the methods by which cutting fluids are applied while machining.	**7**	**CO1**	**L2**
31	Explain Merchant's theory with neat sketches	**7**	**CO1**	**L2**
32	Define machinability considering the cutting force and surface finish as parameters.	**7**	**CO1**	**L2**
33	Explain the mechanism of chip formation in machining ductile and brittle materials.	**7**	**CO1**	**L2**
34	During the turning of a 20mm diameter steel bar at a spindle speed of 400 rpm, a tool life of 20 minutes is obtained. When the same bar is turned at 200 rpm, the tool life becomes 60 minutes. Assume that Taylor's tool life equation is valid, Calculate the tool life when the bar is turned at 300 rpm.	**7**	**CO1**	**L3**

35	For turning a steel rod by a given cutting tool at a given machining condition under a given environment the tool life decreases from 80 min to 20 min. due to increase in cutting velocity, VC from 60 m/min to 120 m/min., then at what cutting velocity the life of that tool under the same condition and environment will be 40 min.?	**7**	**CO1**	**L3**
36	In an orthogonal cutting with a tool of rake angle 15^0, the horizontal component of cutting force is 1250 N, vertical component of cutting force is 1690 N and chip thickness ratio is 0.3. Determine the various components of the cutting force and coefficient of friction. Also determine the components of work done, if the cutting speed is 200 m/min.	**7**	**CO1**	**L3**

Module 2

Sl. No	Question	Marks	CO	BL
1	What is meant by interpolation in NC systems? Explain different types of interpolations.	**3**	**CO2**	**L1**
2	List the four types of APT statements.	**3**	**CO2**	**L1**
3	Write any Five preparatory function code in manual part programming and its explanation	**3**	**CO2**	**L1**
4	Write any two methods of specifying a line in an APT language.	**3**	**CO2**	**L1**
5	How is absolute positioning different from incremental positioning?	**3**	**CO2**	**L1**
6	Mention the purpose of miscellaneous functions in part programming	**3**	**CO2**	**L1**
7	List out the differences between CNC and DNC manufacturing systems.	**3**	**CO2**	**L1**
8	Define any 5 G codes and M codes	**3**	**CO2**	**L1**
9	Explain how feed rate and speed are specified in APT programs.	**3**	**CO2**	**L1**
10	What are the four modifiers used in APT language?	**3**	**CO2**	**L1**
11	How do you fix the program zero point in the NC system?	**3**	**CO2**	**L1**
12	Explain computer assisted part programming.	**3**	**CO2**	**L1**
13	Differentiate between point to point and straight cut NC system.	**3**	**CO2**	**L2**

14	Define the three types of motion commands used in APT language with syntax and examples	**7**	**CO2**	**L2**
15	Mention the purpose of miscellaneous functions in part programming. Write any 2 M – codes with their applications.	**7**	**CO2**	**L2**
16	Write a detailed note on DDA integrator	**7**	**CO2**	**L2**
17	Explain feedback mechanism used in CNC machines.	**7**	**CO2**	**L2**
18	Explain the features of G code Programming	**7**	**CO2**	**L2**
19	Write a short note on 5 axis CNC machines.	**7**	**CO2**	**L2**
20	Explain the features of ladder programming	**7**	**CO2**	**L2**
21	Write a Manual Part Program for the given figure 	**7**	**CO2**	**L3**
22	Write a sample part program for turning operation and explain about each codes used in program.	**7**	**CO2**	**L3**
23	Draw relay ladder diagram for the following sequential operations. Start button pressed, table motor started, package moves to the position of the limit switch and stops. Auxiliary features required are emergency stop, red light to indicate stop condition and green light to indicate package moving condition. Draw input and output connection diagrams also	**7**	**CO2**	**L3**
24	Write a part program to give a finished job as shown in figure using milling operation. (Speed = 1200 rpm, Feed = 125 mm/min., Depth of cut = 3 mm, Thickness of plate = 3 mm.)	**7**	**CO2**	**L3**

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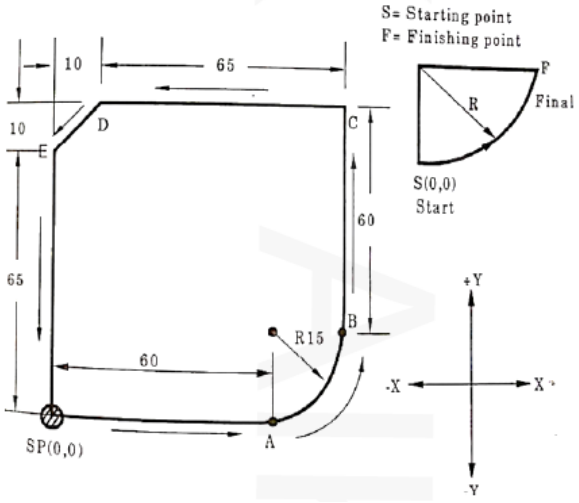
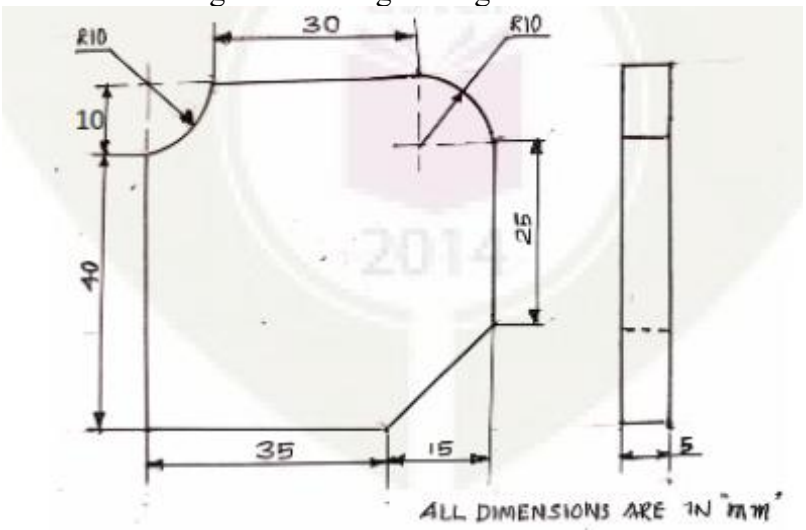
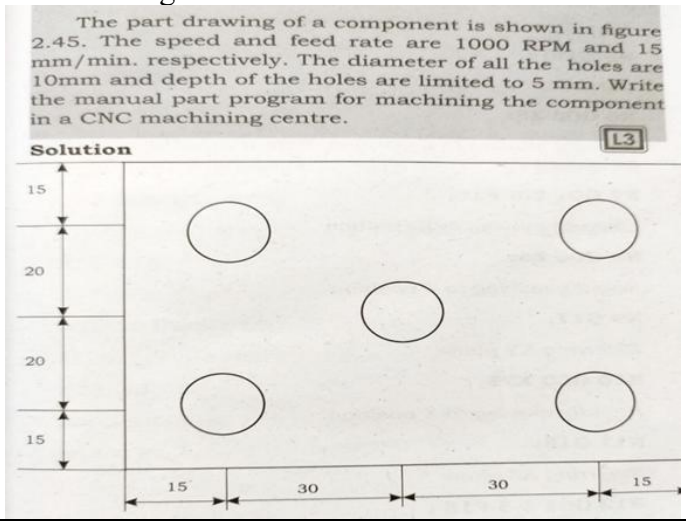
				
25	Write a Part Program for the given figure 	**7**	**CO2**	**L3**
26	The part drawing of a component is shown in figure. The speed and feed rate are 1000 rpm and 15 mm/min respectively. The diameter of all the holes are 10 mm and depth of the holes are limited to 5 mm. Write the manual part program for machining the component in a CNC machining centre. 	**7**	**CO2**	**L3**

Module 3				
Sl. No	**Question**	**Marks**	**CO**	**BL**
1	What are the characteristics of Electro Discharge Machining (EDM)?	**3**	**CO3**	**L1**
2	Write the applications of Wire Cut Electro Discharge Machining.	**3**	**CO3**	**L1**
3	How the amplitude and frequency of vibration effects on material removal rate in Ultra Sonic Machining	**3**	**CO3**	**L1**
4	What are the functions and desirable properties of dielectric fluid in EDM?	**3**	**CO3**	**L1**
5	Describe advantages and limitations of Ion beam machining.	**3**	**CO3**	**L1**
6	What are the advantages and disadvantages of Laser Beam Machining process?	**3**	**CO3**	**L1**
7	How Micro EDM process is different from EDM process?	**3**	**CO3**	**L1**
8	What possible errors are caused in EDM?	**3**	**CO3**	**L1**
9	What are the advantages and disadvantages AWJM? Describe the applications of AWJM.	**3**	**CO3**	**L1**
10	Explain the process parameters of Laser Beam Machining (LBM).	**3**	**CO3**	**L1**
11	Why plasma arc machining is more preferred over electro discharge machining. Explain	**3**	**CO3**	**L1**
12	Explain Ultra Sonic Machining with a neat figure	**7**	**CO3**	**L2**
13	What are the functions and desirable properties of dielectric fluid in EDM? Explain desirable properties of electrode material used in EDM?	**7**	**CO3**	**L2**
14	With a neat sketch explain Electron Beam Machining process	**7**	**CO3**	**L2**
15	List and explain the factors affecting material removal rate and surface quality in electron beam machining	**7**	**CO3**	**L2**
16	Explain the effect of different parameters on material removal rate in USM	**7**	**CO3**	**L2**

17	Explain ECM with neat sketch. Briefly explain the process parameters for the same.	**7**	**CO3**	**L2**
18	Explain desirable properties of electrode material electrode material used in EDM	**7**	**CO3**	**L2**
19	Explain the application of the following electro materials in EDM: a) Copper b) Graphite	**7**	**CO3**	**L2**
20	Write a short note on ECG	**7**	**CO3**	**L2**
21	Explain about the functions of transducer and tool cone in USM	**7**	**CO3**	**L2**
22	What is the function of abrasive slurry in USM? Explain how the abrasive selection is made.	**7**	**CO3**	**L2**
23	Write the working principle of Abrasive Jet Machining with neat figure	**7**	**CO3**	**L2**
24	What are the process parameters in Abrasive Water Jet Machining?	**7**	**CO3**	**L2**
25	Explain the mechanism of material removal in Plasma arc machining	**7**	**CO3**	**L2**
26	Explain solid state Laser Beam Machining Process with neat figure	**7**	**CO3**	**L2**
27	List and explain the factors affecting Heat Affected Zone and Surface quality in Laser Beam Machining.	**7**	**CO3**	**L2**
28	Describe the mechanism of material removal in Ion beam machining	**7**	**CO3**	**L2**
29	Sketch and explain magnetic abrasive finishing and abrasive flow machining	**7**	**CO3**	**L2**
30	Sketch and explain magneto rheological abrasive flow machining	**7**	**CO3**	**L2**
31	With a neat sketch explain Ion Beam Machining process.	**7**	**CO3**	**L2**
32	Explain the principle of laser with neat sketch and explain the working of LBM	**7**	**CO3**	**L2**
33	Explain the effect of different parameters on Material Removal Rate for AJM	**7**	**CO3**	**L2**

Module 4				
Sl. No	**Question**	**Marks**	**CO**	**BL**
1	How explosive forming process is different from other forming processes?	**3**	**CO3**	**L1**
2	Write notes on effect of high speeds on stress strain relationship of metals	**3**	**CO3**	**L1**
3	How sheet metals can be formed?	**3**	**CO3**	**L1**
4	Write in detail the electrohydraulic forming process	**7**	**CO3**	**L2**
5	Explain about high velocity forming methods	**7**	**CO3**	**L2**
6	Define 'P' waves and 'S' waves.	**3**	**CO3**	**L1**
7	What is meant by elastic stress wave? How it is produced?	**3**	**CO3**	**L1**
8	What is high energy rate forming? Compare conventional methods and high velocity forming methods.	**3**	**CO3**	**L1**
9	Compare high energy forming with traditional metal forming	**3**	**CO3**	**L1**
10	List out the advantages of HERF.	**3**	**CO3**	**L1**
11	List out the advantages of HVF methods over conventional methods of forming.	**3**	**CO3**	**L1**
12	List a few applications of HERF.	**3**	**CO3**	**L1**
13	With the help of neat sketch explain the effect of high speed on the stress strain relationship of Cu.	**3**	**CO3**	**L1**
14	Discuss about the effect of high speed on the stress-strain relationship in mild steel and copper with diagram.	**7**	**CO3**	**L2**
15	Explain the two types of explosive forming with neat sketches	**7**	**CO3**	**L2**
16	Explain Electro Magnetic Forming and show that it can be applied to internal, external and surface forming operations	**7**	**CO3**	**L2**
17	Draw a schematic diagram of electro hydroforming and explain	**7**	**CO3**	**L2**
18	Explain the different stages of explosive warming. Why vacuum is necessary in this process.	**7**	**CO3**	**L2**
19	Compare high velocity forming with conventional forming process	**7**	**CO3**	**L2**

20	Explain electro hydraulic forming with a neat sketch.	**7**	**CO3**	**L2**
21	Explain Electro Magnetic Forming and show that it can be applied to internal, external and surface forming operations.	**7**	**CO3**	**L2**
22	Explain the effect of high speed on stress strain relationship of mild steel and aluminium with graphs.	**7**	**CO3**	**L2**
23	Derive an expression for the velocity of an elastic wave travelling along a rod of infinite length	**7**	**CO3**	**L2**

Module 5

Sl. No	Question	Marks	CO	BL
1	What is laminated object manufacturing? Explain the process with sketches.	**3**	**CO5**	**L1**
2	.Give a general classification of micro machining processes.	**3**	**CO5**	**L1**
3	Write a note on Elastic Emission Machining.	**3**	**CO4**	**L1**
4	Write any six-material addition process in Additive Manufacturing	**3**	**CO5**	**L1**
5	Explain the laser welding process	**3**	**CO5**	**L1**
6	Name the advanced machining processes which can be used for magnetic material.	**3**	**CO5**	**L1**
7	List out the differences between conventional machining and micromachining.	**3**	**CO5**	**L1**
8	List any 6 process parameters of Abrasive Flow Machining (AFM).	**3**	**CO5**	**L1**
9	How high accuracy is achieved in diamond turn machining?	**3**	**CO5**	**L1**
10	What do you understand by the term micro machining?	**3**	**CO4**	**L1**
11	Explain Rapid Prototyping (RP) process. List any two advantages	**3**	**CO5**	**L1**
12	Classify the advanced machining processes on the basis of types of energy employed.	**3**	**CO5**	**L1**
13	Explain the importance of micro and nano machining in modern manufacturing industries.	**3**	**CO5**	**L1**
14	Explain two-way Abrasive Flow Machining with neat figure	**7**	**CO5**	**L2**

15	Explain the Magnetic Float Polishing with neat figure	**7**	**CO5**	**L2**
16	Explain Magnetorheological abrasive flow finishing process with suitable diagram	**7**	**CO5**	**L2**
17	With a neat sketch explain Selective laser sintering	**7**	**CO5**	**L2**
18	With a neat sketch explain Diamond turn machining process	**7**	**CO5**	**L2**
19	Explain the working of laser engineered net shaping with sketch	**7**	**CO5**	**L2**
20	What is LIGA process? Explain it with neat sketches	**7**	**CO5**	**L2**
21	Explain fused deposition modelling with a neat sketch.	**7**	**CO5**	**L2**
22	With neat sketch explain Abrasive flow finishing process	**7**	**CO5**	**L2**
23	Describe Laminated Object Manufacturing Process with a neat sketch	**7**	**CO5**	**L2**

Prepared By: Mr. Avinesh Pyarilal (Subject Faculty)

Checked By: Dr. Manoj Jose Kalathil (Subject Group Coordinator)

Approved By: Dr. Ramadas T (HoD - ME)

Course Code & Name: MET 312 NON DESTRUCTIVE TESTING

1. Prescribed Syllabus

Module	Topic	Hours
1	NDT Versus Mechanical testing-Overview of the Non Destructive Testing Methods for the detection of manufacturing defects as well as material characterisation-Relative merits and limitations-various physical characteristics of materials and their applications in NDT. Visual Inspection: Fundamentals of Visual Testing – vision, lighting, material attributes, environmental factors, visual perception, direct and indirect methods – mirrors, magnifiers, Boroscopes and fibro scopes– light sources and special lighting– calibration- computer enhanced system	7
2	Liquid Penetrant Inspection: Principles – types and properties of liquid penetrants developers – advantages and limitations of various methods - Preparation of test materials -Application of penetrants to parts, removal of excess penetrants, post cleaning – Control and measurement of penetrant process variables –selection of penetrant method – solvent removable, water washable, post emulsifiable – Units and lighting for penetrant testing –calibration- Interpretation and evaluation of test results - dye penetrant process applicable codes and standards.	7
3	Magnetic Particle Inspection (MPI): Important terminologies related to magnetic properties of material, principle-magnetizing technique, procedure, and equipment, fluorescent magnetic particle testing method, sensitivity-application and limitation-Methods of magnetization, magnetization techniques such as head shot technique, cold shot technique- central conducto testing, and magnetization using products using yokes-direct and indirect method of magnetization - continuous testing of MPI, residual technique of MPI- checking devices in MPI, Interpretation of MPI, indications, advantage and limitation of MPI.	6
4	Ultrasonic Testing: Basic principles of sound propagation, types of sound waves, Principle of UT-methods of UT, their advantages and limitations-Piezoelectric Material, Various types of transducers/probe-Calibration methods, contact testing and immersion testing, normal beam and straight beam testing, angle beam testing, dual crystal probe, ultrasonic testing techniques resonance testing, through transmission technique, pulse echo testing technique, instruments used UT, accessories such as transducers, types, frequencies, and sizes commonly used. Reference of standard blocks-technique for normal beam inspection-flaw characterization technique, defects in welded products by UT-Thickness determination by ultrasonic method;- Study of A, B and C scan presentations-Time of Flight Diffraction (TOFD).	7

5	Radiography: X-rays and Gamma rays, Properties of X-rays relevant to NDE - Absorption of rays - scattering. Characteristics of films-graininess, Density, Speed, Contrast. Characteristic curves. Inspection techniques like SWSI, DWSI, DWDI, panoramic exposure, real time radiography, films used in industrial radiograph. Eddy Current Testing: Generation of eddy currents – effect of change of impedance on instrumentation – properties of eddy currents – eddy current sensing elements, probes, type of coil arrangement – absolute, differential, lift off, operation, applications, advantages, limitations Field factor and lift of effect, edge effect, end effect, impedance plane diagram in brief, depth of penetration of ECT, relation between frequency and depth of penetration in ECT.	**7**

2. Text Books (T)

T1. Baldev Raj, Practical Non – Destructive Testing, Narosa Publishing House, 1997
T2. J.Prasad and C. G. K. Nair, Non-Destructive Test and Evaluation of Materials, Tata McGraw-Hill Education, 2nd edition (2011).
T3. B.Raj, T. Jayakumar and M. Thavasimuthu, Practical Non Destructive Testing, Alpha Science International Limited, 3 rd edition (2007).
T4. T. Rangachari, J. Prasad and B.N.S. Murthy, Treatise on Non-destructive Testing and Evaluation, Navbharath Enterprises, Vol.3, (1983).
T5. Ed. Peter.J. Shull, Non-destructive Evaluation: Theory, Techniques, and Applications, Marcel Dekker (2002). 2.

3. Reference Books (R)

R1. C. Hellier, Handbook of Non-Destructive Evaluation, McGraw-Hill Professional, 1st edition (2001).
R2 J. Thomas Schmidt, K. Skeie and P. Maclntire, ASNT Non Destructive Testing Handbook: Magnetic Particle Testing, American Society for Non-destructive Testing, American Society for Metals, 2nd edition (1989).
R3. Krautkramer, Josef and Hebert Krautkramer, Ultrasonic Testing of Materials, Springer Verlag, 1990

4. Course Objectives

- To introduce the basic principles, techniques, equipment, applications and limitations of NDT methods such as Visual, Penetrant Testing, Magnetic Particle Testing, Ultrasonic Testing, Radiography, Eddy Current.
- To enable selection of appropriate NDT methods
- To identify advantages and limitations of NDT methods
- To make ware the developments and future trends in NDT

5. Course Pre / Co-requisite

NIL

6. Course Outcomes

After completion of the course, student will be able to

CO1: Have a basic knowledge of surface NDT which enables to carry out various inspections in accordance with the established procedures.

CO2: The students will be able to differentiate various defect types and select the appropriate NDT methods for the specimen.

CO3: Calibrate the instrument and evaluate the component for imperfections using Magnetic Particle Inspection.

CO4: Have a basic knowledge of ultrasonic testing which enables them to perform inspection of samples.

CO5: Have a complete theoretical and practical understanding of the radiographic testing and eddy current testing, interpretation and evaluation.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO 3
CO1	**H**	**H**	**M**									**L**	**M**		
CO2	**H**	**H**	**M**									**L**			**L**
CO3	**H**	**H**	**L**									**M**			**M**
CO4	**H**	**H**	**M**									**M**	**M**		
CO5	**H**	**H**	**M**									**L**	**H**		

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	**PO1**	Knowledge of surface NDT enables students to carry out various inspections in accordance with the established procedures. High correlation is due to the fact that knowledge of surface NDT enables students to find solution to complex engineering problems.
	PO2	Students will be able to perform surface inspections with the knowledge in various surface NDT techniques to analyze engineering problems. High correlation is due to the fact that this involves the analysis of complex engineering problems.
	PO3	By gaining knowledge in various surface NDT techniques students will be able to develop solutions to engineering problems. Medium correlation is due to the fact that this involves standard knowledge

		in consideration for public safety and environmental factors.
	PO12	Knowledge of surface NDT enables students to carry out various inspections in NDT. Medium correlation is due to the fact that this involves standard knowledge of surface NDT to engage in independent and life-long learning in the broadest context of technological change.
	PSO1	Surface Non-Destructive Testing Techniques helps the student to do practical NDT problems. Medium correlation is due to the fact this involves basic knowledge of concurrent technologies to solve practical problems in a sustainable way.
CO2	**PO1**	Knowledge of different defect types enables the students to select appropriate defect types. High correlation is due to the fact that the in-depth knowledge of different NDT techniques can be used to find solution of complex engineering problems.
	PO2	The students will gain an in-depth knowledge in different defect types one can identify the problem with a workpiece. High correlation is due to the fact that this involves deep knowledge of different defect types.
	PO3	By gaining basic knowledge of defect types students can design / develop a solution for the defect in the sample. Medium correlation is due to the fact that this involves standard knowledge of different defect types to select the appropriate NDT technique.
	PO12	By studying different defect types student can have a life long learning in the broadest context of technological change. Low correlation is due to the fact that this involves basic knowledge of different defect types in independent and life-long learning in the broadest context of technological change.
	PSO3	By gaining knowledge of different defect types students will be able to analyze multi-disciplinary systems and investigate different defect by application of appropriate NDT technique. Low correlation is due to the fact that this involves basic knowledge of different defect types to analyze multi- disciplinary systems.
CO3	**PO1**	The knowledge of Magnetic Particle Inspection technique helps the students to apply the knowledge of science and engineering fundamentals. High correlation is due to the fact that the in-depth knowledge of MPI techniques can be used to find solution of complex engineering problems.
	PO2	By studying the MPI technique and the calibration method of the equipment the students will be able to identify and analyze engineering problems. High correlation is due to the fact that the in-depth knowledge of MPI techniques can be used to reach substantiated conclusions using first principles of engineering sciences.
	PO3	Basic theoretical knowledge of MPI technique in NDT will empower students to design system components that meet the specified needs. Low correlation is due to the fact this involves very basic knowledge of design of components in NDT technique with appropriate

		consideration for the public safety and health.
	PO12	The students will be able to have the ability to engage in independent and lifelong learning by having the understanding of MPI technique and calibration method. Medium correlation is due to the fact that this involves standard knowledge of MPI technique that enables students to engage in independent and life-long learning in the broadest context of technological change.
	PSO3	Using the knowledge of MPI technique the student will be able to analyze multi-disciplinary system. Medium correlation is due to the fact that this involves standard knowledge of calibration techniques and evaluation of components of MPI to design and analyze multi-disciplinary system by applying the principles of science and engineering.
CO4	**PO1**	By applying the principles of ultrasound testing students will be able to solve practical problems they may face in the conduct of ultrasound testing. High correlation is due to the fact that this involves in depth knowledge of the principles of UT technique to find solutions of complex engineering problems.
	PO2	Having the knowledge of ultrasound testing, students will be able to analyze the problem, reach substantiated conclusions of the problem in hand using first principles of engineering science. High correlation is due to the fact that this involves deep knowledge of ultrasound testing technique which enables the students to perform inspection of samples.
	PO3	By gaining the knowledge of ultrasound testing students will be able to design and develop system components or processes that meet the specified needs with appropriate consideration for public safety and environmental considerations. Medium correlation is due to the fact that this involves standard knowledge of ultrasound testing technique.
	PO12	The students will be able to have the ability to engage in independent and lifelong learning by having the understanding of ultrasonic testing method. Medium correlation is due to the fact that this involves standard knowledge of ultrasound testing technique that enables students to engage in independent and life-long learning in the broadest context of technological change.
	PSO1	Ultrasound Techniques helps the student to do practical NDT problems. Medium correlation is due to the fact this involves basic knowledge of concurrent technologies to solve practical problems in a sustainable way.
CO5	**PO1**	Knowledge of radiographic testing and eddy current testing enables students to carry out various inspections in accordance with the established procedures. High correlation is due to the fact that knowledge of surface radiographic testing and eddy current testing enables students to find solution to complex engineering problems.
	PO2	Students will be able to perform radiographic testing and eddy current testing with the knowledge in various NDT techniques to analyze engineering problems. High correlation is due to the fact that this involves the analysis of complex engineering problems.

	PO3	By gaining basic knowledge of radiographic testing and eddy current testing, students can analyze the defect in the sample and design / develop a solution for that defect. Medium correlation is due to the fact that this involves standard knowledge of radiographic testing and eddy current testing to interpret and evaluate the defects in the sample.
	PO12	Basic knowledge of radiographic testing and eddy current testing enables students to carry out various inspections in NDT. Low correlation is due to the fact that this involves basic knowledge of radiographic testing and eddy current testing to engage in independent and life-long learning in the broadest context of technological change.
	PSO1	Radiographic testing and eddy current testing Techniques helps the student to do practical NDT problems. High correlation is due to the fact this involves deep knowledge of concurrent technologies to solve practical problems in a sustainable way.

9. Curricular gaps (if any)

NIL

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1			

11. Internal Assessment mark allocation (as per university curriculum)

(Provide details as mentioned in syllabus)

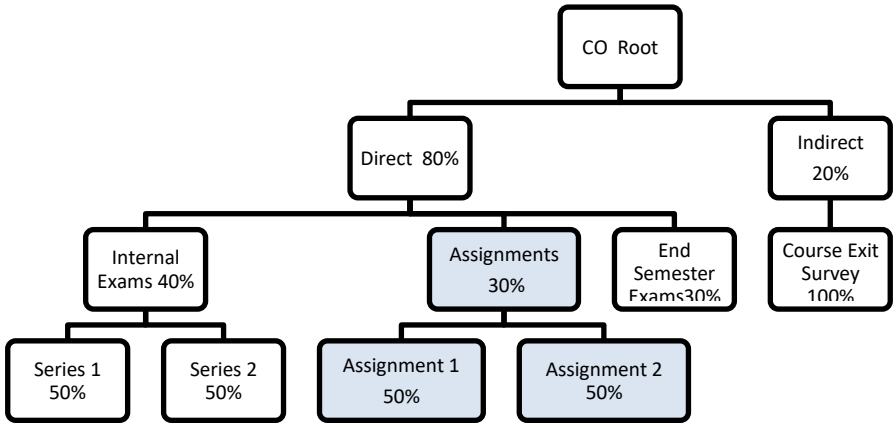
Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. Assessment – CO Mapping (Put‘ x’ if mapping is present)

	Tools		Weightage#	CO1	CO2	CO3	CO4	CO5
Direct Assessment Tools**	Internal Exam(s) 40%	Series 1	20%	x	x			
		Series 2	20%			x	x	x
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x	x			
		Assignment 2	15%			x	x	x

	End Semester Exam	30%	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey	100%	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1	NDT Versus Mechanical testing-Overview of the Non Destructive Testing Methods for the detection of manufacturing defects as well as material characterisation-Relative	1	T1,T2, R1	Lecture
2	characterisation-Relative merits and limitations-various physical characteristics of materials and their applications in NDT.	1	T1,T2, R1	Lecture
3	Fundamentals of Visual Testing	1	T1,T2, R1	Lecture
4	vision, lighting, material attributes, environmental factors, visual perception, direct and indirect methods	1	T1,T2, R1	Lecture

5	mirrors, magnifiers, Boroscopes and fibro scopesâ€“	1	T1,T2, R1	Lecture
6	light sources and special lightingâ€“calibration-	1	T1,T2, R1	Lecture
7	light sources and special lightingÃ¢Â€Â“calibration-	1	T1,T2, R1	Remedial
8	Inspection: Principles â€“ types and properties of liquid penetrants â€“ developers â€“ advantages and limitations of various methods	2	T1,T2, R1	Lecture
9	Preparation of test materials Ã¢Â€Â“	2	T1,T2, R1	Tutorial
10	Application of penetrants to parts, removal of excess penetrants, post cleaning	2	T1,T2, R1	Lecture
11	Application of penetrants to parts, removal of excess penetrants, post cleaning	2	T1,T2, R1	Remedial
12	parts, removal of excess penetrants, post cleaning â€“ Control and measurement of penetrant process variables â€“selection of penetrant method â€“	2	T1,T2, R1	Lecture
13	â€“ solvent removable, water washable, post emulsifiable â€“	2	T1,T2, R1	Lecture
14	â€“ solvent removable, water washable, post emulsifiable â€“	2	T1,T2, R1	Lecture
15	Units and lighting for penetrant testing â€“ calibration-	2	T1,T2, R1	Lecture
16	Units and lighting for penetrant testing Ã¢Â€Â“ calibration-	2	T1,T2, R1	Lecture
17	Interpretation and evaluation of test results	2	T1,T2, R1	Lecture
18	dye penetrant process applicable codes and standards.	2	T1,T2, R1	Lecture
19	dye penetrant process applicable codes and standards.	2	T1,T2, R1	Remedial
20	(MPI): Important terminologies related to magnetic properties of material,	3	T1,T2, R1	Lecture
21	(MPI): Important terminologies related to magnetic properties of material,	3	T1,T2, R1	Tutorial
22	principle-magnetizing technique, procedure, and equipment,	3	T1,T2, R1	Lecture
23	principle-magnetizing technique, procedure, and equipment,	3	T1,T2, R1	Lecture

24	fluorescent magnetic particle testing method, sensitivity-application and limitation-Methods of magnetization,	3	T1,T2, R1	Lecture
25	fluorescent magnetic particle testing method, sensitivity-application and limitation-Methods of magnetization,	3	T1,T2, R1	Remedial
26	magnetization techniques such as head shot technique, cold shot technique-	3	T1,T2, R1	Lecture
27	technique- central conductor testing, and magnetization using products using yokes-direct	3	T1,T2, R1	Tutorial
28	and indirect method of magnetization	3	T1,T2, R1	Lecture
29	- continuous testing of MPI, residual technique of MPI-	3	T1,T2, R1	Lecture
30	- continuous testing of MPI, residual technique of MPI-	3	T1,T2, R1	Remedial
31	checking devices in MPI, Interpretation of MPI,	3	T1,T2, R1	Lecture
32	MPI, indications, advantage and limitation of MPI.	3	T1,T2, R1	Lecture
33	Basic principles of sound propagation, types of sound waves, Principle of UT-methods	4	T1,T2, R1	Lecture
34	absolute, differential, lift off, operation, applications, advantages, limitations Field factor and lift of effect, edge effect, end effect, impedance plane diagram in brief, depth of penetration of ECT,	5	T1,T2, R1	Lecture
35	UT-methods of UT, their advantages	4	T1,T2, R1	Lecture
36	limitations-Piezoelectric Material, Various types	4	T1,T2, R1	Lecture
37	transducers/probe-Calibration methods, contact testing	4	T1,T2, R1	Lecture
38	transducers/probe-Calibration methods, contact testing	4	T1,T2, R1	Remedial
39	immersion testing, normal beam and straight beam testing,	4	T1,T2, R1	Lecture
40	angle beam testing, dual crystal probe,	4	T1,T2, R1	Tutorial
41	ultrasonic testing techniques	4	T1,T2, R1	Lecture
42	resonance testing, through transmission technique,	4	T1,T2, R1	Lecture

43	pulse echo testing technique, instruments used UT,	4	T1,T2, R1	Lecture
44	accessories such as transducers, types, frequencies, and sizes commonly used.	4	T1,T2, R1	Lecture
45	â€“ eddy current sensing elements, probes, type of coil arrangement	5	T1,T2, R1	Lecture
46	characterization technique, defects in welded products by UT-Thickness determination by ultrasonic method;-	4	T1,T2, R1	Lecture
47	Generation of eddy currents â€“ effect of change of impedance on instrumentation â€“	5	T1,T2, R1	Lecture
48	X-rays and Gamma rays, Properties of X-rays relevant to NDE - Absorption of rays - scattering. Characteristics of films- graininess,	5	T1,T2, R1	Lecture
49	Density, Speed, Contrast. Characteristic curves. Inspection techniques like SWSI, DWSI,	5	T1,T2, R1	Lecture
50	DWDI, panoramic exposure, real time radiography, films used in industrial radiography	5	T1,T2, R1	Lecture

15. Question Bank

Module 1				
Sl. No	**Question**	**Marks**	**CO**	**BL**
1.	Differentiate between Destructive and Non- Destructive testing.	4	CO1	2
2.	Explain the scope of NDT.	5	CO1	2
3.	What technique and device is best suited for inspecting aircraft engine peripheral details?	5	CO1,	2
4.	Write short note on holography.	5	CO1	1
5.	What are the mechanical aids used in visual inspection?	6	CO1	1
6.	With the help of suitable examples, differentiate between destructive and non-destructive testing techniques. List the advantages and disadvantages also.	10	CO1,	2
7.	Explain visual inspection process. Also explain about the different types of optical aids used in the process.	5	CO1	2
8.	With the help of a neat diagram, explain computer enhanced visual inspection system.	5	CO1	2

9.	How visual inspection helps in Non Destructive Testing?	5	CO1	2
10.	Explain the functions of developers.	5	CO2	2
11.	What are the different visual aids used in visual inspection? Explain any 3 in detail.	10	CO1	2
12.	Clearly mention the areas of applications of NDT?	5	CO1	2
13.	What are the factors that affect visual testing?	3	CO1	2
14.	What are the differences between endoscope and boroscope?	6	CO1	2
15.	What are the different special lighting methods used for visual inspection?	4	CO1	2
16.	Explain Visual Perception related with NDT?	3	CO1	2
Module 2				
1.	What are the different types of developers? How it can be applied?	5	CO2	2
2.	Differentiate between ordinary penetrant testing and fluorescent penetrant testing.	5	CO2	2
3.	Explain the principle of dye penetrant testing.	5	CO2	2
4.	Clearly mention the advantages, disadvantages and applications of DPT	5	CO2	2
5.	Explain the working principle of liquid penetrant inspection (LPI). With neat sketches explain the various steps involved in performing LPI.	10	CO2	2
6.	List the desirable properties required for a good penetrant used in LPI.	5	CO2	1
7.	Explain about the advantages and disadvantages of LPI.	5	CO2	2
8.	Write short notes about various reasons for false indications during LPI.	5	CO2	2
9.	Explain the various methods of Liquid Penetrant Inspection.	5	CO2	2
10.	Explain the functions of developers.	5	CO2	2
11.	With neat sketches explain the steps involved in conducting the LPI.	4	CO2	2
12.	What are the advantages and limitations of LPI?	3	CO2	2
13.	Explain different types of developers and how it is being applied?	5	CO2	2
14.	What are the advantages and disadvantages of Non aqueous developers and water-soluble developers used in LPI?	3	CO2	2
15.	What are the methods used to remove excess penetrants during LPI	6	CO2	2
16.	List any 3 defects that can be detected using LPI.	3	CO2	1
17.	Define the terms dwell time and development time.	3	CO2	2
18.	List the materials/consumables required for Liquid Penetrant Inspection?	3	CO2	1
19.	What is the sequence of operation of Liquid Penetrant Testing?	3	CO2	2

	Module 3			
1.	Explain the basic steps involved in MPI.	5	CO3	2
2.	Is it essential to demagnetise the specimen before and after the magnetic particle testing? Substantiate your answer.	5	CO3	2
3.	List and describe any four checking devices used in MPI.	10	CO3	1
4.	Differentiate between direct and indirect method of magnetisation. Write the advantages and disadvantages of both methods.	5	CO3	2
5.	A 6 mm carbon steel plate is brought to the testing lab. A magnetic yoke with Ac and DC mode is available. What mode you prefer to reveal internal defects? Why?	5	CO3	2
6.	With the help of neat sketches explain about any four types of magnetisation techniques used in magnetic particle inspection.	10	CO3	2
7.	List the advantages, disadvantages and applications of MPI.	5	CO3	1
8.	What is the use of field indicators in MPI? Explain any one type of field indicator used in MPI.	5	CO3	L2
9.	What is sensitivity in MPI?	5	CO3	L2
10.	Differentiate between Continuous Testing & Residual Testing.	5	CO3	L2
11.	An 8 mm thick MS plate of size 300 mm X 250 mm has to be tested for internal defects. Explain the inspection procedure with sketches using magnetic prod.	10	CO3	L3
12.	Explain permeability, magnetizing force, coercive force, retentivity, residual magnetism.	5	CO3	L2
13.	What is the principle of MPI?	5	CO3	L2
14.	What are the differences between dry continuous and wet continuous MPI?	5	CO3	L2
15.	Explain the application of Magnetic Particle Inspection?	3	CO3	L2
16.	Explain with suitable sketch about following a. Circular magnetization b. Longitudinal magnetization	3	CO3	L2
17.	What is continuous testing and residual technique of MPI	7	CO3	L2
18.	How do we Classify indications in MPI?	3	CO3	L2
19.	What is residual magnetism? Narrate its impact on MPI.	3	CO3	L2
	Module 4			
1.	Explain the different wave forms used in ultrasonic testing.	10	CO4	L2
2.	What are the different types of probes used in ultrasonic testing?	5	CO4	L1

3.	Explain about the working of ultrasonic transducer. Include necessary figures.	5	CO4	2
4.	With the help of neat figures, differentiate between through transmission technique and pulse echo testing techniques used in ultrasonic testing.	5	CO4	2
5.	Illustrate Time of Flight Diffraction (TOFD).	10	CO4	L2
6.	Explain straight beam and angle beam technique used in UT.	5	CO4	L2
7.	With neat sketches explain the following: A–Scan, B–Scan & C-Scan	10	CO4	L2
8.	Explain the steps involved in UT with figure. What are the instruments used in UT?	10	CO4	L2
9.	Explain the following: i. Dual crystal probe ii. Resonance testing	5	CO4	L2
10.	A 10 mm MS plate has to be tested for delamination. Explain the procedure using ultrasonic equipment.	10	CO4	L2
11.	What is the principle of Ultrasonic Testing (UT)?	4	CO4	L2
12.	Explain TOFD in ultrasonic testing.	4	CO4	L2
13.	Explain straight beam and angle beam testing techniques used in UT.	6	CO4	L2
14.	Explain resonance testing technique.	5	CO4	L2
15.	What are the Limitations and applications of UT	7	CO4	L2
16.	What is the need for Calibration of Equipment's in UT	3	CO4	L2
17.	What is Snell's Law and its significance in Ultrasonic Testing?	3	CO4	L2
18.	Explain the significance of the use of couplant in UT with examples	3	CO4	L2
19.	Explain contact testing and immersion testing in Ultrasonic Testing?	3	CO4	L2
	Module V			
1.	With neat sketches explain about the different inspection techniques in radiography testing (RT).	10	CO5	L2
2.	Explain about real time radiography.	5	CO5	L2
3.	Explain about different types of screens used in RT. Mention the advantages also.	5	CO5	L2
4.	Explain about various steps involved in film processing in RT.	5	CO5	L2
5.	Write short notes about various safety aspects required in RT.	5	CO5	L2
6.	Compare and contrast between X-ray and Gamma ray.	7	CO5	L1

7.	Explain the production of X-rays and Gamma rays.	10	CO5	L2
8.	Explain the advantages, disadvantages and applications of RT.	3	CO5	L2
9.	What do you mean by the term panoramic exposure in RT?	7	CO5	L2
10.	With suitable diagram explain the process of radiography testing using Cobalt 60 isotope.	10	CO5	L2
11.	a) Explain SWSI, DWSI and DWDI inspection techniques in radiographic testing. b) What are the properties of X-rays and Gamma rays?	10	CO5	L2
12.	Explain about interpretation and evaluation of test results in RT	10	CO5	L2
13.	Write short notes on electromagnetic radiation sources. Also elaborate on High Energy X-ray source.	10	CO5	L2
14.	a) Explain the principle of eddy current testing. b) What are the applications and advantages of eddy current testing?	10	CO5	L2
15.	a) Explain the following terms associated with ECT: i) Lift off effect ii) Edge effect iii) End effect b) Write short notes about the standard depth of penetration in ECT.	10	CO5	L2
16.	b) Explain the following terms associated with ECT: i) Lift off effect ii) Edge effect iii) End effect b) Write short notes about the standard depth of penetration in ECT.	10	CO5	L2
17.	a) Correlate frequency and depth of penetration in ECT. b) Explain the various applications of ECT.	10	CO5	L2
18.	Explain about eddy current testing (ECT) technique in detail. List the advantages and disadvantages of the process. Include necessary figures.	10	CO5	L2
19.	a) What is sensitivity in ECT? b) Define fill factor with the help of sketches.	10	CO5	L2
20.	Explain how coating thickness measurement is done using ECT.	10	CO5	L2
21.	Explain how conductivity measurement is done using ECT.	10	CO5	L2
22.	Define the terms conductivity, permeability, resistivity, inductance and impedance.	10	CO5	L2
23.	Explain the various equipment and accessories used in ECT.	10	CO5	L2
24.	What are the properties of X- and Gamma Rays.	3	CO5	L2
25.	How the quality of a good radiograph is accessed.	3	CO5	L2
26.	Explain any two types of screens used in radiographic testing.	3	CO5	L2

27.	Define the terms Radiation Energy and intensity.	3	CO5	L2
28.	Explain the effect of change of impedance on instrumentation in Eddy current testing.	3	CO5	L2
29.	What are the electromagnetic sources used in RT?	3	CO5	L2
30.	List the advantages of Eddy current testing?	3	CO5	L2

Prepared By : , Nisha B Nair

Checked By : , Subject Group Coordinator

Approved by : Dr. Ramadas T, HoD (ME)

Course Code & Name: HUT 310 Management for Engineers

1. Prescribed Syllabus

Module	Topic	Hours
1	Introduction to management theory, Management Defined, Characteristic of Management, Management as an art-profession, System approaches to Management, Task and Responsibilities of a professional Manager, Levels of Manager and Skill required	
2	Management Process, Planning types , Mission, Goals, Strategy, Programmes, Procedures, Organising, Principles of Organisation, Delegation, Span of Control, Organisation Structures, Directing, Leadership, Motivation, Controlling.	
3	Concept of productivity and its measurement; Competitiveness; Decision making process; decision making under certainty, risk and uncertainty; Decision trees; Models of decision making.	
4	Project Management, Network construction, Arrow diagram, Redundancy. CPM and PERT Networks, Scheduling computations, PERT time estimates, Probability of completion of project, Introduction to crashing	
5	Introduction to functional areas of management, Operations management, Human resources management, Marketing management, Financial management, Entrepreneurship, Business plans, Corporate social responsibility, Patents and Intellectual property rights.	

2. Text Books (T)

T1. P C Tripathi and P N Reddy,Principles of Management,TMH,4Th edition,2008
T2. M Y Khan and P K Jain,Financial Management,Tata McGraw Hill,2008

3. Reference Books (R)

R1.Rajesh Kumar R,Management for Engineers
R2. Kailas Sree Chandran, Management for Engineers

4. Course Objectives

This course is intended to help the students to learn the basic concepts and functions of management and its role in the performance of an organization and to understand various decision-making approaches available for managers to achieve excellence. Learners shall have a broad view of different functional areas of management like operations, human resource, finance and marketing.

5. Course Pre / Co-requisite

This course is intended to help the students to learn the basic concepts and functions of management and its role in the performance of an organization and to understand

various decision-making approaches available for managers to achieve excellence. Learners shall have a broad view of different functional areas of management like operations, human resource, finance and marketing.

6. Course Outcomes

After completion of the course, student will be able to

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

CO1: Explain the characteristics of management in the contemporary context CO2: Describe the functions of management
CO3: Demonstrate ability in decision-making process and productivity analysis CO4: Illustrate project management technique and develop a project schedule CO5: Summarize the functional areas of management
CO6: Comprehend the concept of entrepreneurship and create business plans

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M				L	M	M	M		M	L	L			
CO2	M				L	L		M	L	M	L	L			
CO3	M	M	M	M	L										
CO4	M	M		M	L						M	L			
CO5	M		M			L	L		L	M	L				
CO6		M	M	M	L	L	L	L	L	L	L	L			

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	PO1	Application of knowledge in engineering fundamentals will enable the students to explain the characteristics of management
	PO5	Selecting and applying appropriate techniques and resources will help the students to study about the characteristics of management
	PO6	Applying reasoning to assess societal health and cultural issues will enable the students to explain about the characteristics of management
	PO7	Understanding the impact of societal contexts, will enable the students to discuss about characteristics of management.
	PO8	Applying ethical principles will help the students to discuss about the characteristics of management
	PO10	Demonstrate an ability to comprehend technical literature to understand different characteristics of management

	PO11	Understanding the management principles and applying these to one's work will enable the students to explain the characteristics of management
	PO12	Source and comprehend technical literature and other credible sources of information to explain the characteristics of management
CO2	PO1	Applying fundamental engineering concepts to Describe the functions of Management
	PO5	Identifying the techniques and resources will help the students to understand the functions of management
	PO6	Identifying various engineering roles to Describe the functions of management
	PO8	Identifying situations of unethical professional conduct and proposing ethical alternatives will help the students to understand the functions of management
	PO9	Recognizing a variety of working and learning preferences to understand various functions of management
	PO10	understanding and interpreting technical and non-technical information and hence to describe the functions of management
	PO11	Identifying the tasks and resources to manage a project enable the students to describe the functions of management
	PO12	Describing the rationale for the requirement for continuing professional development helps to understand the functions of management
CO3	PO1	Applying fundamental engineering concepts will help the students to demonstrate ability in decision making process and productivity analysis
	PO2	Identifying existing processes/solution methods will help students in decision making process and productivity analysis
	PO3	Building models/prototypes to develop a diverse set of design solutions will help students to demonstrate ability in decision making process and productivity analysis
	PO4	Synthesizing information and knowledge about the problem helps in decision making process and productivity analysis.
	PO5	Modifying the techniques to solve engineering problems helps to demonstrate ability in decision making process and productivity analysis
CO4	PO1	Applying fundamental engineering concepts helps the students to illustrate project management technique and develop a project schedule
	PO2	Combining scientific principles and engineering concepts enable the students to formulate project management technique and develop a project schedule

	PO3	Determining design objectives, functional requirements and arrive at specifications helps to illustrate project management technique and develop a project schedule
	PO4	Using appropriate procedures, tools and techniques to conduct experiments and collect data helps to Illustrate project management technique and develop a project schedule
	PO5	Applying appropriate techniques, resources, and modern engineering and IT tools will enable the students to illustrate project management technique and develop a project schedule
	PO11	Using project management tools to schedule an engineering project helps to Illustrate project management technique and develop a project schedule
	PO12	Sourcing and comprehending technical literature and other credible sources of information helps to Illustrate project management technique and develop a project schedule
CO5	PO1	Applying fundamental engineering concepts to solve engineering problems and thereby to Summarize the functional areas of management
	PO6	Identifying and describing various engineering roles helps in Summarizing the functional areas of management
	PO7	Applyig principles of preventive engineering and sustainable development to an engineering activity helps to Summarize the functional areas of management
	PO9	Demonstrating effective communication, problem-solving, conflict resolution and leadership skills enable the students to Summarize the functional areas of Management
	PO10	Communicate effectively on complex engineering activities with the engineering community and with the society helps in summarising the functional areas of management
	PO11	Identify the tasks required to complete an engineering activity, and the resources required to complete the tasks helps in summarising the functional areas of Management
CO6	PO3	Synthesizing engineering requirements from a review of the state-of-the-art helps in Comprehending the concept of entrepreneurship and create business plans
	PO4	Defining a problem, its scope and importance for purposes of investigation enable the students to Comprehend the concept of entrepreneurship and create business plans
	PO5	Identifying the strengths and limitations of tools helps to Comprehend the concept of entrepreneurship
	PO6	Identifying and describing various engineering roles helps to Comprehend the concept of entrepreneurship and create business plans
	PO7	Identifying risks/impacts in the life-cycle of an engineering product or activity enables to Comprehend the concept of entrepreneurship and create business plans

	PO8	Examining and applying moral & ethical principles helps to Comprehend the concept of entrepreneurship and create business plans
	PO9	Implementing the norms of practice of effective team work, to accomplish a goal helps to Comprehend the concept of entrepreneurship and create business plans
	PO10	Producing clear, well-constructed, and well-supported written engineering documents enables in comprehending the concept of entrepreneurship and create business plans
	PO11	Describing various economic and financial costs/benefits of an engineering activity helps to create business plans
	PO12	Identifying historic points of technological advance in engineering that required practitioners to seek education in order to create business plans

9. Curricular gaps (if any)

Nill

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1		Webinar/Industry Visit/Expert talks /NPTEL/project/training Etc	
2		To better attain POs and PSOs and to bridge the gap between industry academia	

11. Internal Assessment mark allocation (as per university curriculum)

(Provide details as mentioned in syllabus)

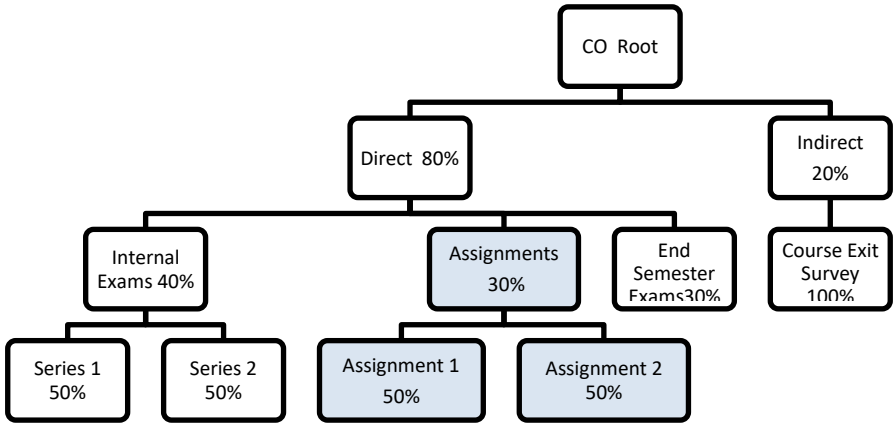
Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. Assessment – CO Mapping (Put‘ x’ if mapping is present)

	Tools		Weightage#	CO1	CO2	CO3	CO4	CO5	CO6
Direct Assessment Tools**	Internal Exam(s) 40%	Series 1	20%	x	x	x			
		Series 2	20%				x	x	X
	Assignment (s)/	Assignment 1	15%	x	x	x			

	Course Project /Quiz etc. 30%	Assignment 2	15%			x	x	x	x
	End Semester Exam		30%	x	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hour	Topic	Module	Reference	Teaching Pedagogy
	Module I			
1.	Introduction to management	1	T1	Lecture
2.	Levels of managers and skill required	1	T1	Lecture
3.	Classical management theories	1	T1	Lecture
4.	neo-classical management theories	1	T1	Lecture
5.	modern management theories	1	T1	
6.	System approaches to Management,	1	T1	Lecture
7.	Task and Responsibilities of a professional Manager	1	T1	Tutorial
	Module 2			
8.	Management process – planning	2	T1	Lecture

9.	Mission – objectives – goals – strategy – policies – programmes– procedures	2	T1	Tutorial
10	Organizing, principles of organizing, organization structures	2	T1	Lecture
11	Directing, Leadership	2	T1	Lecture
12	Motivation, Controlling	2	T1	Lecture
	Module 3			
13	Concept of productivity and its measurement Competitiveness	3	R1	Lecture
14	Decision making process;	3	R1	Lecture
15	Models in decision making	3	R1	Lecture
16	Decision making under certainty and risk	3	R1	Lecture
17	Decision making under uncertainty	3	R1	Lecture
18	Decision trees	3	R1	Tutorial
19	Models of decision-making.	3	R1	Lecture
	Module 4			
20	Project Management	4	R1	Lecture
21	Network construction	4	R1	Lecture
22	Arrow diagram, Redundancy	4	R1	Lecture
23	CPM and PERT Networks	4	R1	Tutorial
24	Scheduling computations	4	R1	Lecture
25	PERT time estimates	4	R1	Lecture
26	Probability of completion of project	4	R1	Lecture
27	Introduction to crashing	4	R1	Lecture
	Module 5			
28	Introduction to functional areas of management,	5	R2	Lecture
29	Operations management	5	R2	Tutorial
30	Human resources management ,	5	R2	Lecture

31	Marketing management	5	R2	Lecture
32	Financial management	5	R2	Lecture
33	Entrepreneurship,	5	R2	Lecture
34	Business plans	5	R2	Lecture
35	Corporate social responsibility, Patents and Intellectual property rights	5	R2	Lecture

15. Question Bank

Module 1				
Sl. No.	Question	Marks	CO	BL
1	Explain the functions of management	3	CO3	L1
2	Illustrate the characteristics of management	3	CO3	L1
3	Explain the importance of management in an organisation	3	CO3	L1
4	Explain the characteristics of management in the contemporary context	3	CO3	L1
5	What are the different levels of management?	3	CO3	L1
6	Compare top level and middle level managements	5	CO3	L1
7	Describe the roles of a manager	6	CO2	L1
8	Comment on the true nature of management. Is it a science or an art?	6	CO3	L1
9	F.W.Taylor contributed some principles of scientific management. Identify the principles and explain briefly	3	CO3	L2
10	What is scientific management?	3	CO2	L2
11	Benefits of scientific management?	6	CO2	L2
12	Weaknesses in scientific management approach	6	CO2	L2
13	Describe the philosophy	6	CO3	L2
14	Explain the systems approach to management with a block diagram	6	CO3	L2
15	How are changes in the external environment compensated in the systems Approach?	6	CO2	L2
16	Discuss different types of management/leadership	10	CO3	L2
17	Explain the different managerial skills	10	CO3	L2
18	Henri Fayol's principles of management	3	CO3	L3
19	Maslow's need hierarchy theory	3	CO3	L3
20	Evolution/development of management	3	CO2	L3
21	Behavioural management /Human relation management	5	CO2	L3
22	McGregor's Theory	6	CO2	L3
23	Modern management theories	6	CO3	L3
24	Contingency approach /Situational approach	6	CO2	L3
25	Ouchi's Theory - Theory Z approach	7	CO3	L3

26	Contributions of Gantt	10	CO2	L3
27	Gilbreth's Contribution to Management	10	CO3	L3
Module 2				
Sl. No.	Question	Marks	CO	BL
1	Define span of control. List the factors affecting it.	3	CO1	L1
2	Define organizational structure.	3	CO1	L1
3	Explain different organizational structures used in industries. Describe the matrix organization in detail and comment on its merits and demerits	8	CO3	L3
4	Explain a) Functional organization b) Matrix organization c) Committee organization. Discuss the merits and demerits of each one.	3	CO3	L1
5	Explain the meaning of line functions and staff functions.	3	CO1	L1
6	Classify the factors affecting the span of control.	3	CO3	L1
7	Distinguish between line and staff functions with the aid of examples.	3	CO3	L1
8	What is an organization chart? What are its merits and demerits?	3	CO3	L1
9	State Douglas Me Gregor's Theory X and Theory Y.	3	CO1	L1
10	How does a leader differ from a manager?	3	CO1	L1
11	Explain trait approach to leadership and contingency approach.	3	CO1	L1
12	Distinguish between trait approach and contingency approach to leadership.	3	CO1	L1
13	Illustrate how power and authority are utilized by an effective leader.	3	CO1	L1
14	Give a brief account of (a) transactional leadership and (b) transformational leadership.	3	CO1	L1
15	Critically evaluate the trait approach with an example.	3	CO3	L1
16	Explain the process of controlling function with the aid of a sketch.	5	CO3	L1
17	Distinguish between feedback and feed forward control mechanisms.	5	CO3	L1
18	Write a short note on strategic planning.	5	CO3	L1
19	What is the difference between vision and mission? Give an example.	5	CO1	L1
20	Explain different steps in planning.	5	CO1	L1
21	What do you mean by top-down policy and bottom-up planning and execution approach?	5	CO1	L1
22	Distinguish between plan, goal and procedure	6	CO3	L1
23	Discuss in detail about narrow span of management.	6	CO1	L1
24	Discuss in detail about wide span of management.	6	CO1	L1
25	Explain the importance of delegation in management.	6	CO1	L1
26	Define planning premises	6	CO1	L1
27	"Planning is looking ahead and control is looking back" Comment	4	CO3	L2
28	Explain the mission, goals, strategy, programmes and procedures of an organisation with suitable examples	4	CO1	L2
29	Differentiate between strategic and tactical decisions	4	CO1	L2
30	Illustrate the different types of organisation structures	4	CO1	L2

31	Explain the factors governing the selection of organisation structures	5	CO3	L2
Module 3				
Sl. No.	Question	Marks	CO	BL
1	Why decision making is a difficult task.	3	CO1	L1
2	List any two methods to deal with decision making under uncertainty.	3	CO1	L1
3	Illustrate the difference between programmed and non-programmed decisions by highlighting suitable examples.	5	CO1	L1
4	What is productivity ? Mention the types of productivity.	5	CO1	L1
5	Discuss the factors influencing productivity.	5	CO1	L1
6	What are the steps involved in decision tree analysis.	5	CO1	L1
7	For what types of projects decision tree is useful.	6	CO1	L1
8	What do you mean by a risky situation in business? How is decision taken under risk?	6	CO1	L1
9	Business always operate in an environment of uncertainty'. Do you agree? Give 3 reasons.	6	CO1	L1
10	Explain the concept of productivity. Bring out its importance.	3	CO1	L2
11	What are the factors affecting productivity?	3	CO1	L2
12	Distinguish between production and productivity.	5	CO1	L2
Module 4				
Sl. No.	Question	Marks	CO	BL
1	Explain the concept and objectives of network analysis. What are its different stages? Discuss its advantages and limitations.	3	CO4	L1
2	Explain PERT and its importance in network analysis?	3	CO4	L1
3	Define organizing and explain the importance of organizing in the present business environment.	3	CO4	L1
4	Explain the concepts of crashing and dummy activity in project management.	3	CO4	L1
5	Differentiate between CPM and PERT.	3	CO4	L1
Module 5				
Sl. No.	Question	Marks	CO	BL
1	Describe any one instance of application of Corporate Social Responsibility.	3	CO5	L1
2	Clearly explain the functions of financial management? Describe the challenges faced by a finance manager.	3	CO5	L1
3	What are the purposes of budget?	5	CO5	L1
4	Classify the various budgets and compare them.	5	CO5	L1

5	Explain what you understand by recruitment. What are the different sources of recruitment? What are the merits and demerits of recruitment through these sources?	6	CO5	L1
6	Describe in detail the various external sources of recruitment. What are the relative merits and demerits of this source?	10	CO5	L1
7	Write a note on staffing function of management.	3	CO5	L2
8	Give three reasons for the delegation of authority.	3	CO5	L2
9	What is a manager inventory chart?	6	CO5	L2
10	Distinguish the following: Recruitment, Selection, Placement and Induction.	6	CO5	L2
11	List the advantages and limitations of interview as a selection technique.	6	CO5	L2
12	What are the requirements of the staff of the firm in order to call it as a culture responsive firm?	6	CO5	L2
13	How entrepreneurs differ from workers?	6	CO5	L2
14	What are the objectives of operations management ?	10	CO5	L2
15	Distinguish between the following: (a) Assets and Liabilities (b) Production concept and Marketing concept (c) Needs and Wants (d) Design functions and Operational control functions in operations	10	CO5	L2

Prepared By : Dr. Manoj Jose Kalathil

Checked By : Prof. Jose V Mathew, Chairperson

Approved By : Prof. Kanaka Xavier, Vice-Principal (Academics)

Course Code & Name: MET308 Comprehensive Course Work

1. Prescribed Syllabus

Module	Topic	Hours
1	FLUID MECHANICS Fluids and continuum, Physical properties of fluids, Newton's law of viscosity. Ideal and real fluids, Newtonian and non-Newtonian fluids. Fluid Statics- Pressure-density-height relationship, manometers, pressure on plane and curved surfaces, center of pressure, buoyancy, stability of immersed and floating bodies Kinematics of fluid flow: Eulerian and Lagrangian approaches, classification of fluid flow, stream lines, path lines, streak lines, stream tubes, , stream function and potential function. Equations of fluid dynamics: Differential equations of mass, energy and momentum (Euler's equation), Bernoulli's equation, Pipe Flow: Viscous flow: shear stress and velocity distribution in a pipe Hagen Poiseuille equation. Darcy-Weisbach equation	
2	METALLURGY AND MATERIAL SCIENCE Development of atomic structure - Primary bonds: - characteristics of covalent, ionic and metallic bond - properties based on atomic bonding Crystallography: - SC, BCC, FCC, HCP structures, APF, Miller Indices: - crystal plane and direction - Modes of plastic deformation: - Slip and twinning. Classification of crystal imperfections - forest of dislocation, role of surface defects on crack initiation- Burgers vector –Frank Read source - Correlation of dislocation density with strength and nano concept - high and low angle grain boundaries– driving force for grain growth and applications Phase diagrams: - need of alloying - classification of alloys - Hume Rothery`s rule – equilibrium diagram of common types of binary systems: five types - Coring - lever rule and Gibb`s phase rule - Reactions- Detailed discussion on Iron-Carbon equilibrium diagram with micro structure and properties -Heat treatment: - TTT, CCT diagram, applications - Tempering-Hardenability, Jominy end quench test, applications- Surface hardening methods.	
3	ENGINEERING THERMODYNAMICS Basic Thermodynamic Concepts Macroscopic and Microscopic viewpoints, Concept of Continuum, Thermodynamic System and Control Volume, Surrounding, Boundaries, Types of Systems, Universe, Thermodynamic properties, Process, Cycle, Thermodynamic Equilibrium, Quasi – static Process, State, Point and Path function. Zeroth Law of Thermodynamics, Measurement of Temperature, reference Points, Temperature Scales. First law of Thermodynamics - First law applied to Non flow and flow Process-SFEE Second Law of Thermodynamics, Kelvin-Planck and Clausius	

	Statements, Equivalence of two statements Entropy- Entropy changes in various thermodynamic processes, principle of increase of entropy and its applications, Available Energy, Availability and Irreversibility- Second law efficiency.	
4	MANUFACTURING PROCESS Casting: -Characteristics of sand - patterns- cores- -chaplets- simple problems- solidification of metals and Chvorinov's rule - Elements of gating system- risering –chills. Welding:-welding metallurgy-heat affected zone- grain size and hardness- stress reliving- joint quality - heat treatment of welded joints - weld ability - destructive and non-destructive tests of welded joints Thermit welding, friction welding - Resistance welding, Arc Welding, Oxyacetyline welding Rolling:- principles - types of rolls and rolling mills - mechanics of flat rolling- Defects-vibration and chatter - flat rolling -miscellaneous rolling process Forging: methods analysis, applications, die forging, defects in forging.	
5	MECHANICS OF MACHINERY Introduction to kinematics and mechanisms - various mechanisms, kinematic diagrams, degree of freedom- Grashof's criterion, inversions, and coupler curves mechanical advantage, transmission angle. Straight line mechanisms exact, approximate. Displacement, velocity analysis– relative motion - relative velocity. Instantaneous centre -Kennedy's theorem. Acceleration analysis- Relative acceleration - Coriolis acceleration - graphical and analytical methods. Cams - classification of cam and followers - displacement diagrams, velocity and acceleration analysis of SHM, uniform velocity, uniform acceleration, cycloidal motion. Graphical cam profile synthesis, pressure angle.	

2. Text Books (T)

Text books related to all the above mentioned subjects Text books related to all the above mentioned subjects

3. Reference Books (R)

Gate exam helper books
Reference books of Mechanics of Fluids, Metallurgy and Material Science, Engineering thermodynamics, Manufacturing Process and Mechanics of Machinery.

4. Course Objectives

The course is designed to ensure that the students have firmly grasped the foundational knowledge in Mechanical Engineering familiar enough with the technological concepts. It provides an opportunity for the students to demonstrate their knowledge in various Mechanical Engineering subjects.

5. Course Pre / Co-requisite

Nil

6. Course Outcomes

After the successful completion of the course the Student will be able to:

CO1 Learn to prepare for a competitive examination

CO2 Comprehend the questions in Mechanical Engineering field and answer them with Confidence.

CO3 Communicate effectively with faculty in scholarly environments

CO4 Analyze the comprehensive knowledge gained in basic courses in the field of Mechanical Engineering

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	H	M										M			
CO2	H	M										M	M		
CO3	H	M										M			
CO4	M	H										M			M
CO5	H	M										M			

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	PO1	Competitive exams require knowledge of Engineering and by applying the knowledge of engineering fundamentals they can solve comples engineering problems associated with mechanical engineering. As it directly affect this objective high correlation is given
	PO2	By understanding the first principles of engineering sciences students will be able to identify, formulate and analyze complex engineering problems.
	PO12	Learning to prepare for competitive exams will make students recognize the need for, and have the preparation and ability to engage in independent and life-long learning
CO2	PO1	By comprehending the questions in mechanical engineering and answering them confidently, students will be able to apply the same in real life complex engineering problems using the knowledge of engineering fundamentals
	PO2	Students will be able to understand the basic principles of engineering sciences. By understanding the first principles of engineering sciences students will be able to identify, formulate and analyze complex engineering problems.

	PO12	By comprehending the questions in mechanical engineering and answering them confidently, students will gain an interest in the fields and thus will constantly look to update their knowledge in the field.
	PSO1	By comprehending the questions in mechanical engineering and answering them confidently, students will be able to demonstrate the knowledge of concurrent technologies to solve the practical problems using the principles of sustainable development
CO3	**PO1**	By communicating effectively with faculty in scholarly environment, students will be able to apply the experience in real life complex engineering problems using the knowledge of engineering fundamentals
	PO2	The scholarly environment creating will help them understand the first principles of engineering science and their application in identifying, formulating and analyzing complex engineering problems.
	PO12	By learning to communicate effectively in scholarly environment, they will feel safe in attending conferences and paper presentations which will surely help them improve their knowledge
CO4	**PO1**	By Analyzing the comprehensive knowledge gained in basic courses in the field of Mechanical Engineering, they can apply that knowledge to solve complex engineering problems
	PO2	By Analyzing the comprehensive knowledge gained in basic courses in the field of Mechanical Engineering, they can identify, formulate, review research literature and analyze complex engineering problems
	PO12	By Analyzing the comprehensive knowledge gained in basic courses in the field of Mechanical Engineering, they will get all the required knowledge to either learn new things in the fields or update themselves with the newer technologies which are coming fast and stronger.
	PSO3	By Analyzing the comprehensive knowledge gained in basic courses in the field of Mechanical Engineering, the students will be able to apply principles of mathematics, science and engineering to design and analyze multi-disciplinary systems

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs

11. Internal Assessment mark allocation (as per university curriculum)

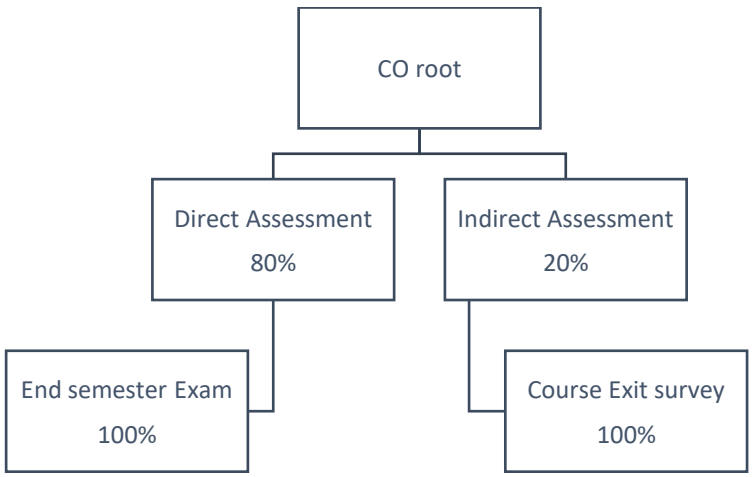
(Provide details as mentioned in syllabus)

Not applicable for the subject
Test Papers -
Assignments -
Total -

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools	Weightage#	CO1	CO2	CO3	CO4
Direct Assessment tools	End Semester Exam	100%	x	x	x	x
Indirect Assessment Tool	Course Exit Survey	100%	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1	Describe the deformation behaviour of elastic solids in equilibrium under the action of a system of forces.	1	T4, R1	Lecture

2	Stress vectors on Cartesian coordinate planes passing through a point and writing stress at a point in the form of a matrix.	1	T4, R1	Lecture
3	Write Cauchy's equation, Equality of cross shear	1	T4, R1	Lecture
4	Normal and shear stress on a plane given stress tensor and direction cosines	1	T4, R1	Lecture
5	Displacement, gradient of displacement, Cartesian strain matrix, Write strain displacement relations	1	T4, R1	Lecture
6	Concepts of principal planes and principal stress, characteristic equation of stress matrix	1	T4, R1	Lecture
7	evaluation of principal stresses and principal planes as an eigen value problem, meaning of stress invariants, maximum shear stress	1	T4, R1	Tutorial
8	Mohrs circle for 2D case	1	T4, R1	Lecture
9	find principal stress, planes, stress on an arbitrary plane, maximum shear stress graphically using Mohrâ€™s circle	1	T4, R1	Tutorial
10	Stress-strain diagram, Stress-Strain curves of Ductile and Brittle Materials, Poissons ratio	2	T4, R1	Lecture
11	Constitutive equations-generalized Hookes law, equations for linear elastic isotropic solids in in terms of Youngs Modulus and Poissons ratio (3D).	2	T4, R1	Lecture
12	Hookes law for Plane stress and plane strain conditions	2	T4, R1	Lecture
13	Relations between elastic constants E, G, and K	2	T4, R1	Lecture
14	Calculation of stress, strain and change in length in axially loaded members	2	T4, R1	Lecture
15	Numerical problems for axially loaded members	2	T4, R1	Tutorial
16	Effects of thermal loading	2	T4, R1	Lecture
17	thermal stress and thermal strain.	2	T4, R1	Lecture
18	Thermal stress on a prismatic bar held between fixed supports	2	T4, R1	Tutorial
19	Torsional deformation of circular shafts, assumptions for shafts subjected to torsion within elastic deformation range, derivation of torsion formula	3	T4, R1	Lecture
20	Torsional rigidity, Polar moment of inertia, comparison of solid and hollow	3	T4, R1	Lecture

	shaft. Simple problems to estimate the stress in solid and hollow shafts			
21	Numerical problems for basic design of circular shafts subjected to externally applied torques	3	T4, R1	Tutorial
22	Shear force and bending moment diagrams for cantilever	3	T4, R1	Lecture
23	simply supported beams subjected to point load, moment, UDL and linearly varying load	3	T4, R1	NPTEL Videos
24	Differential equations between load, shear force and bending moment.	3	T4, R1	Lecture
25	Normal and shear stress in beams:	3	T4, R1	Lecture
26	Derivation of flexural formula, section modulus, flexural rigidity	3	T4, R1	Lecture
27	Shear stress formula for beams: numerical problem to find shear stress distribution for rectangular section	3	T4, R1	Tutorial
28	Deflection of cantilever and simply supported beams subjected to point load, moment and UDL using Macauleys method	4	T4, R1	Lecture
29	procedure and problems with multiple loads	4	T4, R1	Tutorial
30	Linear elastic loading, elastic strain energy and Complementary strain energy	4	T4, R1	Lecture
31	Elastic strain energy for axial loading, transverse shear, bending and torsional loads	4	T4, R1	Lecture
32	Expressions for strain energy in terms of load, geometry and material properties of the body	4	T4, R1	Lecture
33	axial, shearing, bending and torsional loads	4	T4, R1	Lecture
34	Castiglianos second theorem to find displacements, reciprocal relation	4	T4, R1	Lecture
35	Simple problems to find the deflections using Castiglianos theorem	4	T4, R1	Tutorial
36	Fundamentals of bucking and stability, critical load, Eulers formula for long columns, assumptions and limitations	5	T4, R1	Lecture
37	effect of end conditions (derivation only for pinned ends), equivalent length	5	T4, R1	Lecture
38	Critical stress, slenderness ratio	5	T4, R1	Lecture

39	Rankines formula for short columns	5	T4, R1	Lecture
40	Problems of Rankines formula	5	T4, R1	Tutorial
41	Introduction to Theories of Failure. Rankines theory for maximum normal stress	5	T4, R1	Lecture
42	Guests theory for maximum shear stress, Saint-Venants theory for maximum normal strain	5	T4, R1	Lecture
43	Hencky-von Mises theory for maximum distortion energy, Haighs theory for maximum strain energy	5	T4, R1	Tutorial

15. Question Bank

Q. No	Question	Marks	CO	BL
	Part A **Answer all questions, each question carries 1 marks**			
1	Free surface of a liquid tends to contract to the smallest possible area due to force of (A) Surface tension (B) Viscosity (C) Friction (D) Cohesion	**1**	**CO1 to CO4**	**2**
2	The Metacentric heights of two floating bodies A and B are 1 m and 1.5 m respectively. Select the correct statement. (A) The bodies A and B have equal stability (B) The body A is more stable than body B (C) The body B is more stable than body A (D) The bodies A and B are unstable	**1**		**2**
3	The intensity of pressure at any point, in a liquid, is (A) Directly proportional to the area of the vessel containing liquid (B) Directly proportional to the depth of liquid from the surface (C) Directly proportional to the length of the vessel containing liquid (D) Inversely proportional to the depth of liquid from the surface	**1**		**1**
4	A manometer is used to measure (A) Atmospheric pressure (B) Pressure in pipes and channels (C) Pressure in Venturimeter (D) Difference of pressures between two points in a pipe	**1**		**1**
5	For pipes, laminar flow occurs when Reynolds number is (A) Less than 2000 (B) Between 2000 and 4000 (C) More than 4000 (D) Less than 4000	**1**	**CO1 to CO4**	**1**

6	Property of a fluid by which molecules of different kinds of fluids are attracted to each other is called (A) Adhesion (B) Cohesion (C) Viscosity (D) Compressibility	**1**		**1**
7	The units of kinematic viscosity are (A) Metres^2 per sec (B) kg sec/metre (C) Newton-sec per metre (D) Newton-sec per metre	**1**		**1**
8	Newton's law of viscosity is a relationship between (A) Shear stress and the rate of angular distortion (B) Shear stress and viscosity (C) Shear stress, velocity and viscosity (D) Pressure, velocity and viscosity	**1**		**1**
9	Hydrometer is used to determine (A) Specific gravity of liquids (B) Specific gravity of solids (C) Specific gravity of gases (D) Relative humidity	**1**		**1**
10	The dynamic viscosity of the liquid _____ with rise in temperature. (A) Remain unaffected (B) Increases (C) Decreases (D) None of these	**1**	**CO1 to CO4**	**2**
11	The velocity of the liquid flowing through the divergent portion of a Venturimeter (A) Remains constant (B) Increases (C) Decreases (D) Depends upon mass of liquid	**1**		**1**
12	The shear stress-strain graph for a Newtonian fluid is a (A) Straight line (B) Parabolic curve (C) Hyperbolic curve (D) Elliptical	**1**		**1**
13	For a perfect incompressible liquid, flowing in a continuous stream, the total energy of a particle remains the same, while the particle moves from one point to another. This statement is called (A) Continuity equation (B) Bernoulli's equation (C) Pascal's law (D) Archimedes's principle	**1**		**1**
14	The mass per unit volume of a liquid at a standard temperature and pressure is called (A) Specific weight (B) Mass density (C) Specific gravity	**1**		**1**

	(D) None of these			
15	Kinematic viscosity is equal to (A) Dynamic viscosity/density (B) Dynamic viscosity × density (C) Density/dynamic viscosity (D) 1/dynamic viscosity × density	**1**		**1**
16	The atmospheric pressure at sea level is (A) 103 kN/m2 (B) 10.3 m of water (C) 760 mm of mercury (D) All of these	**1**		**1**
17	The shear stress developed in lubricating oil, of viscosity 9.81 poise, filled between two parallel plates 1cm apart and moving with relative velocity of 2 m/s is (a) 20 N/m2 (b) 19.62 N/m2 (c) 29.62 N/m2 (d) 40 N/m2	**1**	**CO1 to CO4**	**3**
18	Work done in a free expansion process is (A) Zero (B) Maximum (C) Minimum (D) Positive	**1**		**2**
19	The measurement of a thermodynamic property known as temperature is based on (A) First law of thermodynamics (B) Second law of thermodynamics (C) Zeroth law of thermodynamics (D) None of these	**1**		**2**
20	A closed system is one in which (A) Mass does not cross boundaries of the system, though energy may do so (B) Mass crosses the boundary but not the energy (C) Neither mass nor energy crosses the boundaries of the system (D) Both energy and mass cross the boundaries of the system	**1**	**CO1 to CO4**	**1**
21	Which of the following is an intensive property of a thermodynamic system? (A) Mass (B) Temperature (C) Energy (D) Volume	**1**		**2**
22	The unit of power in S.I. units is (A) Newton (B) Pascal (C) Erg (D) Watt	**1**		**1**
23	Characteristic gas constant of a gas is equal to (A) Cp /Cv (B) Cv /Cp (C) Cp - Cv	**1**		**1**

	(D) Cp + Cv			
24	The ratio of two specific heats of air is equal to (A) 0.17 (B) 0.24 (C) 0.1 (D) 1.41	**1**		**1**
25	If a gas is heated against a pressure, keeping the volume constant, then work done will be equal to (A) +ve (B) -ve (C) Zero (D) Anywhere between zero and infinity	**1**		**2**
26	Properties of substances like pressure, temperature and density, in thermodynamic coordinates are (A) Path functions (B) Point functions (C) Cyclic functions (D) Real functions	**1**		**2**
27	According to Kelvin-Planck's statement of second law of thermodynamics, (A) It is possible to construct an engine working on a cyclic process, whose sole purpose is to convert heat energy into work (B) It is impossible to construct a device which operates in a cyclic process and produces no effect other than the transfer of heat from a cold body to a hot body (C) It is impossible to construct an engine working on a cyclic process, whose sole purpose is to convert heat energy into work (D) None of the above	**1**	**CO1 to CO4**	**1**
28	The value of n = 1 in the polytropic process indicates it to be (A) Reversible process (B) Isothermal process (C) Adiabatic process (D) Irreversible process	**1**		**2**
29	A perfect gas at 27°C is heated at constant pressure till its volume is double. The final temperature is (A) 54°C (B) 327°C (C) 108°C (D) 654°C	**1**		**3**
30	In an isothermal process, the internal energy of gas molecules (A) Increases (B) Decreases (C) Remain constant (D) May increase/decrease depending on the properties of gas	**1**	**CO1 to CO4**	**2**
31	When two bodies are in thermal equilibrium with a third body, they are also in thermal equilibrium with each other. This statement is called (A) Zeroth law of thermodynamics (B) First law of thermodynamics (C) Second law of thermodynamics	**1**		**1**

	(D) Kelvin Planck's law			
32	A gas is compressed in a cylinder by a movable piston to a volume one-half of its original volume. During the process, 300 kJ heat left the gas and the internal energy remained same. What is the work done on the gas? (a) 100 kNm (b) 150 kNm (c) 200 kNm (d) 300 kNm	**1**		**3**
33	For manufacturing of a certain amount of hole, maximum hole size was found to be 50.14 mm and minimum hole size was found to be 49.98. What will be the Tolerance in mm? a) 0.14 b) 0.15 c) 0.16 d) 0.17	**1**		**3**
34	Which of the following is the odd-one out? a) micro-grinding b) micro-turning c) micro-milling d) micro-EBM	**1**		**1**
35	Which of the following statement is correct about EDM machining? (A) It can machine hardest materials (B) It produces high degree of surface finish (C) The tool and work are never in contact with each other (D) All of these	**1**		**1**
36	Green sand mould indicates that (A) Polymeric mould has been cured (B) Mould has been totally dried (C) Mould is green in colour (D) Mould contains moisture	**1**		**1**
37	An expendable pattern is used in (A) Slush casting (B) Squeeze casting (C) Centrifugal casting (D) Investment casting	**1**	**CO1 to CO4**	**1**
38	An expendable pattern is used in (A) Slush casting (B) Squeeze casting (C) Centrifugal casting (D) Investment casting	**1**		**1**
39	An expendable pattern is used in (A) Slush casting (B) Squeeze casting (C) Centrifugal casting (D) Investment casting	**1**		**1**
40	The reducing or carburizing flame can always be recognized by the presence of _____ distinct flame zones. (A) One	**1**		**1**

	(B) Two (C) Three (D) Four			
41	The important mechanical property for a material to be successfully rolled or forged is..... A. Ductility B. Elasticity C. Mechinability D. Malleability	**1**		**1**
42	Swaging is an operation of..... A. Hot rolling B. Forging C. Extrusion D. Piercing	**1**		**1**
43	Coining is the operation of..... A. Cold forging B. Hot forging C. Cold extrusion D. Reeling	**1**		**1**
44	The system which holds the workpiece against the cutting forces without causing any damage to it, is called? (a) Location (b) Clamping (c) Above both (d) None of the above	**1**	**CO1 to CO4**	**1**
45	Give the locating and clamping principles? (a) Reduce operation time (b) Increase Productivity (c) Reduce the cost of production (d) All of the above	**1**		**1**
46	Broaching is applied for machining (A) Internal and external surfaces (B) Round or irregular shaped holes (C) External flat and contoured surfaces (D) All of these	**1**		**1**
47	The grooving is an operation of (A) Beveling the extreme end of a workpiece (B) Embossing a diamond shaped pattern on the surface of a workpiece (C) Reducing the diameter of a workpiece over a very narrow surface (D) Enlarging the end of a hole cylindrically	**1**		**1**
48	Which one among the following welding processes uses non-consumable electrode? (A) MIG welding (B) Submerged arc welding (C) GTAW (D) Flux coated arc welding	**1**		**1**
49	In a particular type of welding, flux is prepared in the form of a coarse powder and granulated flux is spread over the joint. What is this type of welding process called?	**1**		**1**

	(A) Electric arc welding (B) Submerged arc welding (C) MIG welding (D) TIG welding			
50	Long wires are made by following process..... A. Extrusion B. Rolling C. Piercing D. Drawing	**1**		**1**

Q. No	**Question**	**Marks**	**CO**	**BL**
	Part A **Answer all questions, each question carries 1 marks**			
	Which one of the following mechanisms represents an inversion of single slider crank chain? a) Elliptical trammel b) Oldham's coupling c) Whitworth quick return mechanism d) Pantograph	**1**	**CO1 to CO4**	**2**
2	A planar mechanism has 10 links and 12 joints. The degree of freedom of the mechanism is a) 1 b) 3 c) 2 d) 4	**1**		**2**
3	Number of instantaneous centres of rotation for a 6-link mechanism are a) 4 b) 6 c) 12 d) 15	**1**		**1**
4	Pressure angle of a cam is directly proportional to a) Pitch circle diameter b) Prime circle diameter c) Lift of cam d) Base circle diameter	**1**		**1**
5	For the follower with stroke S following cycloidal motion, the radius of rolling circle will be a) S*2π b) S/2π c) 2π/S d) 2π+S	**1**	**CO1 to CO4**	**1**
6	Which of the following mechanism is an exact straight line motion mechanism? a) Watt's mechanism b) Robert's mechanism c) Peaucellier mechanism d) All of these	**1**		**1**

7	Transmission angle is the angle between the a) Output link and frame b) Output link and coupler c) Input link and frame d) Input link and couple	**1**		**1**
8	The Coriolis component of acceleration is taken into account for a) Slider crank mechanism b) Four bar chain mechanism c) Quick return motion mechanism d) All of these	**1**		**1**
9	The component of the acceleration, parallel to the velocity of the particle, at the given instant is called a) Radial component b) Tangential component c) Coriolis component d) None of these	**1**		**1**
10	For low and moderate speed engines the cam follower should move with a) Cycloidal motion b) Simple Harmonic Motion c) Uniform velocity d) Uniform acceleration and retardation	**1**		**2**
11	Which sand is used for making ferrous and non-ferrous alloys a) Natural sand b) Synthetic sand c) Loam sand d) Refractory sand	**1**		**1**
12	Which among the following wood is most widely used for making patterns a) White Pine b) Mahogany c) Teak d) Maple	**1**	**CO1 to CO4**	**1**
13	13. Which of the following has the most magnitude in rolling a) Slip velocity b) Surface velocity c) Entering velocity d) Exiting velocity	**1**		**1**
14	The earing defect in the rolling of the work piece is not caused by _____ a) Material dependent b) Blank holding c) Low clearance between the roll and workpiece d) Too high speed	**1**		**1**
15	The extra metal which settles down in the gutter is known as a) Flux b) Barrelling c) Slag d) Flash	**1**	**CO1 to CO4**	**1**
16	The distance from the center of arc to the tip of electrode is called a) Arc length	**1**		**1**

	b) Arc distance c) Arc crater d) Arc depth			
17	Which of the following is not included in weldability a) Ability of mechanical soundness b) Service ability of joint c) Strain relieving brittleness d) Metallurgical compatibility of metal	**1**		**3**
18	As the grain size of a metal increases, its strength _____ a) Decreases b) Increases c) Remains constant d) No effect	**1**		**2**
19	Which of the following method is used for making crankshafts? a) Drop forging b) Press forging c) Open die forging d) Closed die forging	**1**		**2**
20	Which is the operation to relive residual stress from the welding joint a) Shot peening b) post heating c) peening d) Pre heating	**1**		**1**
21	Which of the following is the extensive property of the system a) Volume b) Pressure c) Temperature d) Density	**1**		**2**
22	An ideal gas at 27°C is heated at constant pressure till its volume becomes three times. What would be then the temperature of the gas a) 81°C b) 327°C c) 543°C d) 627°C	**1**	**CO1 to CO4**	**1**
23	For a simple closed system of constant composition, the difference between the net heat and work interactions is identifiable as the change in a) Enthalpy b) Entropy c) Flow energy d) Internal Energy	**1**		**1**
24	In throttling process, which one of the following parameters remains constant a) Temperature b) pressure c) entropy d) enthalpy	**1**		**1**
25	When a system undergoes a process such that $\int dQ\ T = 0$ and $\Delta S > 0$, the process is a) Reversible adiabatic b) Irreversible adiabatic	**1**	**CO1 to CO4**	**2**

	c) Isothermal d) None of these			
26	A kinematic chain is known as a mechanism when (a) None of the links is fixed (b) One of the links is fixed (c) Two of the links are fixed (d) None of these	**1**		**2**
27	A pantogram is a mechanism with (a) Lower pairs (b) Higher pairs (c) Rolling pairs (d) Turning pairs	**1**		**1**
28	In a gear having involute teeth, the normal to the involute is tangent to the (a) Pitch circle (b) Base circle (c) Addendum circle (d) Dedendum circle	**1**		**2**
29	A mechanism is an assemblage of (a) Two links (b) Three links (c) Four or more than four links (d) All of these	**1**	**CO1 to CO4**	**3**
30	Which type of gear train is used in clock mechanism to join hour and minute hand (a) Simple gear train (b) Compound gear train (c) Reverted gear train (d) Epicyclic gear train	**1**		**2**
31	A circle passing through the pitch point with its center at the center of cam axis is known as (a) Pitch circle (b) Base circle (c) Prime circle (d) Outer circle	**1**		**1**
32	What causes transformation of deformed martensite into austenite phase? a. Heating b. Cooling c. both a. and b. d. all of the above	**1**		**3**
33	What is the effect of high temperatures on material properties? a. loss of cohesive strength b. increase in stiffness c. increase in hardness d. All of the above	**1**		**3**
34	What is meant by ductility? a. Metals can be drawn into sheets b. Metals undergo elastic deformation under tensile loads c. Metals undergo plastic deformation under tensile loads	**1**		**1**

	d. All of the above			
35	When are the slip lines observed? a. after plastic deformation b. before plastic deformation c. after mechanical working d. after annealing	**1**		**1**
36	What is meant by Frenkel defect? a. defect in which positive and negative ions are missing b. defect in which interstitial position is occupied by missing atoms c. defect in which interstitial position is occupied by extra atom in the crystal without disorganizing the parent atom d. none of the above	**1**	**CO1 to CO4**	**1**
37	Why are internal stresses not produced in hot working process? a. Micro structures undergo distortion b. Hot working process do not undergo recrystallization c. Hot working process undergo recrystallization d. None of the above	**1**		**1**

Prepared By : Prof. Asha K R (Subject Faculty)

Checked By : Prof. JVC Maliackal (Subject Group Coordinator)

Approved By : Dr. Ramadas T (HOD - ME)

Course Code & Name: MEL332 COMPUTER AIDED DESIGN & ANALYSIS LAB

1. Prescribed Syllabus

Creating high end part models
Creating assembly models
Stuctural Thermal and Fluid flow analysis

Sl No	Experiments
1	Shaft Support
2	Jaw of the vice
3	Socket and spigot Joint
4	Flanged Coupling
5	Plummer Block
6	Knuckle Joint
7	Structural Analysis-1
8	Structural Analysis-2
9	Structural Analysis-3
10	Thermal Analysis – 1
11	Thermal Analysis -2
12	Fluid Flow Analysis

2. Text Books (T)

T1. Daryl Logan, A First course in Finite Element Method, Thomson Learning, 2007
T2. David V Hutton, Fundamentals of Finite Element Analysis, Tata McGraw Hill, 2003
T3. Ibrahim Zeid, CAD/CAM Theory and Practice, McGraw Hill, 2007

3. Reference Books (R)

R1. Daryl Logan, A First course in Finite Element Method, Thomson Learning, 2007
R2. David V Hutton,Fundamentals of Finite Element Analysis, Tata McGraw Hill,2003
R3. Ibrahim Zeid, CAD/CAM Theory and Practice, McGraw Hill, 2007

4. Course Objectives

- To introduce students to the basics and standards of engineering design and analysis related to machines components.
- To make students familiarize with different soild modelling and analysis soft wares

- To convey the principles and requirements of modelling and analysis of machine elements.
- To introduce the preparation of part modelling and assembly modelling of machineries
- To introduce standard CAD packages to perform Finite Element Analysis of machine parts

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5. Course Pre / Co-requisite

EST 110- Engineering Graphics
MEL 201- Computer Aided Machine Drawing

6. Course Outcomes

After the completion of the course the student will be able to
CO1: Gain working knowledge in Computer Aided Design and modelling procedures.
CO2: Gain knowledge in creating solid machinery parts.
CO3: Gain knowledge in assembling machine elements.
CO4: Gain working knowledge in Finite Element Analysis.
CO5: Solve simple structural, heat and fluid flow problems using standard software

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	H					H				M					H
CO2	H		L			H				H					H
CO3	H	H				H			M	M				M	H
CO4	H	L	H			H		M	M	H				M	H
CO5	H	H	M			H		H	H	H				H	H

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	PO1	nowledge in CAD and modeling procedures has high correlation with applying mathematics, science, and engineering fundamentals to solve complex engineering problems, as these skills are essential for accurate design and analysis in specialized engineering fields.
	PO6	ain working knowledge in CAD and modeling procedures is crucial as it involves applying contextual engineering knowledge to address societal, health, safety, legal, and cultural issues, thereby integrating engineering practice with responsible decision-making.
	PO10	omputer Aided Design (CAD) supports effective communication in engineering by providing precise visualizations and documentation. Medium correlation is due to CAD's role in crafting clear design reports

		and presentations, which are crucial for conveying complex engineering concepts.
	PSO3	omputer Aided Design and modeling leverage principles of mathematics, science, and engineering to create and analyze multi-disciplinary systems. High correlation exists as these skills integrate fundamental knowledge to solve complex design and engineering challenges effectively
CO2	**PO1**	reating solid machinery parts involves deep knowledge of mathematics, science, engineering fundamentals, and a specialized field. High correlation exists as these skills are essential for designing and solving complex engineering problems
	PO3	reating solid machinery parts involves fundamental design principles and practical application. This has a low correlation with designing system components for complex problems, as the latter requires extensive consideration of public health, safety, and broader societal impacts.
	PO6	esigning solid machinery parts requires advanced engineering principles and contextual awareness of societal, health, safety, legal, and cultural issues. High correlation is due to the integration of technical skills with professional responsibilities to address complex, real-world engineering challenges
	PO10	reating solid machinery parts requires in-depth knowledge of engineering principles and design techniques. High correlation exists as it involves understanding and applying complex engineering concepts to develop detailed documentation, communicate effectively, and make informed decisions in machinery design.
	PSO3	reating solid machinery parts requires applying principles of mathematics, science, and engineering to design and analyze complex systems. High correlation exists as both involve integrating multidisciplinary knowledge to address and solve engineering challenges.
CO3	**PO1**	nowledge of assembling machine elements requires applying mathematical, scientific, and engineering fundamentals. High correlation exists as it involves deep understanding and specialized skills to address complex engineering challenges in mechanical systems
	PO2	nowledge in assembling machine elements directly involves applying principles from mathematics, natural sciences, and engineering sciences to solve complex engineering problems. High correlation is due to the need for deep understanding and application of these fundamentals in assembly tasks
	PO6	nowledge in assembling machine elements ensures proper functioning and safety of machinery. High correlation with applying reasoning to assess societal, health, and safety issues stems from understanding how correct assembly impacts overall engineering practice and compliance with safety standards.
	PO9	nowledge in assembling machine elements is crucial for effective teamwork and leadership in engineering projects. Medium correlation arises because it enhances practical skills and collaboration in diverse, multidisciplinary settings, essential for successful project execution

	PO10	ssembling machine elements requires understanding and applying engineering principles, linking directly to effective communication and documentation of complex activities. The medium correlation arises from the need to clearly convey assembly processes and documentation to both technical and non-technical audiences.
	PSO2	ssembling machine elements requires technical expertise and project management skills. Medium correlation exists as it involves applying engineering principles in a professional, ethical manner to effectively manage and execute projects, aligning with scientific management principles.
	PSO3	nowledge in assembling machine elements is crucial as it applies principles of mathematics, science, and engineering to design and analyze multi-disciplinary systems. High correlation arises from integrating fundamental engineering principles with practical application in system design and analysis
CO4	**PO1**	nite Element Analysis utilizes advanced mathematics, physics, and specialized engineering knowledge to simulate and solve complex structural and thermal problems, demonstrating a high correlation with the application of fundamental and specialized engineering principles.
	PO2	nite Element Analysis helps analyze complex engineering problems, but the correlation is low as FEA focuses on numerical methods and simulations, rather than directly applying first principles of mathematics and natural sciences.
	PO3	nite Element Analysis aids in designing solutions for complex engineering problems. High correlation exists because FEA integrates engineering principles and analysis to create system components that meet safety, cultural, and environmental considerations effectively.
	PO6	nderstanding Finite Element Analysis requires applying engineering fundamentals and context-specific knowledge to address societal and safety issues in professional practice. High correlation is due to the need for detailed analysis and responsible decision-making in engineering design and problem-solving.
	PO8	nderstanding Finite Element Analysis involves ethical application of engineering principles in problem-solving. Medium correlation arises as it requires both technical proficiency in FEA and adherence to professional ethics in engineering practice to ensure responsible and accurate results.
	PO9	roperties of Fluids are used to solve hydrostatic engineering problems. High correlation is due to the fact that this involves the deep knowledge of science, engineering fundamentals, and an engineering specialization to solve the complex engineering problems.
	PO10	lastering Finite Element Analysis requires deep knowledge of engineering principles and specialized techniques. High correlation

		exists as this involves effectively communicating complex analysis results through reports, presentations, and instructions to both the engineering community and society
	SO2	nite Element Analysis (FEA) helps in accurate simulations and problem-solving in engineering design. This supports the management of engineering projects by applying scientific principles and ethical practices to address complex challenges effectively.
	PSO3	nite Element Analysis applies principles of mathematics, science, and engineering to model and solve complex systems. High correlation exists as it integrates advanced analytical techniques and engineering fundamentals to address multi-disciplinary design and analysis challenges
CO5	**PO1**	olving structural, heat, and fluid flow problems using standard software requires applying advanced mathematics, science, and specialized engineering knowledge, demonstrating a high correlation with solving complex engineering challenges
	PO2	tructural, heat, and fluid flow problems use fundamental principles of engineering and mathematics. High correlation is due to the integration of these principles with advanced software to analyze and solve complex engineering issues effectively
	PO3	sing standard software for structural, heat, and fluid flow problems demonstrates a medium correlation, as it requires applying fundamental engineering principles to design solutions that address complex issues with considerations for safety and societal impact
	PO6	tandard software for solving structural, heat, and fluid flow problems requires applying engineering fundamentals and contextual knowledge. High correlation exists as it involves assessing societal and safety issues, ensuring solutions meet professional and ethical standards in engineering practice
	PO8	tandard software for structural, heat, and fluid flow problems demands a deep understanding of engineering principles. This high correlation aligns with ethical practice, ensuring professional integrity and adherence to norms while solving complex engineering challenges
	PO9	sing standard software for structural, heat, and fluid flow problems requires a deep understanding of engineering principles and teamwork. High correlation is due to the integration of individual expertise with collaborative efforts in solving complex engineering challenges
	PO10	tandard software for structural, heat, and fluid flow problems necessitates a deep understanding of engineering fundamentals and specialization. High correlation exists as effective communication of complex analyses and solutions relies on clear documentation, presentations, and instructions.
	PSO2	sing standard software to solve structural, heat, and fluid flow problems requires a strong grasp of engineering principles. This high correlation aligns with managing projects professionally, ensuring solutions are based on scientific management principles and ethical standards
	PSO3	olving structural, heat, and fluid flow problems using standard software requires applying mathematical, scientific, and engineering principles. High correlation exists as it involves comprehensive knowledge of these

		fundamentals to design and analyze complex, multi-disciplinary systems.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs

11. Assessment Pattern (as per university curriculum)

(Provide details as mentioned in syllabus)

Continuous Internal evaluation - 75 marks

End Semester Examination - 75 marks

Total -150 marks

Evaluation criteria (as per syllabus)

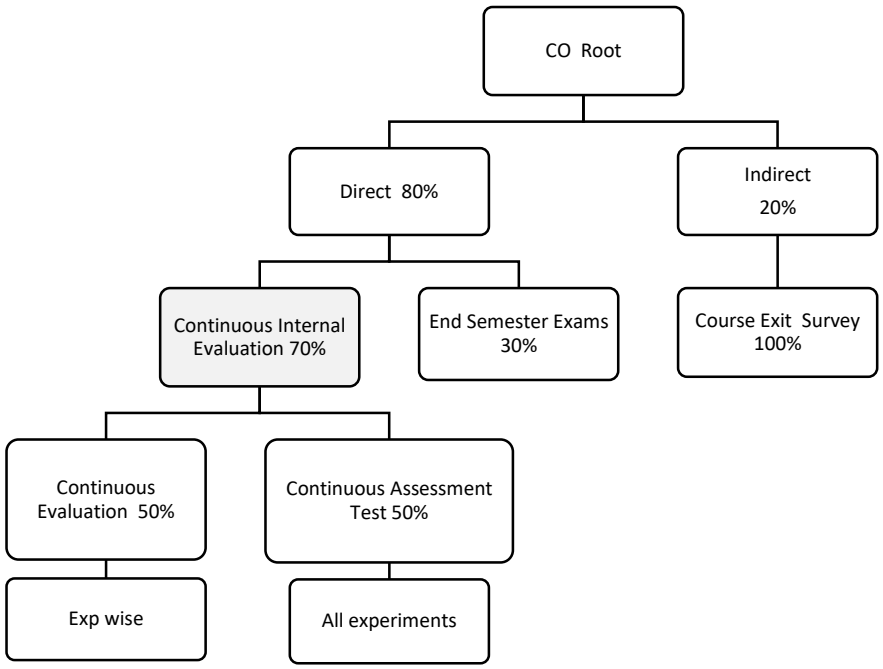
Sl. No.	Nature of Evaluation**	Evaluation Pattern**	Topics of Evaluation **	Duration**	Weightage of marks**
1.	**Continuous Internal evaluation (75 marks)**				
a.	Attendance	90%-100% - 15 marks 85% -90% - 13.5 marks 75% -85 % - 12 marks 70% - 75% - 10.5 marks 65% - 70% - 9 marks 60% - 65% - 7.5 marks	NA	NA	10%
b.	Continuous Evaluation	Accuracy and completeness – 20 marks Record – 10 marks, Total – 30 marks	Each experiment	3 hours	20%
c.	Continuous Assessment Test	Two internal exams Total 30 Marks	All Experiments		20%
2.	**End Semester Examination (75 marks)**				
a.	End semester Examination	Sketching- 15 marks, CAD Drawing –50 marks and viva – 10	All Experiments	3hrs	50%

		marks. Total 75 marks for End Semester Examination			

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools**	**Weightage#**	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Direct Assessment Tools	Continuous Evaluation Experiment wise CO mapping	35%	x	x	x	x	x
	Continuous Assessment Test	35%	x	x	x	x	x
	End Semester Exam – 30%	**30%**	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey	100%	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Weeks(W)	Experiments	Relevance to COs
1	Shaft Support	CO1, CO2
2	Jaw of the vice	CO1, CO2
3	Socket and spigot Joint	CO1, CO2, CO3
4	Flanged Coupling	CO1, CO2, CO3
5	Plummer Block	CO1, CO2, CO3
6	Knuckle Joint	CO1, CO2, CO3
7	Structural Analysis-1	CO4, CO5
8	Structural Analysis-2	CO4, CO5
9	Structural Analysis-3	CO4, CO5
10	Thermal Analysis – 1	CO4, CO5
11	Thermal Analysis -2	CO4, CO5
12	Fluid Flow Analysis	CO4, CO5
Total No. of Hours	33	

Prepared By : Mr. Jibin Jose, (Subject Faculty)

Checked By : Ms. JVC Malieckel (Subject group coordinator)

Approved By : Dr. Ramadas T (HOD - ME)

Course Code & Name: MEL334 THERMAL ENGINEERING LAB-2

1. Prescribed Syllabus

1. Determination of LMTD and effectiveness of parallel flow, Counter flow and cross flow heat exchangers
2. Performance studies on a shell and tube heat exchanger
3. Development of heat transfer correlation for heat exchangers/condenser using modified Wilson Plot Method
4. Determination of heat transfer coefficients in free convection
5. Determination of heat transfer coefficients in forced convection
6. Determination of thermal conductivity of solids (composite wall/metal rod)
7. Determination of thermal conductivity of powder
8. Determination of thermal conductivity of liquids
9. Measurement of unsteady state conduction heat transfer
10. Determination of emissivity of a specimen
11. Determination of Stefan Boltzman constant
12. Measurement of solar radiation
13. Experimental study of dropwise and filmwise condensation
14. Experiments on boiling heat transfer
15. Study and performance test on refrigeration (Refrigeration Test rig)
16. Study and performance test on air conditioning equipment (Air Conditioning test rig)
17. Performance study on heat pipe
18. Calibration of Thermocouples
19. Calibration of Pressure gauge

Sl No	Experiments
1	Determination of heat transfer coefficients in free convection
2	Determination of emissivity of a specimen
3	Calibration of Thermocouples
4	Calibration of Pressure gauge
5	Determination of thermal conductivity of solids (composite wall)
6	Determination of LMTD and effectiveness of parallel flow and counter flow heat exchangers
7	Determination of thermal conductivity of powder
8	Study and performance test on refrigeration
9	Study and performance test on air conditioning equipment
10	Performance study on heat pipe
11	Measurement of solar radiation
12	Determination of heat transfer coefficients in forced convection

2. Text Books (T)

T1. Sachdeva R.C., Fundamentals of Engineering Heat and Mass Transfer, New Age Science Limited, 2009
T2. R.K.Rajput. Heat and mass transfer, S.Chand &Co., 2015
T3. Kothandaraman C.P., Fundamentals of Heat and Mass Transfer, New Age International

3. Reference Books (R)

R1.Yunus A. Cengel, "Heat Transfer a Practical Approach", Tata McGraw-Hill Education, 4th Edition, 2012.
R2. R. C. Sachdeva, "Fundamentals of Engineering, Heat and Mass Transfer", New Age publication, 3 rd Edition, 2012.
R3. Holman J.P, "Heat transfer", Mc Graw-Hill, 10th. Ed., 2009
R4. Frank P. Incropera and David P. Dewitt, Heat and Mass Transfer, John Wiley and sons, 2011
R5.Kothandaraman, C.P., Fundamentals of Heat and Mass Transfer, New Age International, New Delhi, 2006

4. Objectives

1. The course is intended to enable the students to get exposed to equipment related to heat and mass transfer. This includes understanding the working of equipments related to various heat transfer processes viz conduction, convection, radiation and mass transfer.
2. These equipments are heat exchangers, refrigeration and air conditioning systems, compressor/blower and their applications in real life problems.
3. Also the thermo physical properties of materials which are integral to these equipments will also be evaluated. Apart from this, calibration of various instruments which are essential to these equipments will be done.

5. Course Pre / Co-requisite

Should have undergone a course of Heat and Mass Transfer

6. Course Outcomes

After the completion of the course the student will be able to
CO1: Evaluatethermal properties of materials in conduction, convectionand radiation
CO2: Analyze the performance of heat exchangers
CO3: Illustrate the operational performances of refrigeration and air conditioning systems
CO4: Perform calibration of thermocouples and pressure gauges

7. Mapping of Course Outcomes with Program Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	H		M	H		H	M		H	M		M	M	M	H
CO2	H		M	H		H	M		H	M		M	M	M	H
CO3	H		M	H		H	M	H	H	M		M	M	H	H
CO4	H		M	H		H	M	H	H	M		M	M	H	H

8. Justification for CO-PO-PSO Correlation

CO1	**POI :** Strong correlation as students will apply fundamental principles of heat transfer (conduction, convection, and radiation) using mathematical and engineering knowledge.
	PO3: Medium correlation as students analyze heat transfer mechanisms and evaluate thermal properties to solve engineering problems.
	PO4: High correlation because students will be required to conduct experiments and interpret data related to thermal properties.
	PO6 ;Strong correlation as students will apply fundamental principles of heat transfer (conduction, convection, and radiation) using mathematical and engineering knowledge to assess societal, health, safety, legal, and cultural issues relevant to professional engineering practice.
	PO7: Medium correlation since knowledge of heat transfer mechanisms contributes to sustainable engineering practices and energy efficiency.
	PO9: High correlation as students collaborate in teams to conduct thermal experiments and validate theoretical concepts.
	PO10: Medium correlation since students will document their findings and communicate results effectively in reports.
	PO12 : Medium correlation as students will apply fundamental principles of heat transfer (conduction, convection, and radiation) using mathematical and engineering knowledge to recognize the need for, and develop the ability to engage in, independent and lifelong learning in the broadest context of technological change.
	PSO1: Medium correlation as students will develop expertise in analyzing thermal properties of engineering materials.
	PSO2 : Medium correlation as the acquired knowledge will help students assess real-world heat transfer problems in mechanical systems.
	PSO3 : Strong correlation as students will apply fundamental principles of heat transfer (conduction, convection, and radiation) using mathematical and engineering knowledge.

CO2	**PO1:**Strong correlation as students will apply mathematical, scientific, and engineering fundamentals, along with specialized knowledge, to analyze the performance of heat exchangers and solve complex engineering problems.
	PO3: Medium correlation as students analyze heat exchangers' efficiency using fundamental engineering principles.
	PO4: High correlation because students will perform experiments to evaluate heat exchanger performance using scientific methods
	PO6: Strong correlation as students will apply reasoning informed by contextual knowledge to analyze the performance of heat exchangers, considering societal, health, safety, legal, and cultural issues relevant to professional engineering practice.
	PO7: Medium correlation as students understand how efficient heat exchange impacts energy conservation and sustainability.
	PO9: High correlation since students work in teams to assess experimental data related to heat exchangers.
	PO10: Medium correlation as students document and present experimental results related to heat exchangers.
	PO12: Medium correlation as students will apply their ability for independent and lifelong learning to analyze the performance of heat exchangers in the broadest context of technological change.
	PSO1: Medium correlation because analyzing heat exchanger performance is crucial for mechanical engineering applications.
	PSO2 : Medium correlation as students will apply principles of scientific management to analyze the performance of heat exchangers while managing engineering projects as a professional team with an ethical attitude.
	PSO3: High correlation as students will develop expertise in thermal systems analysis, which is applicable in industrial and research settings.
CO3	**PO1**: High correlation as students apply fundamental thermodynamic principles to refrigeration and air conditioning systems.
	PO3: Medium correlation as students will apply their knowledge to illustrate the operational performance of refrigeration and air conditioning systems while designing solutions for complex engineering problems that consider public health, safety, cultural, societal, and environmental aspects.
	PO4 : Strong correlation as students will apply research-based knowledge and methods, including experiment design, data analysis, and information synthesis, to illustrate the operational performances of refrigeration and air conditioning (HVAC) systems and provide valid conclusions for complex problems.
	PO6 :Strong correlation as students will apply reasoning informed by contextual knowledge to illustrate the operational performances of refrigeration and air conditioning (HVAC) systems while assessing societal, health, safety, legal, and cultural issues relevant to professional engineering practice.

	PO7 :Medium correlation as students will apply their understanding of the impact of professional engineering solutions in societal and environmental contexts while illustrating the operational performances of refrigeration and air conditioning (HVAC) systems, demonstrating the knowledge of and need for sustainable development.
	PO8 :Strong correlation as students will apply ethical principles and commit to professional ethics and responsibilities while illustrating the operational performances of refrigeration and air conditioning (HVAC) systems, ensuring compliance with engineering standards and best practices.
	PO9: High correlation since teamwork is essential in evaluating and troubleshooting HVAC systems.
	PO10: Medium correlation as students will apply effective communication skills to illustrate the operational performances of refrigeration and air conditioning (HVAC) systems, ensuring clear and professional interaction with the engineering community and society at large.
	PO12: Medium correlation as students develop a mindset for continuous learning by keeping up with advancements in refrigeration and air conditioning technologies.
	PSO1: Medium correlation because students will gain hands-on experience in analyzing refrigeration systems.
	PSO2: Strong correlation as students will apply principles of scientific management to illustrate the operational performances of refrigeration and air conditioning (HVAC) systems while managing engineering projects as a professional team with an ethical attitude.
	PSO3: High correlation as students develop expertise in designing and optimizing refrigeration and air conditioning systems.
CO4	**PO1:** High correlation as students apply fundamental principles of measurement and instrumentation to accurately calibrate thermocouples and pressure gauges.
	PO3: Medium correlation as students will apply their knowledge to perform calibration procedures that ensure measurement accuracy, which is crucial for solving complex engineering problems related to thermal and fluid systems.
	PO4: Strong correlation as students will use research-based methods, including experimental setup, data analysis, and error estimation, to perform precise calibration of thermocouples and pressure gauges and provide valid conclusions.
	PO6: Strong correlation as students will apply reasoning informed by contextual knowledge to assess the importance of accurate calibration in ensuring safety, compliance with industrial standards, and reliable data for engineering applications.
	PO7: Medium correlation as students will understand the impact of accurate instrumentation in societal and environmental contexts, ensuring reliable measurements in energy efficiency, pollution control, and sustainable engineering practices.
	PO8: Strong correlation as students will apply ethical principles and professional responsibilities while performing calibration, ensuring integrity, accuracy, and compliance with engineering standards and best practices.
	PO9: High correlation since teamwork is essential in calibration tasks, requiring collaboration between engineers, technicians, and quality control professionals to maintain measurement accuracy.
	PO10: Medium correlation as students will develop effective communication skills to document calibration procedures, prepare reports, and convey findings clearly to engineering teams and industry stakeholders.
	PO12: Medium correlation as students develop a mindset for continuous learning by keeping up with advancements in calibration techniques, measurement standards, and emerging sensor technologies.

	PSO1: Medium correlation because students will gain hands-on experience in calibrating thermocouples and pressure gauges, ensuring accuracy in engineering applications.
	PSO2: Strong correlation as students will apply principles of scientific management to perform calibration tasks efficiently while maintaining ethical standards and accuracy in engineering projects.
	PSO3: High correlation as students develop expertise in precision measurement, calibration procedures, and instrumentation, which are critical for maintaining high- quality engineering systems.

9. Curricular gaps (if any) : Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	-	-	-

11. Course Plan / Schedule of experiments

Weeks(W)	Experiments	Relevance to COs
1	Determination of heat transfer coefficients in free convection	CO1
2	Determination of emissivity of a specimen	CO1
3	Calibration of Thermocouples	CO4
4	Calibration of Pressure gauge	CO4
5	Determination of thermal conductivity of solids (composite wall)	CO1
6	Determination of LMTD and effectiveness of parallel flow and counter flow heat exchangers	CO2
7	Determination of thermal conductivity of powder	CO1
8	Study and performance test on refrigeration	CO3
9	Study and performance test on air conditioning equipment	CO3
10	Performance study on heat pipe	CO1
11	Measurement of solar radiation	CO1
12	Determination of heat transfer coefficients in forced convection	CO1
Total No. of Hours	36	

12. Assessment Pattern (as per curriculum)

Continuous Internal evaluation - 75 marks

End Semester Examination - 75 marks

Total -150 marks

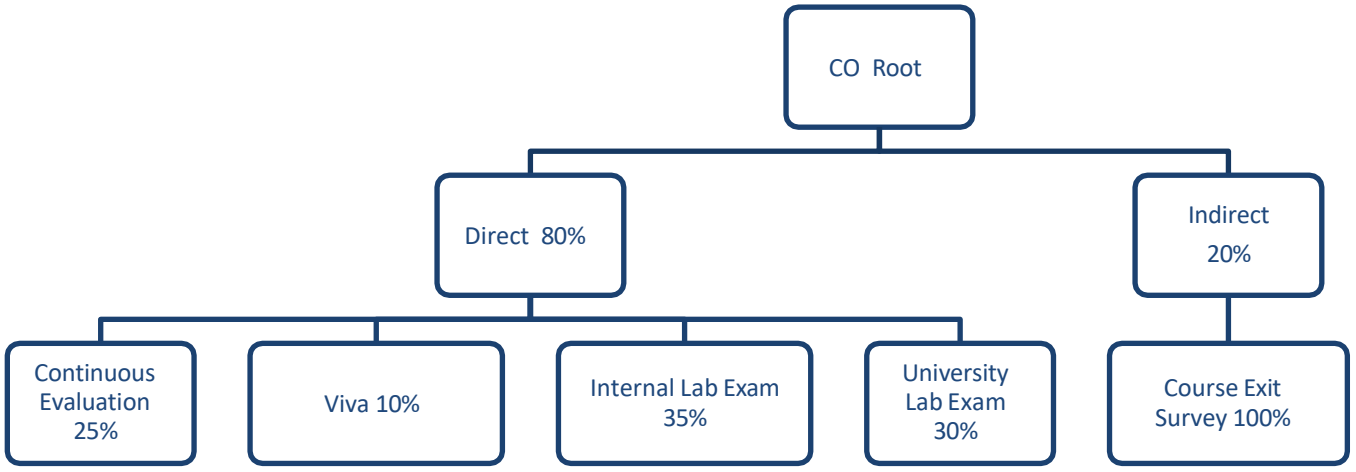
13. Evaluation criteria (as per syllabus)

Sl. No	Nature of Evaluation	Evaluation Pattern	Topics of Evaluation	Duration	Weightage of marks
1.	**Continuous Internal evaluation (75 marks)**				
a.	Attendance	90%-100% - 15 marks 85% -90% - 13.5 marks 75% -85 % - 12 marks 70% - 75% - 10.5 marks 65% - 70% - 9 marks 60% - 65% - 7.5 marks	NA	NA	20%
b.	Continuous Assessment	10 marks for performance Total no. of experiments: 10 Total – 100 marks will be converted to 20 while calculating internals	Each experiment	2.5 hours	26.67%
c.	Viva Voce	10 marks for viva. Total no. of experiments: 10 Total – 100 marks will be converted to 10 while calculating internals	Each experiment	2.5 hours	13.33%
d.	Internal Test	Preliminary Work – 10 marks Conducting Experiment – 10 marks Performance and Result – 5 marks Viva – 5 marks Total – 30 marks	All Experiments	2.5 hours	40%
2.	**End Semester Examination (75 marks)**				
a.	End semester Examination	(a) Preliminary work: 15 Marks (b) Implementing the work/ Conducting the experiment: 10 Marks (c) Performance, result and inference (usage of equipment's and troubleshooting): 25 Marks (d) Viva voce: 20 marks (e) Record: 5 Marks	All Experiments	2.5 hours	100%

14. Assessment – CO Mapping (Put‘ x’ if mapping is present)

	Tools**	Weightage#	CO1	CO2	CO3	CO4
Direct Assessment Tools 80%	Continuous Evaluation Experiment wise CO mapping	25%	x	x	x	x
	Viva – Voce Experiment wise CO mapping	10%	x	x	x	x
	Internal Lab Exam	35%	x	x	x	x
	End Semester Exam	**50%**	x	x	x	x
Indirect Assessment Tool 20%	Course Exit Survey	100%	x	x	x	x

15. Assessment Configuration



Prepared By : Mr. Jaison Joseph (Subject Faculty)

Checked By : Ms. Nisha B Nair (Subject group coordinator)

Approved By : Dr. Ramadas T (HOD - ME)

Semester: 7

Curriculum

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MET401	DESIGN OF MACHINE ELEMENTS	2-1-0	3	3
B	MET463	OPERATIONS MANAGEMENT	2-1-0	3	3
C	EET435	RENEWABLE ENERGY SYSTEMS	2-1-0	3	3
D	MCN401	INDUSTRIAL SAFETY ENGINEERING	2-1-0	3	-
S	MEL411	MECHANICAL ENGINEERING LAB	0-0-3	3	2
T	MEQ413	SEMINAR	0-0-3	3	2
U	MED415	PROJECT PHASE I	0-0-6	6	2
R/M/H	VAC	Remedial/Minor/Honours course	3-1-0	4*	4
TOTAL				24/28	15/19

Course Code & Name: MET401 Design of Machine Elements

1. Prescribed Syllabus

Module	Topic	Hours
1	Shafting: - material, design considerations, causes of failure in shafts, design based on strength, rigidity, and critical speed, design for static and fatigue loads, repeated loading, reversed bending. Design of flat belt:- material for belts, slip of the belts, creep, centrifugal tension, Power transmitted by flat belts, Design procedure of flat belts Design of connecting rod in IC engine.	10
2	Design of clutches:-single and multiple plate clutch, cone clutch, centrifugal clutch Design of brakes:-band brakes, block brakes, simple and differential band brake, internal expanding shoe brake	5
3	Sliding contact bearing:- lubrication, lubricants, viscosity, journal bearings, hydrodynamic theory, Petroff's equation, bearing characteristic number, Sommerfeld number, Heat generated in bearings, Heat dissipated by bearings, Design procedure of Journal bearings. Ball and roller bearings:- Types, bearing life, static and dynamic load capacity, Stribeck's Equation, selection of bearings, selection of taper roller bearings, Design procedure of Ball and roller bearings, Needle bearings.	7
4	Gears:- Materials of gears, terminology of spur Gear, Interference and undercutting, Gear tooth failures, Beam strength of Gear tooth, Estimation of module, Buckingham's equation for dynamic load, wear load, endurance strength of tooth, Gear proportions, Merits and demerits of each type of gears, Design procedure of Spur gear. Helical gears:- Terminology, Virtual or equivalent number of teeth, Tooth proportions, Beam strength, and Wear strength of Helical gears, Design procedure of Helical gear	8
5	Bevel gears:- Classification, Terminology, Pitch angle for bevel gears, Strength of bevel gear, beam strength, wear tooth load, Formative number of teeth, Design procedure of Bevel gear. Worm gears:- Characteristics of worm gears, Terminology, Advantages and disadvantages, Applications, Terms in Worm gear, Strength of Worm gear, Dynamic strength, Wear tooth load, Design procedure of Worm gear.	5

2. Text Books (T)

T1. J. E. Shigley, Mechanical Engineering Design, McGraw Hill, 2003
T2. Jalaludeen, Machine Design, Anuradha Publications, 2016
T3. V.B.Bhandari, Design of Machine elements, McGraw Hill, 2016
T4. Rajendra Karwa, Machine Design, Laxmi Publications (P) LTD, New Delhi, 2006

3. Reference Books (R)

R1. M. F. Spotts, T. E. Shoup. Design of Machine Elements, Pearson Education, 2006

R2. Siegel, Maleev& Hartman, Mechanical Design of Machines, International Book Company, 1983
R3. Juvinall R.C & Marshek K.M. Fundamentals of Machine Component Design, John Wiley
R4 Mechanics of Materials, Pytel A. and Kiusalaas J, Cengage Learning India Private Limited, 2015

4. **Course Objectives**

This course focuses on important topics in design of machine elements. It covers the topics of shaft design with due consideration based on strength and rigidity. The course also includes the design procedure of flat belts and connecting rod of IC engines. The other topics included are journal bearings design, ball and roller bearings, spur gear and helical gear deign considerations. The syllabus also covers design procedure of bevel gear and worm gear.

5. Course Pre / Co-requisite

MET 304 Dynamics and Design of Machinery

6. Course Outcomes

On successful completion of this course students shall be able to
CO1: Design shafts based on strength, rigidity and design for static and fatigue loads, design flat belts and connecting rod of IC engines.
CO2: Design clutches and brakes
CO3: Analyse sliding contact bearings and understand design procedure of journal, ball and Roller bearings.
CO4: Design Spur gear and helical gear
CO5: Design Bevel gears and worm gears

7. Mapping of Course Outcomes with Program Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	H	H	H												H
CO2	H	H	H												H
CO3	H	H	H												H
CO4	H	H	H												H
CO5	H	H	H												H

8. Justification for CO-PO-PSO Correlation

CO1	**PO1**	Students will be able to resolve complicated problems in the design of machine elements if they have the knowledge to perform fundamental design of shafts subjected to torsional loads, tension in flat belts, and analysis of design aspects of connecting rods. Due to the thorough understanding of science, engineering basics, and technical specialty required to address complicated engineering issues, there is a high correlation.

	PO2	Students will be able to recognise, formulate, and analyse complex problems in the vehicle structure, aircraft structure, ship structure, etc. with a clear

		understanding of how to perform basic design of shafts subjected to torsional loading. tension in flat belt, and analyse design aspects of connecting rod. Due to the comprehensive understanding required to compute unbalanced forces and couples in IC Engines employing first principles of mathematics, science, and engineering, there is a close agreement.
	PO3	Students will be able to design safe structures by applying the fundamental principles of shafts subjected to torsional loading, flat belt tension, and connecting rod design analysis. The high connection is caused by the fact that this only involves fundamental information that satisfies the necessary requirements while taking relevant public health, safety, and environmental factors into account
	PSO3	Design, analysis and implementation of shaft, flat belt and connecting rod are used for design solutions of complex engineering problems. High correlation is due to the fact that this involves the deep knowledge of engineering principles to design and analyse various types machine elements.
CO2	**PO1**	Students will learn the principles of engineering, including how to construct brakes based on different types of loads and clutches utilising uniform pressure theory and uniform wear theory. Due to the thorough understanding of science, engineering basics, and technical specialty required to address complicated engineering issues, there is a strong association.
	PO2	Students' ability to recognise, express, and analyse complex issues in the machine elements will be enhanced by their analysis of design factors for effective designing of clutches and brakes. Due to the fact that this requires a profound understanding of fundamental concepts in mathematics, science, and engineering, there is a high correlation.
	PO3	By using design considerations, students will be able to create clutches and brakes. Due to the fact that this requires fundamental knowledge that satisfies the required needs while taking acceptable public health, safety, and environmental factors into account, there is a close agreement.
	PSO3	By following the steps for building brakes and clutches with the use of a design data book and the information already available, different types of brakes and clutches may be created, and difficult technical challenges can be solved. Due to the fact that this requires in-depth understanding of engineering principles to develop and analyse various sorts of machine components, there is a strong correlation.
CO3	**PO1**	Students will acquire the engineering fundamentals necessary to design bearings utilising the Petroff's equation, and Stribeck's equation. Due to the thorough understanding of science, engineering basics, and technical specialty required to address complicated engineering issues, there is a high correlation.
	PO2	One can demonstrate acceptable bearings to be employed under a specific loading system by researching different types of loads which will help the students address the challenging design problems. As a result, that this entails a profound understanding of fundamental math concepts, science, and engineering, there is a clear relationship.

	PO3	The system's driving forces are recognised. To choose appropriate design parameters, formulas are solved. The high connection is caused by the fact that this only involves fundamental information that satisfies the necessary requirements while taking relevant public health, safety, and environmental factors into account.
	PSO3	Various theorems are used in the design and study of bearings to create answers to challenging technical hurdles. Due to the fact that this requires in-depth understanding of engineering principles to develop and analyse diverse types of machine elements, there is a high correlation.
CO4	**PO1**	Students may calculate the velocity of gears in a gear train using their understanding of engineering foundations and gear nomenclature. Due to the thorough understanding of science, engineering basics, and technical specialty required to address complicated technical hurdles, there is a high correlation.
	PO2	By applying the fundamentals of mathematics and engineering, students are able to comprehend, analyse, and draw supported conclusions about complicated engineering problems involving gear mechanisms. Due to the fact that this requires fundamental understanding of mathematics, science, and engineering, there is a high correlation.
	PO3	Students are capable of developing and analysing gear mechanisms that satisfy the required requirements while taking proper public safety precautions. Due to the fact that this only comprises fundamental information and takes public health, safety, and environmental concerns into proper consideration, there is a high association.
	PSO3	Complex engineering challenges can be solved by developing the appropriate types of gears by following the gear design technique with the aid of a design data book and relevant information. Due to the fact that this requires in-depth understanding of engineering principles to develop and analyse various sorts of machine components, there is a high correlation.
CO5	**PO1**	Students will learn the foundations of engineering as they relate to the various types of gears. Due to the thorough grasp of science, engineering concepts, and technical specialty required to address complicated engineering issues, there is a high correlation.
	PO2	Students ought to be able to identify the various forces at work in gears. Due to the fact that this requires fundamental understanding of mathematics, science, and engineering, there is a high correlation.
	PO3	With the use of a design data book and the required specifications, students can create gear designs. Due to the fact that this only comprises fundamental information and takes public health, safety, and environmental concerns into proper consideration, there is a high connection.
	PSO3	Complex engineering challenges can be solved by developing the appropriate types of gears by following the gear design approach with the aid of a design data book and relevant information. Due to the fact that this requires in-depth understanding of engineering principles to develop and analyse various sorts of machine components, there is a high correlation.

9. Curriculum gaps (if any)

Nil

10. Course Enrichment Activities

Sl No	Description	Proposed Activities	Relevance to POs and PSOs
1	Design procedure of flat belts	Case Study	PO1, PO2, PO3 and PO8
2	Gear proportions	Case Study	PO1, PO2, PO3 and PO8

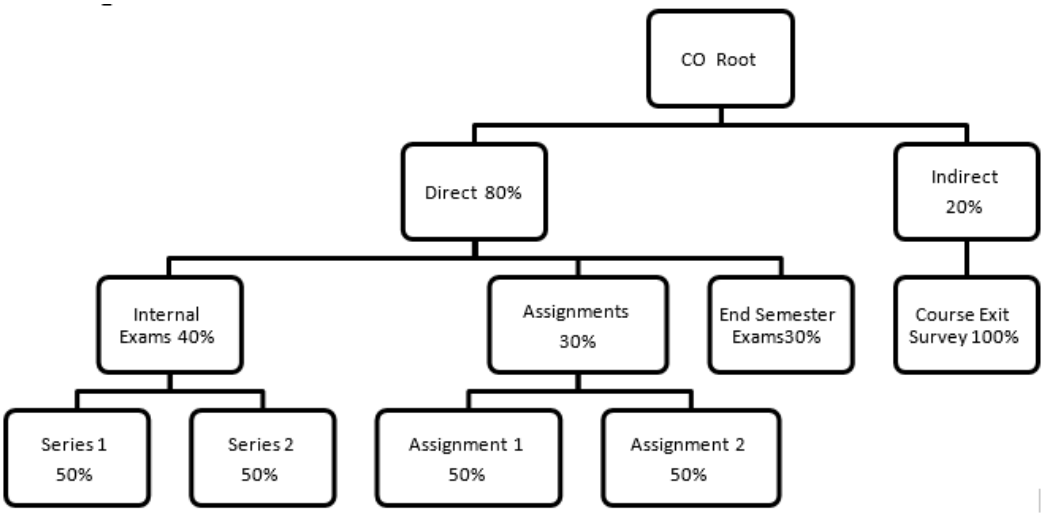
11. Internal Assessment mark allocation

Continuous Assessment Tests - 25 marks
Assignments - 15 marks
Attendance - 10 marks
Total - 50 marks

12. Assessment – CO Mapping

	Tools		**Weightage**	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Direct Assessment Tools 80%	Internal Examinations 40%	Series 1	50%	x	x			
		Series 2	50%			x	x	x
	Assignments 30%	Assignment 1	50%	x	x			
		Assignment 2	50%			x	x	x
	End Semester Exam 30%		100%	x	x	x	x	x
Indirect Assessment Tool 20%	Course Exit Survey		100%	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

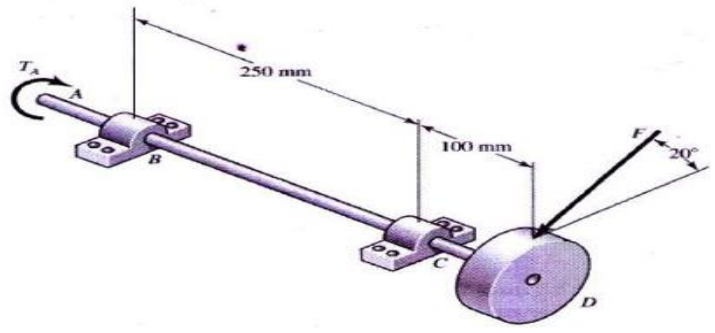
Hour	Topic	Module	Reference	Teaching Pedagogy
1	Shafting: - material, design considerations, causes of failure in shafts	1	T3	Tutorial
2	design based on strength, rigidity, and critical speed, design for static and fatigue loads	1	T3	Lecture
3	design based on strength, rigidity, and critical speed, design for static and fatigue loads	1	T3	Lecture
4	repeated loading, reversed bending	1	T3	Lecture
5	Remedial	1	T3	Remedial
6	repeated loading, reversed bending.	1	T3	Tutorial
7	Design of flat belt	1	T3	Lecture
8	Design of flat belt	1	T3	Lecture
9	Design of flat belt	1	T3	Lecture
10	Design of connecting rod in IC engine	1	T3	Lecture
11	Design of connecting rod in IC engine	1	T3	Tutorial

12	Remedial	1	T3	Remedial
13	Design of clutches:-single and multiple plate clutch	2	T3	Lecture
14	Design of cone clutch, centrifugal clutch	2	T3	Lecture
15	Design of brakes:-band brakes, block brakes, simple and differential band brake	2	T3	Lecture
16	Design of brakes:-band brakes,block brakes,simple and differential band	2	T3	Lecture
17	Design of internal expanding shoe brake.	2	T3	Lecture
18	Remedial	2	T3	Remedial
19	Sliding contact bearing:- lubrication, lubricants, viscosity, journal bearings, hydrodynamic theory, Petroffâ€™s equation	3	T3	Lecture
20	bearing characteristic number, Sommerfeld number, Heat generated in bearings,	3	T3	Tutorial
21	Heat dissipated by bearings, Design procedure of Journal bearings.	3	T3	Lecture
22	Remedial	3	T3	Remedial
23	Heat dissipated by bearings, Design procedure of Journal bearings.	3	T3	Lecture
24	Ball and roller bearings:- Types, bearing life, static and dynamic load capacity	3	T3	Lecture
25	Stribeckâ€™s Equation, selection of bearings, selection of taper roller bearings	3	T3	Lecture
26	Design procedure of Ball and roller bearings, Needle bearings	3	T3	Lecture
27	Remedial	3	T3	Remedial
28	Gears:- Materials of gears, terminology of spur Gear,	4	T3	Lecture
29	Interference and undercutting, Gear tooth failures,	4	T3	Lecture
30	Beam strength of Gear tooth, Estimation of module,	4	T3	Lecture

31	Buckinghamâ€™s equation for dynamic load, wear load	4	T3	Lecture
32	Remedial	4	T3	Remedial
33	Design procedure of Spur gear.	4	T3	Lecture
34	Helical gears:- Terminology, Virtual or equivalent number of teeth, Tooth proportions, Beam strength, and Wear strength of Helical gears	4	T3	Lecture
35	Design procedure of Helical gear	4	T3	Lecture
36	Design procedure of Helical gear	4	T3	Lecture
37	Remedial	4	T3	Remedial
38	Design procedure of Bevel gear.	5	T3	Lecture
39	Design procedure of Spur gear.	5	T3	Lecture
40	Design procedure of Bevel gear.	5	T3	Lecture
41	Worm gears:- Characteristics of worm gears, Terminology, Advantages and disadvantages, Applications, Terms in Worm gear, Strength of Worm gear, Dynamic strength, Wear tooth load	5	T3	Tutorial
42	Design procedure of Worm gear	5	T3	Lecture
43	Remedial	5	T3	Remedial

15. Question Bank

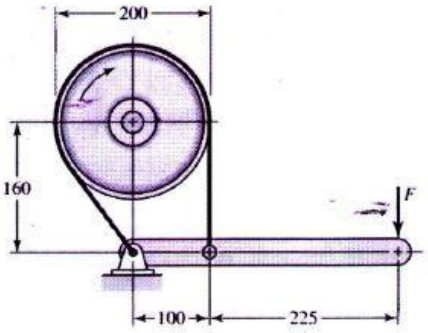
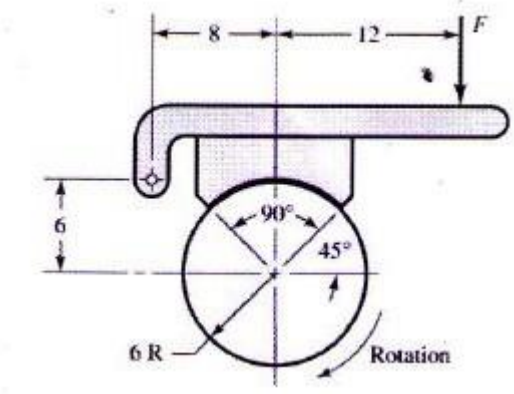
Sl. No.	Question	Marks	CO	BL
	Module 1			
1	What is the advantage of having I section in connecting rods?	**3**	**CO1**	**L1**

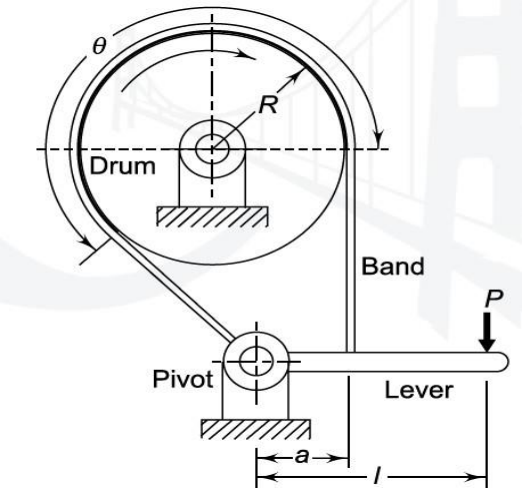
2	Explain strength-based design and rigidity-based design	**3**	**CO1**	**L1**
3	What types of stresses are induced in shafts	**3**	**CO1**	**L1**
4	Define equivalent torsional moment and equivalent bending moment? State when these two terms are used in the design of shafts.	**3**	**CO1**	**L1**
5	What is the manufacturing method for connecting rod	**3**	**CO1**	**L1**
6	Why are connecting rods made of I sections?	**3**	**CO1**	**L1**
7	Which theories of failure are applicable for shafts? Why?	**3**	**CO1**	**L1**
8	What is the advantage of having I section in connecting rods?	**3**	**CO1**	**L1**
9	Compare the strength and stiffness of a hollow shaft of same external diameter as that of a solid shaft. The diameter ratio of hollow shaft is 0.60.	**3**	**CO1**	**L3**
10	The rotating solid steel shaft is simply supported by bearings at points B and C and is driven by a gear (not shown) which meshes with the spur gear at D, which has a 150-mm pitch diameter. The force F from the drive gear acts at a pressure angle of 20°. The shaft transmits a torque to point A of $T_A = 340$ N · m. The shaft is machined from steel with yield tensile strength, $\sigma_y = 420$ MPa and ultimate tensile strength, $\sigma_{ut} = 560$ MPa. Using a factor of safety of 2.5, determine the minimum allowable diameter of the 250-mm section of the shaft based on maximum normal stress.	**14**	**CO1**	**L3**
				

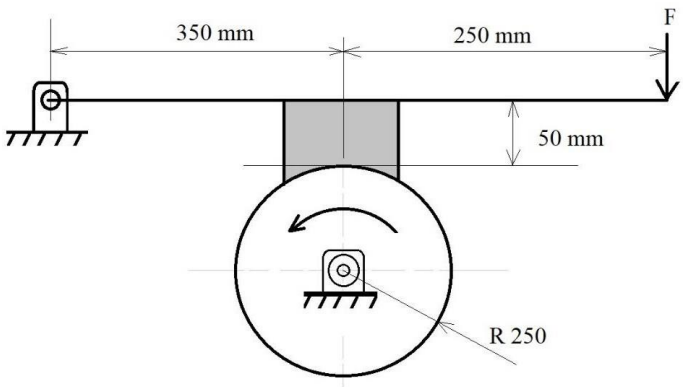
11	A shaft of a motor is supported at two points which are 900 mm apart. The motor develops 20 kW at 1500 rpm. The armature of the motor can be considered as a uniformly distributed load of 15 N/mm, centrally spread over a length of 600 mm; selecting a suitable material and choosing appropriate value for the factor of safety, determining the diameter of the motor shaft.	14	CO1	L3
12	Select a suitable flat belt for a horizontal drive for a compressor. An electric motor of 6.5 kW having a speed of 1500 rpm is used to drive the compressor. The speed of the compressor pulley is 500 rpm. Assume a service factor of 1.2, slip = 2.5 %, and working stress of 2.3 MPa.	14	CO1	L3
13	Design a belt drive to transmit 30 hp at 740 rpm to an aluminium rolling machine, the speed ratio being 3. The distance between the pulleys is 3 m. Diameter of the rolling machine pulley is 1.2 m.	14	CO1	L3
14	A power transmission shaft made of C45 steel is supported in bearings 2 m apart. The shaft carries a 200 mm diameter pulley weighing 1 kN at its midpoint and it receives power by a belt drive. The shaft transmits power by another machine by means of a flexible coupling just outside the right bearing. The power transmitted is 20 kW at 120 rpm. The ratio of belt tension is 3:1. Estimate the size of the shaft. Also calculate the twist in the shaft. Assume that the load is applied gradually.	10	CO1	L3
15	Design a flat-belt drive for a fan running at 360 rpm which is driven by a 12 kW, 1440 rpm motor. The belt drive is open-type and space is available for a centre distance of 2 m approximately.	14	CO1	L3

16	A shaft supporting two pulleys at free end and supported on two bearings. The shaft transmits 7.5 kW power at 360 rpm from pulley 1 to pulley 2. The diameter of pulley 1 and pulley 2 are 250 mm and 500 mm respectively. The mass of the pulley 1 and pulley 2 are 10 kg and 30 kg respectively. The belt tensions act vertically downward and ratio of belt tensions on tight side to slack side for each pulley is 2.5: 1. The shaft material yield strength is 380 MPa and factor safety is 3. Length of the shaft is 1000 mm and distance between the pulley and bearings are 250 mm. Determine the diameter of the shaft.	14	CO1	L3
17	Design a flat belt drive for a flour mill which is driven by a 55 kW, 1200 rpm electrical motor. The motor pulley is of 400 mm diameter and that the driven pulley is 1200 mm in diameter. The centre distance is 3 m., assuming a service factor of 1.2.	14	CO1	L3

Module 2				
1	Explain uniform wear theory and uniform pressure theory in friction clutches	**3**	**CO2**	**L1**
2	What do you mean by self-locking and self-energizing in brake	**3**	**CO2**	**L1**
3	Why are clutches usually designed on the basis of uniform wear	**3**	**CO2**	**L1**
4	What is a differential band brake	**3**	**CO2**	**L1**
5	Why heat-dissipation is necessary in clutches?	**3**	**CO2**	**L1**
6	What is internal expanding shoe brake? Where do you use it?	**3**	**CO2**	**L1**
7	What is a self-actuating or self-energizing brake?	**3**	**CO2**	**L1**

8	The brake shown in the figure (with dimensions in mm) has a coefficient of friction of 0.30 with an angle of contact of 270° and is to operate using a maximum force F of 400 N. If the band width is 50 mm, find the band tensions and the braking torque. 	**8**	**CO2**	**L3**
9	A single plate clutch having one pair of contacting surfaces to transmit 15 kW at 1500 rpm. The coefficient of friction between contact face is 0.35 and the permissible intensity of pressure should not exceed 0.6 N/mm^2. The outer diameter of the clutch is 300 mm. Determine the clutch dimensions by assuming uniform wear theory.	14	CO2	L3
10	The block-type hand brake shown in the figure (with dimensions in cm) has a face width of 12.5 mm and a mean coefficient of friction of 0.25. For an estimated actuating force of 900 N, find the maximum pressure on the shoe and find the braking torque 	6	CO2	L3

11	A simple band brake is to be designed to stop the rotation of a shaft transmitting a power of 50 kW at a rated speed of 600 rpm. The diameter of the drum is 600 mm, angle of contact of the band on drum is 225^0 and the total length of the lever is 1000 mm. Distance between the fulcrum and the other end of the band is 300 mm. The drum rotates in the clockwise direction and free end of the lever at the left side of the drum. Selecting suitable materials determine: (i) band dimensions, (ii) brake lever dimensions, and (iii) diameter of fulcrum pin.	14	CO2	L3
12	A cone clutch with asbestos friction lining transmits 30 kW power at 500 rpm. The coefficient of friction is 0.2 and the permissible intensity of pressure is 0.35 N/mm2. The semi-cone angle is 12.5°. The outer diameter is fixed as 300 mm from space limitations. Calculate: (i) the inner diameter; (ii) the face width of the friction lining; and (iii) the force required to engage the clutch.	14	CO2	L3
13	A simple band-brake is shown in Fig. 1 and have the following data: a = 250 mm, l = 750 mm ɵ = 225°, R = 250 mm. The width of the friction lining is 60 mm and the coefficient of friction is 0.4. The maximum intensity of pressure is 0.25 N/mm2. Calculate (i) the band tension on tight and loose sides;	10	CO2	L3
	(ii) the actuating force; and (iii) the torque capacity of the brake. 			

14	Obtain an expression for the condition of self-locking in differential band brake? Why should it be avoided in speed-control brakes?	4	CO2	L2
15	A multi - plate disc clutch of steel on bronze category is to transmit 5 kW at 800 rpm. The inner diameter of contact = 90 mm and the outer diameter of contact = 150 mm. The wet coefficient of friction = 0.14. The average allowable maximum pressure = 0.35 MPa. Assume uniform wear theory and determine (i). Number of steel and bronze discs (ii). Axial force required.	7	CO2	L3
16	Derive the expression for the torque carrying capacity of centrifugal clutch.	7	CO2	L2
17	A single short block brake has drum radius of 250 mm with torque capacity of 300 N-m as shown in figure below rotates at 120 rpm. Assume coefficient of friction is 0.35 and intensity of pressure is 1.2 MPa. Take length of the block is twice the width. Calculate: (i) The actuating force and the hinge point reactions, (ii) The rate of heat generation, and (iii) The dimensions of the block.  	14	CO2	L3
	Module 3			
1	Distinguish between hydrostatic and hydrodynamic bearings.	**3**	**CO3**	**L1**
2	Define (i) bearing characteristic number (ii) Sommerfeld number.	**3**	**CO3**	**L1**
3	State desirable properties of a good lubricant.	**3**	**CO3**	**L1**
4	Enumerate the advantages of needle roller bearings.	**3**	**CO3**	**L1**
5	Enumerate any two advantages and disadvantages of rolling-contact bearings over sliding contact bearings.	**3**	**CO3**	**L1**

6	What is bearing modulus as applied to the journal bearing?	**3**	**CO3**	**L1**
7	Why are ball and roller bearings called antifriction bearings	**3**	**CO3**	**L1**
8	Select a suitable deep groove ball bearing for supporting a radial load 20 kN and axial load of 6 kN for a life of 4000 hours at 1000 rpm. Select from series 63. Calculate expected life of the selected bearing.	**14**	**CO3**	**L3**
9	Design a suitable journal bearing for a centrifugal pump using the following data: Load on the bearing = 8 kN, diameter of the journal = 80 mm, speed = 1440 rpm, at the working temperature 75°C. Calculate cooling requirements, if any.	**14**	**CO3**	**L3**
10	A lightly loaded 0.1 m long journal bearing is acted on by 0.6 kN radial load. The 0.07 m diameter journal is rotating at 1500 rpm. The viscosity of the oil is 3.5 cP and radial clearance of 5×10^{-5} m. Determine the frictional power loss using Petroff's equation.	**14**	**CO3**	**L3**
11	Select suitable deep groove ball bearing for a shaft diameter of 50 mm. The shaft operates at 3000 rpm and is acted upon by steady and continuous 5000 N radial load and 2000 N thrust load. The life expectancy of the bearing is 20000 hours.	**14**	**CO3**	**L3**
12	Design a journal bearing for a centrifugal pump to the following specification: Diameter of the journal = 75 mm Speed of the journal = 1140 rpm	**14**	**CO3**	**L3**
	Load on each journal = 12 kN			
13	A bearing for an axial flow compressor is to carry a radial load of 2500 N and thrust of 1500 N. The service imposes light shock and the bearing will be in use for 40 hours/ week for 5 years. The speed of the shaft is 1000 rpm. Select a suitable ball bearing for the purpose. Diameter of the shaft is 50 mm.	10	CO3	L3
14	Design a full journal bearing subjected to 15 kN at1200 rpm. The bearing temperature is 550C and ambient temperature is320C. The journal diameter is 100 mm and l/d ratio is1.5. Check whether artificial cooling is required or not.	14	CO3	L3
15	A ball bearing SKF 6212 is subjected to an axial force of 13 kN and a radial load of 28 kN. Find the $L10$ life and $L50$ life in hours.	7	CO3	L3

<table>
<tr><td>16</td><td>Calculate the expected life of the bearing in hours for a single-row deep groove ball bearing. The dynamic load capacity is 42000 N and operates on the following work cycle:
<table><tr><th>Sl. No</th><th>Load (N)</th><th>Speed (rpm)</th><th>Time (%)</th></tr><tr><td>1</td><td>5500</td><td>500</td><td>25</td></tr><tr><td>2</td><td>12000</td><td>800</td><td>50</td></tr><tr><td>3</td><td>8000</td><td>500</td><td>25</td></tr></table></td><td>7</td><td>CO3</td><td>L3</td></tr>
<tr><td colspan="5">Module 4</td></tr>
<tr><td>1</td><td>What is Lewi's form factor? How does it vary with number of teeth on gear?</td><td>3</td><td>CO4</td><td>L1</td></tr>
<tr><td>2</td><td>Define virtual number of teeth in helical gear</td><td>3</td><td>CO4</td><td>L1</td></tr>
<tr><td>3</td><td>What are the advantages of 20 degree full depth involute teeth gears?</td><td>3</td><td>CO4</td><td>L1</td></tr>
<tr><td>4</td><td>Compare the contact between mating teeth of parallel and crossed helical gears</td><td>3</td><td>CO4</td><td>L1</td></tr>
<tr><td>5</td><td>State two important reasons for adopting involute curve for gear tooth profile.</td><td>3</td><td>CO4</td><td>L1</td></tr>
<tr><td>6</td><td>What are the advantages of helical gears over spur gears?</td><td>3</td><td>CO4</td><td>L1</td></tr>
<tr><td>7</td><td>What is the stub involute gear tooth system?</td><td>3</td><td>CO4</td><td>L1</td></tr>
<tr><td>8</td><td>State advantages of helical gears over spur gears.</td><td>3</td><td>CO4</td><td>L1</td></tr>
<tr><td>9</td><td>Design a pair of spur gear to transmit 10 kW at a pinion speed of 2000 rpm. The driven gear is to run at 500 rpm. Selecting suitable materials, decide upon the dimensions of the gear pair.</td><td>14</td><td>CO4</td><td>L3</td></tr>
<tr><td>10</td><td></td><td>14</td><td>CO4</td><td>L3</td></tr>
</table>

	Design a pair of helical gears to transmit 10 kW at 1000 rpm of the pinion. A speed reduction ratio of 5 is required. Give the details in a table and show the nomenclature in a neat sketch.			
11	Design a pair of spur gear to transmit 20 kW power with velocity ratio of 4:1. The pinion is rotating at 1200 rpm. The centre distance between parallel shaft is 150 mm.The allowable static stress for pinion and gear materials are 206.3 MPa and 137.2 MPa respectively.	**14**	**CO4**	**L3**
12	Design a pair of equal diameter helical gears to transmit 35 kW at 1000 rpm. The parallel shafts are 0.5 m apart. Assume the helix angle is 30^0, pressure angle is 20^0 stub. The gear is made of steel.	**14**	**CO4**	**L3**
13	An electric motor is to be connected to a reciprocating pump through a gear pair. The gears are overhanging their shafts. Motor speed = 1440 rpm, speed reduction ratio = 5, Motor power = 37 kW. Both the pinion and gear are made of steel with a maximum safe stress of 200 N/mm2. The gear to have 20o pressure angle. Design a spur gear drive to suit the above condition.	**14**	**CO4**	**L3**
14	Design a helical gear drive to transmit a power of 15 kW at 1440 rpm to the following specifications; speed reduction is 3, pressure angle 20o, helix angle is 15o. The material of both gears is C45 steel. Allowable static stress is 180 N/mm2.	**14**	**CO4**	**L3**
15	An electric motor is to be connected to a reciprocating pump through a gear pair. The gears are overhanging their shafts. Motor speed = 1440 rpm, speed reduction ratio = 5, Motor power = 37 kW. Both the pinion and gear are made of steel with a maximum safe stress of 200 N/mm2. The gear to have 20o pressure angle. Design a spur gear drive to suit the above condition.	**14**	**CO4**	**L3**
16	Design a pair of helical gear for continuous operation. Both gears are made of Cast Iron Grade 20. The design data are: Power: 35 kW; Speed of pinion: 1500 rpm ; Number of teeth on pinion : 24; Pressure angle : 200 FDI; helix angle : 300; speed reduction : 3:1. Assume the starting	**14**	**CO4**	**L3**

	torque is 20 % greater than the mean torque.			
	Module 5			
1	How will you estimate the wear strength of bevel gear?	**3**	**CO5**	**L1**
2	Why is the efficiency of worm gear drive low?	**3**	**CO5**	**L1**
3	What kind of contact occurs between worm and worm wheel? How does it differ from other types of gears?	**3**	**CO5**	**L1**
4	What is the relationship between actual and virtual number of teeth and the pitch angle in bevel gears?	**3**	**CO5**	**L1**
5	List the demerits of worm gear drive over other gear drives	**3**	**CO5**	**L1**
6	Under what circumstances the bevel gears are used? Give a detailed classification of bevel gears.	**4**	**CO5**	**L2**
7	A pair of bevel gears is required to transmit 30 kW at 500 rpm. The output shaft is running at 200 rpm and is at right angles to the input shaft. The gear is of cast iron and the pinion of cast steel. Design the gears.	**14**	**CO5**	**L3**
8	Determine the dimensions of a pair of worm and worm wheel for transmitting 2 kW at a worm speed of 1200 rpm. The desired ratio is about 12. Choosing proper materials decide all the dimensions.	**14**	**CO5**	**L3**
9	Five kW of power at 1500 rpm is supplied to the worm shaft. The normal pressure angle is 20^0 degrees and coefficient of friction is 0.1. Determine the components of gear tooth force acting on the worm and worm wheel. The worm and worm gear is designated as 3/60/10/8.	**14**	**CO5**	**L3**
10	With a neat sketch explain the terminology of bevel gears.	**10**	**CO5**	**L3**
11	Design a pair of bevel gear to transmit 15 kW at the pinion speed of 1620 rpm and the gear ratio is 4.The tooth profiles of the gear are of 200 made of steel with a maximum safe stress of 300 N/mm2.	**14**	**CO5**	**L3**
12	Design a worm gear drive to transmit a power of 23 kW. The worm speed is 1440 rpm and the speed of the wheel is 60 rpm. The drive should have a minimum efficiency of 80% and above.	**14**	**CO5**	**L3**

Prepared By : Binju Varghese P

Checked By : Nisha B Nair

Approved by : Dr. Ramadas T, HoD (ME)

Course Code & Name: MET463 Operations Management

1. Prescribed Syllabus

Module 1

Introduction to operations management: operations function, operations strategy, system concept of production, types of production system – job shop production – batch production mass production, process planning, make or buy decisions, process reengineering. Facilities location: Facility location factors, location analysis techniques – location factor rating – centre of gravity technique – load distance technique.

Module 2

Capacities and facilities: capacity planning, facility layout – objectives, types of layout process layout – product layout – fixed position layout – cellular layout, systematic layout planning, layout design procedures – CRAFT – CORELAP – ALDEP.Assembly line balancing: methods for line balancing – rank positional weight method –COMSOAL.

Module 3

Demand forecasting: need and uses of forecasting, components of forecasting demand, time series methods – moving average – weighted moving average – exponential smoothing – adjusted exponential smoothing – linear regression – seasonal adjustments, forecast accuracy

Module 4

Aggregate planning: aggregate planning strategies – heuristic method for aggregate planning. Materials requirement planning: objectives, master production schedule, bill of materials, MRP calculations, lot sizing in MRP – economic order quantity method for lot sizing minimum cost per period method – periodic order quantity method – least unit cost method, evolution from MRP to manufacturing resource planning (MRP II).

Module 5

Introduction to production scheduling: objectives – processing characteristics and constraints – performance measures, Gantt chart, single machine scheduling – SPT rule to minimize mean flow time – EDD rule to maximum lateness, parallel processors – minimization of makes pan – mean weighted flow time – McNaughton's algorithm, flow shop scheduling –extension of Johnson's rule for 3 machine problem – Palmer's heuristic

2. Objectives

This course is designed to facilitate the students to acquire knowledge about operations management concepts, tools, and techniques. This course covers the system concept of production, facility location analysis, facility layout, line balancing, demand forecasting, aggregate planning, material requirement planning, and production scheduling. It empowers the students to amalgamate their knowledge and thus inculcate the skills needed to apply these concepts, tools and techniques in industry

3. Text Books (T)

T1. Roberta S. Russell and Bernard W. Taylor III, Operations Management, John Wiley & Sons, Inc., Seventh Edition, 2011

T2. R. Paneerselvam, Production and Operations Management, PHI, 2010

4. Reference Books (R)

R1. P. B. Mahapatra, Operations Management: A Quantitative Approach, PHI, 2010
R2. G. Sreenivasan, Quantitative Models in Operations and Supply Chain Management PHI.
R3. Heizer and Render, Operations Management, Pearson Education, Eleventh Edition

5. Course Pre / Co-requisite

NIL

6. Course Outcomes

On successful completion of this course, students shall be able to
CO1: Understand operations and production systems and perform facility location analysis.
CO2: knowledge of facility layout, layout planning, and performing line balancing.
CO3 Compute demand forecast and forecast accuracy.
CO4: Perform aggregate planning and materials requirement planning.
CO5. Apply various algorithms for production scheduling.

7. Mapping of Course Outcomes with Program Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M	M				L		L		L	M	M		M	
CO2	H	H	M	L	M					L	M	M			H
CO3	H	H	M	L	L					L	M	M			H
CO4	H	H	M		H					L	M	M		M	H
CO5	H	H	M	L	L					L	M	M			H

8. Justification for CO-PO-PSO Correlation

CO1	**PO1**	The correlation between operations, production systems, and facility location analysis to engineering knowledge is evident through the application of various engineering principles and methodologies hence a medium correlation required.
	PO2	problem analysis is integral to successful operations, production systems, and facility location analysis. By systematically identifying challenges, analysing their underlying causes, and implementing effective solutions, engineers contribute to improved efficiency, quality, and strategic decision making in these areas; hence a medium correlation is required.
	PO6	The relationship between engineering and society is significant and multidimensional. Engineers are responsible not only for developing efficient and innovative solutions but also for considering the broader social, ethical, and environmental impacts of their decisions hence low correlation is required
	PO8	The low correlation between ethics and operations, production systems, and facility location analysis is significant as engineers must balance economic goals with ethical considerations.
	PO10	The low correlation between communication and operations, production systems, and facility location analysis is evident in how it facilitates collaboration, transparency, and informed decision-making. Effective communication enables engineers to work efficiently, engage stakeholders, and ensure the success of projects in these areas.
	PO11	The medium correlation between project management, finance, operations, production systems, and facility location analysis is evident in how they collectively contribute to successful project execution, cost optimization, and informed decision-making. By integrating these disciplines, organizations can ensure efficient operations, manage costs effectively, and make strategic choices that align with their goals and objectives
	PO12	Medium correlation because lifelong learning is crucial in operations, production systems, and facility location analysis. It empowers professionals to embrace new technologies, adapt to changes, and make informed decisions that drive efficiency, innovation, and strategic success in these areas.
	PSO2	Medium correlation because of understanding operations and production systems to perform facility location analysis to manage the engineering project as a professional team with an ethical attitude.
CO2	**PO1**	facility layout, layout planning, and line balancing are integral parts of engineering knowledge because they require a deep understanding of optimization, technical expertise, problem-solving, and cross-disciplinary applications. Engineers use these skills to create efficient, safe, and productive environments across a wide range of industries, hence highly correlated
	PO2	the high correlation between knowledge of facility layout, layout planning, line balancing, and problem analysis lies in the systematic approach, data-driven decision-making, critical thinking, and focus on continuous improvement that both areas share. Engineers who excel in problem analysis are well-equipped to identify inefficiencies, design effective solutions, and optimize processes to achieve better outcomes in terms of layout and production line efficiency.
	PO3	The medium correlation between knowledge of facility layout, layout planning, line balancing, and the design and development of solutions is rooted in their shared elements of holistic thinking, problem-solving, innovation, and iterative

		improvement. Engineers who possess strong skills in solution design are well-equipped to approach facility layout and production line optimization with a systematic and creative mindset, leading to more effective and efficient outcomes.
	PO4	Engineers who are adept at optimizing facility layouts and production processes are well-equipped to approach complex problem investigations with a structured and systematic mindset, leading to more effective problem-solving outcomes, hence low correlation
	PO5	The medium correlation between knowledge of facility layout, layout planning, and performing line balancing with modern tool usage is rooted in the efficiency, accuracy, and capabilities that these tools offer
	PO10	Engineers who can effectively convey their ideas, collaborate with stakeholders, and present their findings clearly and concisely are better positioned to implement and drive positive changes in facility layout and production processes hence its low correlated
	PO11	The medium correlation between knowledge of facility layout, layout planning, line balancing, and project management and finance stems from the need to align optimization efforts with organizational goals, manage resources efficiently, mitigate risks, and make informed decisions considering both technical and financial factors
	PO12	The medium correlation between knowledge of facility layout, layout planning, line balancing, and lifelong learning is founded on the need to adapt to changes, embrace innovation, and stay current with evolving practices and technologies
	PSO3	High correlation is due to apply principles of mathematics, science, and engineering to design and analyze multi-disciplinary systems for facility layout, layout planning, and performing line balancing
CO3	**PO1**	Demand forecasting and forecast accuracy are critical aspects of engineering knowledge, enabling efficient resource management, effective project planning, and overall improved decision-making within the engineering field hence highly correlated.
	PO2	Demand forecasting and forecast accuracy are relevant in problem analysis within engineering as they ensure that the right resources, skills, and solutions are available to tackle technical challenges. Accurate forecasts optimize resource allocation, guide skill development, drive research efforts, and ultimately lead to more efficient problem resolution, hence highly correlated
	PO3	The problem analysis concepts enhance problem-solving by allowing organizations to allocate resources effectively, plan budgets efficiently, respond swiftly to challenges, and minimize disruptions hence medium correlation
	PO4	Demand forecasting and forecast accuracy are not typically directly applicable to conducting investigations of complex problems in the way they might be in supply chain management or resource allocation hence low correlation.
	PO5	Demand forecasting and forecast accuracy play a vital role in modern tool usage. By accurately predicting demand, organizations can efficiently manage their resources, enhance operational efficiency, and deliver valuable modern tools to meet the needs of their customers and industries hence the low correlation.

	PO10	Both demand forecasting and communication are crucial aspects of business operations, they have distinct focuses, methodologies, and objectives. Their low correlation stems from their catering to different organizational needs, stakeholders, and functions.
	PO11	Demand forecasting and forecast accuracy have a medium correlation with project management and finance due to their shared impact on resource planning, scheduling, risk management, and financial decision-making.
	PO12	Demand forecasting and forecast accuracy have a medium correlation with life-long learning due to their impact on skill development, career planning, and adapting to changing market dynamics.
	PSO3	High correlation due to the fact that apply principles of mathematics, science and engineering to design and analyze multi-disciplinary systems to compute demand forecast and forecast accuracy.
CO4	**PO1**	Engineering knowledge underpins the technical aspects of production and manufacturing, directly influencing aggregate and materials requirement planning. The accuracy and effectiveness of these planning processes depend on a solid understanding of the engineering principles and requirements associated with the products being produced, hence highly correlated.
	PO2	High correlation from the fact that problem analysis provides the foundation for effective aggregate planning and materials requirement planning by identifying challenges, guiding improvements, and fostering a proactive and adaptive approach to production and resource management. The ability to analyse problems and devise solutions directly influences the accuracy and efficiency of these planning processes.
	PO3	Medium correlation from the fact that a well-integrated approach between design and planning teams ensures that products are manufactural, materials are procured efficiently, and production processes are aligned with the intended design
	PO5	Modern tools and technologies significantly enhance the accuracy, efficiency, and adaptability of aggregate and materials requirement planning. These tools enable organizations to leverage data, streamline processes, and respond effectively to dynamic market conditions, indicating a strong correlation between planning processes and modern tool usage.
	PO10	Communication is an integral part of both aggregate planning and materials requirement planning. The success of these planning processes relies on the accurate exchange of information, collaborative decision-making, and the ability to respond to changes effectively. Therefore, there is a low correlation between communication and the effectiveness of planning processes.
	PO11	There is a medium correlation between aggregate planning, materials requirement planning, project management, and finance. These functions are closely interlinked through resource allocation, scheduling, budgeting, and risk management. Collaboration and alignment between these areas contribute to efficient operations and achieving organizational goals.
	PO12	The medium correlation from continuous learning ensures that planners remain adaptable, knowledgeable, and well-equipped to handle the dynamic challenges and opportunities in their roles, ultimately contributing to more effective and efficient planning processes.

	PSO2	Medium correlation is due to managing engineering projects as a professional team with an ethical attitude by applying principles of scientific management to perform aggregate planning and material requirement planning
	PSO3	Applying mathematics, science, and engineering principles to design and analyze multi-disciplinary systems to perform aggregate planning and materials requirement planning hence the high correlation
CO5	**PO1**	Production scheduling is a critical aspect of engineering and manufacturing processes. Various algorithms can be applied to optimize production schedules, considering resource availability, production capacity, order priority, and more factors. Here are some algorithms commonly used in production scheduling, along with their justification in engineering knowledge hence highly correlated.
	PO2	High correlation from the fact that problem analysis is a crucial step in production scheduling, as it involves understanding the specific constraints, objectives, and requirements of the manufacturing process. Different algorithms can be applied based on the problem's characteristics and complexities.
	PO3	The design and development of solutions in production scheduling require selecting algorithms that can effectively balance optimization objectives while considering practical constraints.Various algorithms can be applied in a medium correlation with the design and development of solutions in production scheduling
	PO4	When conducting investigations of complex problems in production scheduling with a low correlation, the focus is on quickly generating feasible solutions rather than deeply optimizing them
	PO5	With low correlation with communication, the focus is on using simple algorithms for production scheduling that are easy to communicate and understand across different teams and stakeholders.
	PO10	With low correlation with communication, the focus is on using simple algorithms for production schedules that are easy to communicate and understand across different teams and stakeholders.
	PO11	Production scheduling is closely related to project management and finance, as it involves optimizing resources, meeting deadlines, and managing costs. Here's how various algorithms with a medium correlation can be applied in this context:
	PO12	Production scheduling is a field that continuously evolves due to changing technologies, methodologies, and market demands. Applying various algorithms for production scheduling with a medium correlation to lifelong learning signifies the ongoing need for engineers and professionals to adapt and enhance their skills
	PSO3	Applying the principles of mathematics, science, and engineering to design and analyze various algorithms for production scheduling, hence the high correlation

9. Curricular gaps (if any)

Industry 4.0 and digital Transformation, Simulation software for Operation analysis

1 Product and Service Design: The provided curriculum does not include product/service design and development.

2 Supply Chain Management: Critical area that covers supply chain design, inventory management, and logistics is missing
3 Sustainability in Operations: Focus on sustainable practices in operations is missing.

10. Course Enrichment Activities

Sl No	Description	Proposed Activities	Relevance to POs and PSOs
		NPTEL COURSE	PO5,PO1,PO2

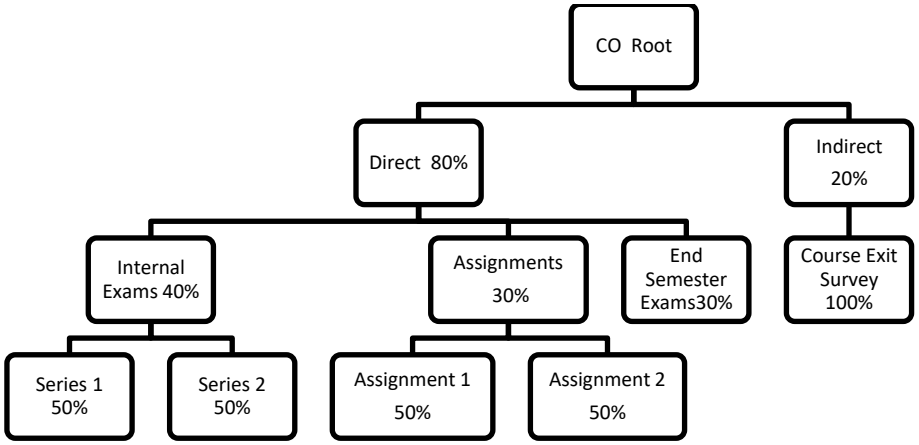
11. Internal Assessment mark allocation

Continuous Assessment Tests	- 25 marks
Assignments	- 15 marks
Attendance	- 10 marks
Total	- 50 marks

12. Assessment – CO Mapping

	Tools		Weightage	CO1	CO2	CO3	CO4	CO5
Direct Assessment Tools 80%	Internal Examinations 40%	Series 1	20%	X	X			
		Series 2	20%			X	X	X
	Assignments 30%	Assignment 1	15%	X	X			
		Assignment 2	15%			X	X	X
	End Semester Exam		30%	X	X	X	X	X
Indirect Assessment Tool 20%	Course Exit Survey		100%	X	X	X	X	X

13. Assessment Configuration



14 Course Outline

Hour	Topic	Module	Reference	Teaching Pedagogy
1	Introduction to operations management: operations function operations strategy,	1	T2,R3	Lecture
2	system concept of production, types of production system	1	T2,R4	Lecture
3	job shop production – batch production –job shop production – batch production –mass production.	1	T2,R5	Tutorial
4	Process planning, make or buy decisions,	1	T2,R6	Lecture
5	Process planning, make or buy decisions,	1	T2,R7	Remedial
6	Facilities location: Facility location factors, location analysis techniques – location factor rating	1	T2,R8	Lecture
7	Center of gravity technique –load distance technique.	1	T2,R9	Remedial
8	Capacities and facilities: capacity planning, facility layout –objectives	1	T2,R10	Lecture
9	types of layout – process layout – product layout – fixed position layout – cellular layout	2	T2,R11	Tutorial
10	Systematic layout planning,	2	T2,R12	Lecture
11	layout design procedures – CRAFT	2	T2,R13	Remedial

12	CORELAP – ALDEP.	2	T2,R14	Lecture
13	Assembly line balancing: methods for line balancing	2	T2,R15	Tutorial
14	rank positional weight method – COMSOAL.	2	T2,R16	Lecture
15	Demand forecasting: need and uses of forecasting	3	T2,R17	Remedial
16	components of forecasting demand.	3	T2,R18	Lecture
17	Time series methods – moving average – weighted moving	3	T2,R19	Tutorial
18	exponential smoothing	3	T2,R20	Remedial
19	adjusted exponential smoothing	3	T2,R21	Tutorial
20	Linear regression – seasonal adjustments	3	T2,R22	Tutorial
21	forecast accuracy.	3	T2,R23	Lecture
22	Aggregate planning	4	T2,R24	Lecture
23	aggregate planning strategies	4	T2,R25	Lecture
24	heuristic method for aggregate planning.	4	T2,R26	Lecture
25	Materials requirement planning: objectives, master production schedule, bill of materials, MRP calculation	4	T2,R27	Lecture
26	lot sizing in MRP –economic order quantity method for lot sizing – minimum cost per period method	4	T2,R28	Lecture
27	periodic order quantity method – least unit cost method.	4	T2,R29	Tutorial
28	Evolution from MRP to manufacturing resource planning	4	T2,R30	Lecture
29	Introduction to production scheduling: objectives	5	T2,R31	Remedial
30	processing characteristics and constraints – performance measures, Gantt chart.	5	T2,R32	Lecture
31	Single machine scheduling – SPT rule to minimize mean flow time	5	T2,R33	Tutorial
32	EDD rule to maximum lateness, parallel processors –minimization of makespan	5	T2,R34	Lecture

33	mean weighted flow time – McNaughton's algorithm.	5	T2,R35	Lecture
34	Flow shop scheduling – extension of Johnson's rule for 3 machines Problem	5	T2,R36	Remedial
35	Palmer's heuristic.	5	T2,R37	Tutorial

14 Question Bank

Module 1				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	Define 'Production'	**3**	**CO1**	**L1**
2	Define production system	**3**	**CO1**	**L1**
3	Mention the different types of production systems.	**3**	**CO1**	**L1**
4	Explain shop production	**3**	**CO1**	**L2**
5	Explain batch production	**3**	**CO1**	**L2**
6	Explain mass production	**3**	**CO1**	**L2**
7	Explain continuous production	**3**	**CO1**	**L2**
8	List any four advantages of job shop production.	**3**	**CO1**	**L1**
9	List any four limitations of job shop production.	**3**	**CO1**	**L1**
10	List any four advantages of batch production.	**3**	**CO1**	**L1**
11	List any four limitations of batch production.	**3**	**CO1**	**L1**
12	List any four advantages of mass production.	**3**	**CO1**	**L1**
13	List any four limitations of mass production.	**3**	**CO1**	**L1**
14	List any four advantages of continuous production.	**3**	**CO1**	**L1**
15	List any four limitations of continuous production.	**3**	**CO1**	**L1**
16	Briefly explain the production system and its characteristics.	**7**	**CO1**	**L2**
17	Explain shop production. Describe its characteristics, advantages and limitations?	**7**	**CO1**	**L2**
18	Explain batch production, Describe its characteristics, advantages and limitations?	**7**	**CO1**	**L2**

<table>
<tr><td>19</td><td>Describe mass production. Explain its characteristics, advantages and limitations?</td><td>7</td><td>CO1</td><td>L2</td></tr>
<tr><td>20</td><td>Describe continuous production. Explain its characteristics, advantages and limitations?</td><td>7</td><td>CO1</td><td>L2</td></tr>
<tr><td>21</td><td>Explain the factors to be considered while selecting the location for the new organisation</td><td>7</td><td>CO1</td><td>L2</td></tr>
<tr><td>22</td><td>Explain different operations strategies in case of location choice for existing organisation.</td><td>7</td><td>CO1</td><td>L2</td></tr>
<tr><td>23</td><td>There are five existing facilities that are to be served by a single new facility. The details of the existing facility are shown in the following table.
<table>
<tr><td>Existing facility</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td></tr>
<tr><td>Coordinates (a_i, b_i)</td><td>5, 10</td><td>20, 5</td><td>15, 20</td><td>30, 25</td><td>25, 5</td></tr>
<tr><td>Number of trips of load /year(w_i)</td><td>100</td><td>300</td><td>200</td><td>300</td><td>100</td></tr>
</table>
a) Find the optimum location of the new facilities based on the center of gravity method. b)Plot the existing facility and location of the new facility on a grid map</td><td>7</td><td>CO3</td><td>L3</td></tr>
<tr><td colspan="5">Module 2</td></tr>
<tr><td>Sl. No.</td><td>Question</td><td>Marks</td><td>CO</td><td>BL</td></tr>
<tr><td>1</td><td>Define plant layout.</td><td>3</td><td>CO2</td><td>L1</td></tr>
<tr><td>2</td><td>List various types of layout? Explain the application of each.</td><td>3</td><td>CO2</td><td>L2</td></tr>
<tr><td>3</td><td>Compare product layout and process layout.</td><td>3</td><td>CO2</td><td>L1</td></tr>
<tr><td>4</td><td>List the significance of group layout</td><td>3</td><td>CO2</td><td>L1</td></tr>
<tr><td>5</td><td>Outline the principles of plant layout</td><td>3</td><td>CO2</td><td>L1</td></tr>
<tr><td>6</td><td>Explain how the plant layouts are related to type of production</td><td>3</td><td>CO2</td><td>L2</td></tr>
<tr><td>7</td><td>Explain the various tools and .techniques of plant layout.</td><td>3</td><td>CO2</td><td>L2</td></tr>
<tr><td>8</td><td>Explain the procedure for plant layout.</td><td>3</td><td>CO2</td><td>L2</td></tr>
</table>

<table>
<tr><td>9</td><td>List advantages of computer packages in plant layout</td><td>3</td><td>CO2</td><td>L1</td></tr>
<tr><td>10</td><td>Explain the steps in SLP</td><td>3</td><td>CO2</td><td>L2</td></tr>
<tr><td>11</td><td>Explain ALDEP</td><td>3</td><td>CO2</td><td>L2</td></tr>
<tr><td>12</td><td>Explain CORELAP</td><td>3</td><td>CO2</td><td>L2</td></tr>
<tr><td>13</td><td>Explain CRAFT.</td><td>7</td><td>CO2</td><td>L2</td></tr>
<tr><td>14</td><td>Explain the input requirement for CORELAP.</td><td>7</td><td>CO2</td><td>L2</td></tr>
<tr><td>15</td><td>Explain the detailed procedure for CRAFT and its Implementation.</td><td>7</td><td>CO2</td><td>L2</td></tr>
<tr><td>16</td><td>Compare CRAFT and ALDEP method .</td><td>7</td><td>CO2</td><td>L2</td></tr>
<tr><td>17</td><td>Explain the procedure of ALDEP algorithm with the REL chart.</td><td>7</td><td>CO2</td><td>L2</td></tr>
<tr><td>18</td><td>Discuss about CRAFT algorithm to design a layout with illustration.</td><td>7</td><td>CO2</td><td>L2</td></tr>
<tr><td>19</td><td>Mention the application of CORELAP.</td><td>3</td><td>CO2</td><td>L1</td></tr>
<tr><td>20</td><td>Discuss the merit and demerit of CRAFT method ?How does ALDEP differ from CORELAP.</td><td>7</td><td>CO2</td><td>L2</td></tr>
<tr><td>21</td><td>A company is setting up an assembly line to produce 192 units per 8 shifts. The following table identifies the work elements, time and immediate predecessors.
<table>
<tr><th>Work element</th><th>Time (Sec)</th><th>Immediate predecessors</th></tr>
<tr><td>A</td><td>40</td><td>-</td></tr>
<tr><td>B</td><td>80</td><td>A</td></tr>
<tr><td>C</td><td>30</td><td>D,E,F</td></tr>
<tr><td>D</td><td>25</td><td>B</td></tr>
<tr><td>E</td><td>20</td><td>B</td></tr>
<tr><td>F</td><td>15</td><td>B</td></tr>
<tr><td>G</td><td>120</td><td>A</td></tr>
<tr><td>H</td><td>145</td><td>G</td></tr>
<tr><td>I</td><td>130</td><td>H</td></tr>
<tr><td>J</td><td>115</td><td>C, I</td></tr>
</table></td><td>7</td><td>CO2</td><td>L3</td></tr>
</table>

	Group the activities in the workstation using the rank positional weight method and compute the balancing efficiency.			
Module 3				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	Explain the need for sales forecasting	**7**	**CO3**	**L2**
2	Explain the basis for classifying forecasts into short-term and long-term forecasting	**7**	**CO3**	**L2**
3	Explain different methods of sales forecasting and discuss the merits and limitations of sales forecasting method	**7**	**CO3**	**L2**
4	Explain time series analysis. What are the components of time series? How the forecast is made from the time series?	**7**	**CO3**	**L2**
5	List the importants of sales forecast.	**3**	**CO3**	**L1**
6	Explain how forecasting is useful in production scheduling.	**3**	**CO3**	**L1**
7	Explain the Least Square method of forecasting	**7**	**CO3**	**L2**
8	Explain different forecasting method	**3**	**CO3**	**L2**
9	Discuss judgemental techniques for forecasting	**3**	**CO3**	**L2**
10	Describe disadvantages in using causal forecasting method.	**3**	**CO3**	**L1**
11	Contrast forecasting and predicting. Give an example for each.	**3**	**O3**	**L1**
12	Discuss forecast errors.	**7**	**CO3**	**L2**
13	Explain the cost accuracy trade-off in forecasting.	**7**	**CO3**	**L2**
14	Compare the Moving Average and exponential smoothing methods.	**7**	**CO3**	**L2**
15	List the limitations of moving average method	**3**	**CO3**	**L1**
16	Explain moving average method and the exponential smoothing method of forecasting related.	**7**	**CO3**	**L2**
17	Explain the criteria based on which you assess the different forecasting techniques. Would root mean square error to be the criterion? Whether error is the only criterion.	**7**	**CO3**	**L2**

<table>
<tr><td>18</td><td>Differentiate with examples Independent and dependent demand.</td><td>7</td><td>CO3</td><td>L2</td></tr>
<tr><td>19</td><td>From the list of moving averages, weighted moving averages, exponential smoothing, and linear regression analysis, which forecasting technique would you consider most accurate? Why?</td><td>3</td><td>CO3</td><td>L1</td></tr>
<tr><td>20</td><td>Differentiate between MAD and standard deviation.</td><td>7</td><td>CO3</td><td>L2</td></tr>
<tr><td>21</td><td>From the following time series data of the sales project, find out the sales for the next three years
<table><tr><td>Year</td><td>x</td><td>2001</td><td>2002</td><td>2003</td><td>2004</td><td>2005</td><td>2006</td><td>2007</td></tr><tr><td>Sales(1000 unit)</td><td>y</td><td>80</td><td>90</td><td>92</td><td>83</td><td>94</td><td>99</td><td>92</td></tr></table></td><td>7</td><td>CO3</td><td>L3</td></tr>
<tr><td>22</td><td>A firm uses simple exponential smoothing with $\alpha = 0.1$ to forecast demand. The forecast for the week of February was 500 units, whereas the actual demand was 450 units. a) Forecast the demand for the next week. b) Continue forecasting through assuming that subsequent demands were 505, 516, 488, 467, 554 and 510 units.</td><td>7</td><td>CO3</td><td>L3</td></tr>
<tr><td colspan="5">Module 4</td></tr>
<tr><td>Sl. No.</td><td>Question</td><td>Marks</td><td>CO</td><td>BL</td></tr>
<tr><td>1</td><td>Discuss production planning and control.</td><td>3</td><td>CO4</td><td>L2</td></tr>
<tr><td>2</td><td>Define aggregate production planning.</td><td>3</td><td>CO4</td><td>L1</td></tr>
<tr><td>3</td><td>Define the master production schedule.</td><td>3</td><td>CO4</td><td>L1</td></tr>
<tr><td>4</td><td>Define material requirement planning.</td><td>3</td><td>CO4</td><td>L1</td></tr>
<tr><td>5</td><td>Define capacity planning.</td><td>3</td><td>CO4</td><td>L1</td></tr>
<tr><td>6</td><td>Describe routing</td><td>3</td><td>CO4</td><td>L2</td></tr>
<tr><td>7</td><td>Explain scheduling</td><td>3</td><td>CO4</td><td>L2</td></tr>
<tr><td>8</td><td>Mention the types of scheduling.</td><td>3</td><td>CO4</td><td>L1</td></tr>
<tr><td>9</td><td>Discuss need of production planning and control.</td><td>3</td><td>CO4</td><td>L1</td></tr>
<tr><td>10</td><td>List of objectives of production planning and control.</td><td>3</td><td>CO4</td><td>L1</td></tr>
<tr><td>11</td><td>Explain guidelines for aggregate planning.</td><td>7</td><td>CO4</td><td>L2</td></tr>
<tr><td>12</td><td>Explain the functions of master production schedule.</td><td>7</td><td>CO4</td><td>L2</td></tr>
<tr><td>13</td><td>Explain the objective of MRP.</td><td>7</td><td>CO4</td><td>L2</td></tr>
</table>

<table>
<tr><td>14</td><td>Explain the techniques of routing.</td><td>7</td><td>CO4</td><td>L2</td></tr>
<tr><td>15</td><td>Explain the scheduling strategies.</td><td>7</td><td>CO4</td><td>L2</td></tr>
<tr><td>16</td><td>Discuss the phases of production planning and control.</td><td>7</td><td>CO4</td><td>L2</td></tr>
<tr><td>17</td><td>Discuss the functions of PP & C.</td><td>7</td><td>CO4</td><td>L2</td></tr>
<tr><td>18</td><td>Discuss the operations planning and scheduling systems.</td><td>7</td><td>CO4</td><td>L2</td></tr>
<tr><td>19</td><td>Discuss the aggregate plan and master schedule.</td><td>7</td><td>CO4</td><td>L2</td></tr>
<tr><td>20</td><td>Discuss the MRP system</td><td>7</td><td>CO4</td><td>L2</td></tr>
<tr><td>21</td><td>Discuss the process of capacity planning.</td><td>7</td><td>CO4</td><td>L2</td></tr>
<tr><td>22</td><td>Discuss the scheduling methods.</td><td>7</td><td>CO4</td><td>L2</td></tr>
<tr><td>23</td><td>Describe the output of aggregate planning. When is aggregate planning most useful? Discuss the advantages and disadvantages of using part time workers, subcontracting work, and building up inventory as strategies for meeting demand.</td><td>7</td><td>CO4</td><td>L3</td></tr>
<tr><td colspan="5">Module 5</td></tr>
<tr><td>Sl. No.</td><td>Question</td><td>Marks</td><td>CO</td><td>BL</td></tr>
<tr><td>1</td><td>Compare single-machine scheduling and flow shop scheduling</td><td>3</td><td>CO5</td><td>L2</td></tr>
<tr><td>2</td><td>State the assumptions in flow shop scheduling?</td><td>3</td><td>CO5</td><td>L1</td></tr>
<tr><td>3</td><td>Explain the concept of single machine scheduling problem</td><td>7</td><td>CO5</td><td>L2</td></tr>
<tr><td>4</td><td>Define the term scheduling ?</td><td>3</td><td>CO5</td><td>L1</td></tr>
<tr><td>5</td><td>Explain the different performance measures in scheduling</td><td>7</td><td>CO5</td><td>L2</td></tr>
<tr><td>6</td><td>Give example of four types of operation and suggest which scheduling objective might be appropriate for each</td><td>3</td><td>CO5</td><td>L2</td></tr>
<tr><td>7</td><td><table><tr><td>Job</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td></tr><tr><td>M-1</td><td>5</td><td>21</td><td>16</td><td>6</td><td>25</td><td>19</td><td>20</td><td>10</td><td>6</td></tr><tr><td>M-2</td><td>3</td><td>2</td><td>4</td><td>2</td><td>4</td><td>3</td><td>1</td><td>2</td><td>1</td></tr></table></td><td>7</td><td>CO5</td><td>L3</td></tr>
</table>

<table>
<tr><td></td><td>Consider the following n jobs parallel identical problem .Find the schedule which will minimise the weighted mean flow ,if the number parallel identical machine is 3</td><td></td><td></td><td></td></tr>
<tr><td>8</td><td>Consider the following 2 machine 6 job flow shop problem Obtain the optimum schedule and corresponding make span for the above problem
<table>
<tr><td>Job</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td></tr>
<tr><td>M1</td><td>5</td><td>10</td><td>8</td><td>9</td><td>6</td><td>12</td></tr>
<tr><td>M2</td><td>7</td><td>8</td><td>13</td><td>7</td><td>11</td><td>10</td></tr>
</table></td><td>7</td><td>CO5</td><td>L3</td></tr>
<tr><td>9</td><td><table>
<tr><td>Job</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>M1</td><td>7</td><td>1</td><td>15</td><td>8</td></tr>
<tr><td>M2</td><td>8</td><td>4</td><td>12</td><td>5</td></tr>
</table>
Using Johnsons algorithm ,obtain the optimal sequence and corresponding makes span</td><td>7</td><td>CO5</td><td>L3</td></tr>
<tr><td>10</td><td><table>
<tr><td>Job</td><td>1</td><td>2</td><td>3</td><td>4</td></tr>
<tr><td>M1</td><td>11</td><td>13</td><td>15</td><td>12</td></tr>
<tr><td>M2</td><td>10</td><td>8</td><td>6</td><td>7</td></tr>
<tr><td>M3</td><td>12</td><td>20</td><td>15</td><td>19</td></tr>
</table>
Check whether Johnson’s rule can be extended to this problem, if so, what is the optimum schedule and corresponding make span?</td><td>7</td><td>CO5</td><td>L3</td></tr>
</table>

Prepared By: Dr. Ramadas.T(Subject Faculty)

Checked By: Dr. Manoj Jose Kalathil (Subject Group Coordinator)

Approved By: Dr.Ramadas.T (HOD - ME)

Course Code & Name: EET 435 Renewable Energy Systems

1. Prescribed Syllabus

Module	Topic	Hours
1	Introduction, Classification of Energy Resources- Conventional Energy Resources - Availability and their limitations- Non-Conventional Energy Resources – Classification, Advantages, Limitations; Comparison. SOLAR THERMAL SYSTEMS- Principle of Conversion of Solar Radiation into Heat – Solar thermal collectors. – Flat plate collectors. Solar concentrators (parabolic trough, parabolic dish, Central Tower Collector). SOLAR ELECTRIC SYSTEMS- Solar Thermal Electric Power Generation – Solar Photovoltaic – Solar Cell fundamentals - characteristics, classification, .construction. Solar PV Systems – stand-alone and grid connected- Applications.	7
2	ENERGY FROM OCEAN- Ocean Thermal Energy Conversion (OTEC)- Principle of OTEC system- Open Cycle (Claude cycle), Closed Cycle (Anderson cycle) and Hybrid cycle. Siteselection criteria- Biofouling- Advantages & Limitations of OTEC. TIDAL ENERGY – Principle of Tidal Power- Components of Tidal Power Plant (TPP)- Classification-single basin- double basin types – Limitations -Environmental impacts.	7
3	WIND ENERGY- Introduction- Basic principles of Wind Energy Conversion Systems (WECS) wind speed measurement- Classification of WECS- types of rotors. wind power equation -Betz limit. Electrical Power Output and Capacity Factor of WECS- Advantages and Disadvantages of WECS -site selection criteria.	7
4	BIOMASS ENERGY- Introduction- Biomass fuels-Biomass conversion technologies -Urban waste to Energy Conversion- Biomass Gasification- Biomass to Ethanol Production- Biogas production from waste biomass- factors affecting biogas generation-types of biogas plants – KVIC and Janata model- Biomass program in India.	6
5	SMALL HYDRO POWER- Classification as micro, mini and small hydro projects - Basic concepts and types of turbines- selection considerations. EMERGING TECHNOLOGIES: Fuel Cell- principle of operation –classification- conversion efficiency and losses - applications .Hydrogen energy -hydrogen production - electrolysis - thermo chemical methods -hydrogen storage and utilization.	8

2. Text Books (T)

T1. G. D. Rai, " Non Conventional Energy Sources", Khanna Publishers, 2010
T2. Rao S. and B. B. Parulekar, Energy Technology, Khanna Publishers, 1999

3. Reference Books (R)

R1. G.N. Tiwari: Solar Energy-Fundamentals, Design, Modelling and Applications, Narosa Publishers, 2002
R2. Earnest J. and T. Wizelius, Wind Power Plants and Project Development, PHI Learning, 2011.
R3. Sab S. L., Renewable and Novel Energy Sources, MI. Publications, 1995.
R4. Sawhney G. S., Non-Conventional Energy Resources, PHI Learning, 2012.
R5. Tiwari G. N., Solar Energy- Fundamentals, Design, Modelling and Applications, CRC Press, 2002.
R6. A.A.M. Saigh (Ed): Solar Energy Engineering, Academic Press, 1977
R7. Abbasi S. A. and N. Abbasi, Renewable Energy Sources and Their Environmental Impact, Prentice Hall of India, 2001..
R8. Boyle G. (ed.), Renewable Energy - Power for Sustainable Future, Oxford University Press, 1996
R9. Earnest J. and T. Wizelius, Wind Power Plants and Project Development, PHI Learning, 2011.
R10. F. Kreith and J.F. Kreider: Principles of Solar Engineering, McGraw Hill, 197
R11. F. Kreith and J.F. Kreider: Principles of Solar Engineering, McGraw Hill, 1978 62.
R12. Khan B.H, Non Conventional Energy resources Tata McGraw Hill, 2009.

4. Course Objectives

To inculcate in students an awareness of new and renewable energy sources.

5. Course Pre / Co-requisite

Students who have taken EET383 MINOR are not eligible to take this course.

6. Course Outcomes

After the completion of the course the student will be able to

CO1:Choose the appropriate energy source depending on the available resources.
CO2:Explain the concepts of solar thermal and solar electric systems.
CO3:Illustrate the operating principles of wind, and ocean energy conversion systems.
CO4:Outline the features of biomass and small hydro energy resources
CO5: Describe the concepts of fuel cell and hydrogen energy technologies

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	M					L	M								

CO 2	H												M		
CO 3	H					L	L						M		
CO 4	H					L	L								
CO 5	H														

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	PO1	Knowledge in different energy source depending on the available resources will enable them to apply it in complex electrical engineering problems.
	PO6	Awareness to choose the appropriate energy source will help the students to assess the social health andsafety and its consequent responsibilities.
	PO7	Understanding the impact of different sources of energy depending on available resources, students will be able to incorporate sustainable practices for engineering solutions.
CO2	PO1	Insight of solar thermal and solar electric systems will help the students to apply it to get solution for complex engineering solutions.
	PSO1	Knowledge in solar thermal and solar electric systems will enable the students to design and debug the respective electric circuits by assimilating advances in allied fields.
CO3	PO1	Knowledge in operating principles of wind and ocean energy conversion systems will help the students to apply it in complex electrical engineering problems.
	PO6	Understanding about the wind and ocean energy conversion systems will help the students to assess the safety and its consequent responsibilities relevant to engineering practice.
	PO7	Knowledge about the impact of different wind and ocean energy conversion systems, students will be able to demonstrate and incorporate sustainable methods for engineering solutions.
	PSO1	Acquaintance with ocean and wind energy conversion system will enable

		the students to design and debug the respective electric circuits by assimilating advances in allied fields.
CO4	PO1	Knowledge about the features of biomass and small hydro energy resources will assist the students to apply it to find solutions for engineering problems.
	PO6	Insight about the features of biomass and small hydro energy resources will enable students to assess the social health and safety and thereby its consequent responsibilities relevant to professional engineering practice.
	PO7	Awareness about the biomass and small hydro energy resources will enable students to demonstrate and incorporate methods for sustainable development.
CO5	PO1	Knowledge in fuel and hydrogen energy technology will help the students to apply and find solutions for complex electrical engineering problems.

9. Curricular gaps (if any)

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	NPTEL Course	Sustainable Power Generation, IIT Guwahati	PO1, PO7, PO9, PO12

11. Internal Assessment mark allocation (as per university curriculum)

(Provide details as mentioned in syllabus)

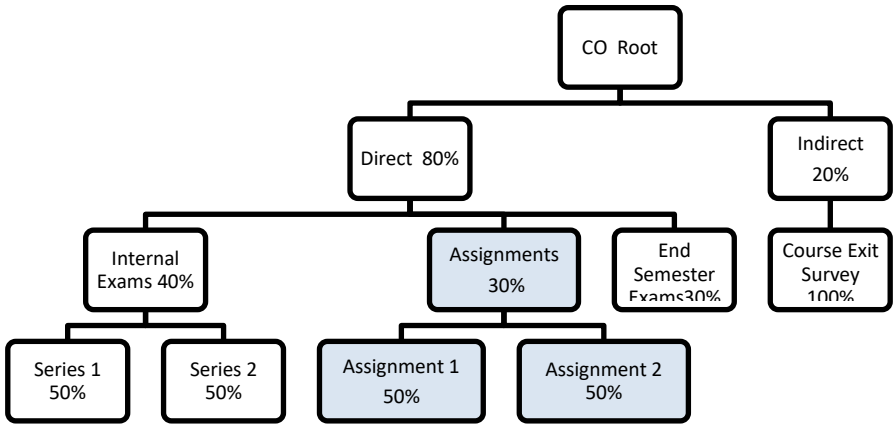
Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		**Weightage#**	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Direct Assessment	Internal Exam(s) 40%	Series 1	20%	x	x	x		
		Series 2	20%				x	x

Tools**	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x	x			
		Assignment 2	15%			x	x	x
	End Semester Exam		30%	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1	Classification of Energy Resources- Conventional Energy - Resources - Availability and their limitations	1	T1,R4	Lecture
2	Non-Conventional Energy Resources – Classification, Advantages, Limitations, Comparison.	1	T1, R4	Lecture
3	SOLAR THERMAL SYSTEMS- Principle of Conversion of Solar Radiation into Heat – Solar thermal collectors.	1	T1, R1	Lecture
4	Flat plate collectors. Solar concentrators (parabolic trough,	1	T1, R1	Lecture

	parabolic dish, Central Tower Collector)			
5	SOLAR ELECTRIC SYSTEMS- Solar Thermal Electric Power Generation	1	T1, R1	Lecture
6	Solar Photovoltaic – Solar Cell fundamentals - characteristics, classification, construction.	1	T1, R1	Lecture
7	Solar PV Systems – stand-alone and grid connected- Applications	1	T1, R1	Lecture
8	Ocean Thermal Energy Conversion (OTEC)- Principle of OTEC system-	2	T1, R4	Lecture
9	Open Cycle (Claude cycle), Closed Cycle (Anderson cycle)	2	T1, R4	Lecture
10	Hybrid cycle. Site-selection criteria	2	T1, R4	Lecture
11	Biofouling- Advantages & Limitations of OTEC	2	T1, R4	Lecture
12	TIDAL ENERGY – Principle of Tidal Power- Components of Tidal Power Plant (TPP)-	2	T1, R4	Lecture
13	Classification-single basin- double basin types –Limitations and environmental impacts	2	T1, R4	Lecture
14	Classification-single basin- double basin types –Limitations and environmental impacts	2	T1, R4	Lecture
15	Introduction- Basic principles of Wind Energy Conversion Systems (WECS)	3	T1, R2, R4	Lecture
16	Wind speed measurement	3	T1, R2, R4	Lecture
17	Classification of WECS- types of rotors	3	T1, R2, R4	Lecture
18	Classification of WECS- types of rotors	3	T1, R2, R4	Lecture
19	Wind power equation -Betz limit	3	T1, R2, R4	Lecture
20	Electrical Power Output and Capacity Factor of WECS	3	T1, R2, R4	Lecture
21	Wind Turbine - Numerical	3	T1, R2, R4	Tutorial
22	Wind power - Numerical	3	T1, R2, R4	Tutorial
23	Advantages and Disadvantages of WECS -site selection criteria	3	T1, R2, R4	Lecture
24	Urban waste to Energy Conversion	4	T1, R12	Lecture
25	Biomass Gasification- Biomass to Ethanol Production	4	T1, R12	Lecture
26	Biogas production from waste biomass	4	T1, R12	Lecture
27	Biogas production from waste biomass	4	T1, R12	Lecture

28	Types of biogas plants – KVIC and Janata model	4	T1, R12	Lecture
29	Biomass program in India.	4	T1, R12	Lecture
30	Classification as micro, mini and small hydro projects	5	T1, R12	Lecture
31	Basic concepts and types of turbines-selection considerations.	5	T1, R12	Lecture
32	Basic concepts and types of turbines-selection considerations.	5	T1, R12	Lecture
33	EMERGING TECHNOLOGIES: Fuel Cell-principle of operation	5	T1, R12	Lecture
34	Classification- conversion efficiency and losses - applications	5	T1, R12	Lecture
35	Hydrogen energy -hydrogen production	5	T1, R12	Lecture
36	Electrolysis -thermo chemical methods	5	T1, R12	Lecture
37	Hydrogen storage and utilization.	5	T1, R12	Lecture

15. Question Bank

	Module 1			
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1.	Explain the role of non-conventional energy sources on the basis of current energy demands of the world.	3	CO1	L2
2.	Explain the principle of solar energy conversion into heat energy.	3	CO2	L2
3.	What are solar collectors? Give their classification and compare them based on construction and area of applications.	10	CO2	L2
4.	Write about any three types of solar cells based on construction materials	4	CO2	L2
5.	Explain about standalone and grid connected solar photo voltaic systems	10	CO2	L3
6.	Explain the voltage-current characteristics of a solar cell with neat sketch	4	CO2	L2
7.	Differentiate between Conventional and Non-conventional sources of energy	3	CO1	L2
8.	Explain 3 applications of stand-alone solar PV systems	3	CO2	L2
9.	Draw a fully labelled sketch and explain the working of a Solar Thermal Electric Power generation system using Central Tower solar-collector.	10	CO2	L3
10.	Draw a fully labelled I-V Curve of a solar cell indicating all relevant voltages and currents. Also indicate the voltage and	4	CO2	L3

	current corresponding to the maximum power point and show how the Fill Factor can be computed from this curve.			
11.	With a neat labelled diagram explain the construction and working of a Flat plate solar collector	10	CO2	L3
12.	Compare the features(4 points) of non-concentrating and non-concentrating type solar collectors.	4	CO2	L2
13.	List any three advantages and disadvantages of solar PV systems.	3	CO2	L2
14.	Compare concentrating and non-concentrating collectors.	3	CO2	L2
15.	Describe the classification of energy sources with suitable examples.	6	CO1	L2
16.	With a neat sketch, explain how the solar energy is harvested using a central tower collector. List any two advantages.	8	CO2	L3
17.	Discuss the important parameters to be considered while selecting a solar panel for its good performance. How is its performance affected by the variation in insolation?	7	CO2	L3
18.	Explain the working of a stand-alone PV system with a suitable block diagram.	7	CO2	L3
19.	Discuss primary and secondary energy sources. Describe future of non-conventional energy resources in India.	3	CO1	L2
20.	List the different types of solar cells? Write about any three types of solar cells.	3	CO2	L2
21.	Explain the principle and working of the following solar radiation measuring instruments: (i)Pyranometer (ii)Pyrheliometer and (iii)Sunshine recorder	10	CO2	L2
22.	Discuss the advantages and disadvantages of PV system over conventional power system.	4	CO2	L2
23.	Explain various factors contributing to losses in solar cell. How is the efficiency reduced due to these factors.	7	CO2	L3
24.	Explain the construction of a solar cell with the help of a neat diagram.	7	CO2	L2
	Module 2			
Sl. No.	**Question**	**Marks**	**CO**	**BL**
25.	List out any four environmental impacts of OTEC systems	3	CO3	L2
26.	List the different components of the tidal power plant. Explain the function of each component.	3	CO3	L2
27.	Discuss the basic principle of OTEC. Describe a closed cycle OTEC with its advantages and disadvantages.	10	CO3	L3
28.	What is biofouling? How it affects efficiency of energy conversion and how can it be minimised?	4	CO3	L2
29.	List the different classifications of tidal power plants. Explain the components and detailed working operation of double basin tidal power plant with neat sketch.	10	CO3	L3
30.	Discuss the limitations of the tidal power production	4	CO3	L2
31.	Differentiate between Open Cycle and Closed Cycle OTEC systems	3	CO3	L2
32.	Explain the environmental impacts of Tidal Energy	3	CO3	L2

	conversion systems			
33.	With a neat diagram explain the working of a Hybrid Cycle OTEC system	10	CO3	L3
34.	Explain the advantages of OTEC systems	4	CO3	L2
35.	Draw a schematic diagram and explain the working of a double-basin Tidal power Plant	10	CO3	L3
36.	Dicuss the environmental impacts of Tidal Power plants	4	CO3	L2
37.	Dicuss the important criteria for selecting a site for the installation of an OTEC system	3	CO3	L2
38.	Explain the principle of tidal energy conversion.	3	CO3	L2
39.	Explain the principle of an OTEC system. List any 2 advantages and limitations. What are its environmental impacts (any 4 points)?	6	CO3	L2
40.	With the help of block diagrams, differentiate the working of an open cycle and a closed cycle OTEC system.	8	CO3	L3
41.	Elaborate on how the tidal phenomena occur with suitable sketches. List 2 advantages and disadvantages of tidal energy conversion systems.	7	CO3	L2
42.	Draw and label the layout of a double basin-type tidal power plant and explain the working.	7	CO3	L3
43.	List the main types of OTEC plants? Describe the working of open cycle OTEC power plant with its neat sketch.	10	CO3	L3
44.	Discuss the environmental impacts due to construction of OTEC plants.	4	CO3	L2
45.	Explain the various methods of tidal power generation. What are the limitations of each method.	10	CO3	L3
46.	Discuss the site requirements to construct a tidal power plant.	4	CO3	L2
	Module 3			
Sl. No.	**Question**	**Marks**	**CO**	**BL**
47.	Three-bladed wind rotor with blade length of 52 m is operating in a wind stream having wind velocity of 13 m/s. Air density is 1.23 kg/m3 and power coefficient may be taken as 0.3. Calculate the extractable power from the wind.	3	CO3	L3
48.	Discuss the advantages and disadvantages of horizontal and vertical axis wind mills.	3	CO3	L2
49.	What is mean by betz limit? Derive the expression for the power extracted by a wind turbine.	8	CO3	L3
50.	List the different types of generators used with wind turbines.	6	CO3	L1
51.	List 3 important criteria for the selection of site for a WECS	3	CO3	L1
52.	A wind turbine rotor has a blade diameter of 20 m. At a wind speed of 16 m/s the turbine produces a power output of 270 kW. Given that the density of air is 1.2 kg/m3 determine the maximum power coefficient of the turbine.	3	CO3	L3
53.	Explain in detail the different types of classifications of Wind Energy Conversion systems	10	CO3	L2

54.	Explain how wind speed is measured using an anemometer	4	CO3	L2
55.	Derive the equation for estimating the power in wind available at a site.	3	CO3	L3
56.	Explain the concept of pitch control in a wind turbine and discuss its importance.	3	CO3	L2
57.	Define the capacity factor of a wind energy system. What is the capacity factor of a WES delivering average energy of 10000 GWh for the last 10 years if its rated power capacity is 300 MW?	5	CO3	L3
58.	Prove that the maximum wind turbine output is extracted when the downwind velocity is one-third of the upwind velocity.	10	CO3	L3
59.	With the help of a neat sketch, explain the important parts of a horizontal axis wind energy system. What are the aerodynamic forces acting on the blades of the turbine?	10	CO3	L2
60.	Determine the power in the wind if the wind speed is 8 m/s and the blade length is 50 m. Air density is 1.23 kg/m3. What is the maximum theoretical value of the power that can be extracted from the wind using a turbine? If the power coefficient of a turbine is 0.30 at a wind velocity of 20 m/s, what is the power output of the turbine?	5	CO3	L3
61.	Prove that the maximum wind turbine output can be achieved when Vd = 1/3 Vu, where Vd and Vu are down-stream and up-stream wind velocity respectively.	8	CO3	L3
62.	An aero-generator generates an output of 1800 W at wind speed of 6 m/s at one atmospheric pressure and at temperature of 24 °C. What will be the output, if the same wind Energy aero-generator is installed on the top of a hill where the temperature is 10 °C, pressure is 0.85 atmospheric and wind speed is 8 m/s? Given, 1 atm pressure = 1.01325 $\times 10^5$ Pa Gas constant R = 287	6	CO3	L3
63.	A propeller type wind turbine has following data: Speed of free wind at a height of 10 m = 13 m/s, Air density = 1.226 kg/m3, α = 0.14, Height of tower = 100 m, Diameter of rotor = 80 m, Wind velocity at the turbine reduces by 20%, Generator efficiency = 80%. Find the following: (i) Total power available in wind (ii) Power extracted by the turbine (iii) Electrical power generated	8	CO3	L3
64.	Explain the power–speed characteristics of a wind turbine.	6	CO3	L2
65.	Compare between the horizontal and vertical axis wind turbines.	3	CO3	L2
66.	Discuss the environmental impacts of wind energy?	3	CO3	L2
	Module 4			
Sl. No.	**Question**	**Marks**	**CO**	**BL**
67.	Define biomass gasification. List different types of biomass gasifiers.	3	CO4	L1
68.	List the factors affecting the biogas generation	3	CO4	L1
69.	Describe the construction and working of a biogas plant, its	10	CO4	L2

	material aspects, and utilization of plant products with a neat diagram			
70.	Explain the advantages and uses of biogas.	4	CO4	L2
71.	List the different types of biogas plants. Explain the construction, working of a fixed dome type biogas plant and floating dome type biogas plant	10	CO4	L2
72.	Disuss the factors affecting the selection of a particular model of a biogas plant	4	CO4	L2
73.	Identify the product obtained from Biomass gasification? Name the stages involved in the gasification process	3	CO4	L1
74.	Name the process used to produce biogas from wet biomass? Explain the stages involved in this process.	3	CO4	L2
75.	How can Urban waste be converted to useful energy? Draw a neat diagram and explain the step-by-step process	10	CO4	L2
76.	Explain the process of converting Biomass to Ethanol	4	CO4	L2
77.	Explain the working of the KVIC biogas model using a schematic diagram.	10	CO4	L2
78.	Explain any four significant factors which affect the performance of a Biogas plant.	4	CO4	L2
79.	Draw the block diagram representation of biomass to the ethanol conversion.	3	CO4	L1
80.	Explain the different stages in the biomass gasification process.	3	CO4	L2
81.	Urban areas are having the issue of managing waste on a day-to-day basis. Propose a scheme to convert this waste to electrical energy.	7	CO4	L3
82.	Discuss the factors that affect biogas production?	7	CO4	L2
83.	Explain the construction and working of a biomass gasifier.	7	CO4	L2
84.	Compare the constructional features of the KVIC and Janata models of biogas plants with suitable sketches.	7	CO4	L3
85.	Explain the concept of biomass gasification.	3	CO4	L2
86.	List the sources of biogas generation?	3	CO4	L1
87.	Describe the different types of biomass conversion technologies.	7	CO4	L2
88.	Explain the ethanol production process from biomass.	7	CO4	L2
89.	List the different types of biogas plants. Explain the construction, working of a fixed dome type biogas plant and floating dome type biogas plant	10	CO4	L2
90.	Discuss the factors affecting the selection of a particular model of a biogas plant	4	CO4	L2
	Module 5			
Sl. No.	**Question**	**Marks**	**CO**	**BL**
91.	Disucss the risks for the hydrogen energy storage	3	CO5	L2
92.	Define fuel cells and list their applications	3	CO5	L1
93.	Explain about the components of a small hydroelectric power generation scheme with the help of a neat diagram.	8	CO5	L3
94.	Explain about any two methods of hydrogen production.	6	CO5	L2

95.	Explain the working of a H_2O_2 fuel cell and also write the advantages and disadvantages of a fuel cell	8	CO5	L3
96.	Discuss the advantages and applications of hydrogen energy	6	CO5	L2
97.	List three methods for storing hydrogen	3	CO5	L1
98.	Discuss the benefits of using hydrogen as a fuel?	3	CO5	L2
99.	Draw a neat schematic of a Hydrogen-Oxygen fuel cell, write down the chemical reactions involved and explain the working.	10	CO5	L3
100.	Explain any 2 methods used for storage of Hydrogen	4	CO5	L2
101.	List the different types of turbines used in Small Hydropower plants? With neat sketch explain any two such turbines	10	CO5	L3
102.	Explain how Hydrogen is produced by Electrolysis	4	CO5	L2
103.	Discuss the different methods used for the storage of hydrogen.	3	CO5	L2
104.	How does the polarisation effect in a fuel cell affect the conversion efficiency?	3	CO5	L2
105.	Draw and label the layout of a micro-hydro project and explain its working.	7	CO5	L3
106.	Explain how is hydrogen produced using the electrolytic method with a suitable diagram.	7	CO5	L3
107.	Describe the construction and working of an alkaline fuel cell. List two applications.	7	CO5	L2
108.	List the different turbines used in small hydro projects and discuss their selection criteria	7	CO5	L2
109.	List the properties of hydrogen? Describe why is it considered as a secondary energy source	3	CO5	L2
110.	Define fuel cells and list their applications	3	CO5	L1
111.	Explain about the components of a small hydroelectric power generation scheme with the help of a neat diagram.	8	CO5	L3
112.	Explain about any two methods of hydrogen production.	6	CO5	L2
113.	Explain the working of a H_2O_2 fuel cell and also write the advantages and disadvantages of a fuel cell	8	CO5	L3
114.	Discuss the advantages and applications of hydrogen energy	6	CO5	L2

Prepared By : Thomas Felix

Checked By : , Subject Group Coordinator

Approved by : Dr. Ramadas T, HoD (ME)

Course Code & Name: MCN401 Industrial Safety Engineering

1. Prescribed Syllabus

Module	Topic	Hours
1	Need for safety. Safety and productivity. Definitions: Accident, Injury, Unsafe act, Unsafe Condition, Dangerous Occurrence, Reportable accidents. Theories of accident causation. Safety organization- objectives, types, functions, Role of management, supervisors, workmen, unions, government and voluntary agencies in safety. Safety policy. Safety Officer-responsibilities, authority. Safety committee-need, types, advantages.	5
2	Personal protection in the work environment, Types of PPEs, Personal protective equipment-respiratory and non-respiratory equipment. Standards related to PPEs. Monitoring Safety Performance: Frequency rate, severity rate, incidence rate, activity rate. Housekeeping: Responsibility of management and employees. Advantages of good housekeeping. 5 s of housekeeping. Work permit system- objectives, hot work and cold work permits. Typical industrial models and methodology. Entry into confined spaces.	7
3	Introduction to construction industry and safety issues in construction Safety in various construction operations – Excavation and filling – Under-water works – Under-pinning & Shoring – Ladders & Scaffolds – Tunneling – Blasting – Demolition – Confined space – Temporary Structures. Familiarization with relevant Indian Standards and the National Building Code provisions on construction safety. Relevance of ergonomics in construction safety. Ergonomics Hazards - Musculoskeletal Disorders and Cumulative Trauma Disorders.	7
4	Machinery safeguard-Point-of-Operation, Principle of machine guarding -types of guards and devices. Safety in turning, and grinding. Welding and Cutting-Safety Precautions of Gas, welding and Arc Welding. Material Handling-Classification-safety consideration- manual and mechanical handling. Handling assessments and techniques- lifting, carrying, pulling, pushing, palletizing and stocking. Material Handling equipment-operation & maintenance. Maintenance of common elements-wire rope, chains slings, hooks, clamps. Hearing Conservation Program in Production industries.	8
5	Hazard and risk, Types of hazards –Classification of Fire, Types of Fire extinguishers, fire explosion and toxic gas release, Structure of hazard identification and risk assessment. Identification of hazards: Inventory analysis, Fire and explosion hazard rating of process plants - The Dow Fire and Explosion Hazard Index, Preliminary hazard analysis, Hazard and Operability study (HAZOP)) – methodology, criticality analysis, corrective action and follow-up. Control of Chemical Hazards, Hazardous properties of chemicals, Material Safety Data Sheets (MSDS).	8

2. Text Books (T)

T1. I. R.K Jain (2000) Industrial Safety, Health and Environment management systems, Khanna Publications.

3. Reference Books (R)

1. Paul S V (2000), Safety management System and Documentation training Programme handbook, CBS Publication.
2. Krishnan, N.V. (1997). Safety management in Industry. Jaico Publishing House, New Delhi.
3. John V. Grimaldi and Rollin H.Simonds. (1989) Safety management. All India Traveller Book Seller, Delhi.
4. Ronald P. Blake. (1973). Industrial safety. Prentice Hall, New Delhi.
5. Alan Waring. (1996). Safety management system. Chapman & Hall, England.
6. Vaid, K.N., (1988). Construction safety management. National Institute of Construction Management and Research, Mumbai.
7. AIChE/CCPS. (1992). Guidelines for Hazard Evaluation Procedures. (second edition). Centre for Chemical Process Safety, American Institute of Chemical Engineers, New York

4. Course Objectives

The general objective of this course is to give knowledge of various safety management principles, various safety systems, various machine guarding devices, hazard identification techniques, energy sources, systems & applications and the need in the present context. Students will be able to compare different hazard identification tools and choose the most appropriate based on the nature of industry. It aims to equip students in working with projects and to take up research work in connected areas.

5. Course Pre / Co-requisite

Nil

6. Course Outcomes

After completion of the course, student will be able to

CO1: Describe the theories of accident causation and preventive measures of Industrial accidents.

CO2: Explain about personal protective equipment, its selection, safety performance & indicators and importance of housekeeping.

CO3: Explain different issues in construction industries.

CO4: Describe various hazards associated with different machines and mechanical material handling.

CO5: Utilise different hazard identification tools in different industries with the knowledge of different types of chemical hazards.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO 3
CO1	M	M				M	M	M				H			
CO2	M	M	M		M	M	M	M				H	H		
CO3	M	M	M		M	M	M	M	M	M		M	H		
CO4	M	M	M		M	M	M	M	M	M		M	H		
CO5	M	M	M	M	M	M	M	M	M	M		M	H		

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	PO1	Having knowledge in engineering fundamentals helps the students in understanding the theories of accident causation and thereby helps to prevents industrial accidents
	PO2	Understanding the theories of accident makes the students to analyze the causes of such accidents and helps to prevent industrial accidents.
	PO6	As an engineer, by understanding the causes of an accident helps a student in preventing such mistakes in near future and thereby increasing the social commitment of an engineer.
	PO7	By understanding the environmental impacts of an industrial accident helps the students in preventing such accidents and create a safe and sustainable environment.
	PO8	Understanding the theories of accidents helps the students in applying ethical methods of safety practices thereby preventing accidents in industry.
	PO12	By recalling the theories of accident causation will help the students in gaining lifelong knowledge of the causes of accidents and forge them to take safe decisions thereby preventing of an industrial accident.
CO2	PO1	Understanding the significance of personal protection will help students to solve the problem of increased accident rates in industries.
	PO2	Analyzing the relation between safety performance in an industry and usage of personal protective equipment can help to reach substantiated conclusions regarding safety
	PO3	Design solutions for safety related problems in industries with appropriate consideration for the public health and safety, societal, and environmental considerations.
	PO5	Select and use appropriate personal protection equipment based on the working environment.
	PO6	Understanding the concepts of safety performance will enable students to suggest measures taken to mitigate and contain accidents in industries for the safety and health of society.
	PO7	Understanding the impact of industrial personal protection in societal and

		environmental contexts for sustainable development.
	PO8	By understanding the importance of personal protection and safety performance, students will be able to apply ethical principles and commit to professional ethics and responsibilities.
	PO12	Life-long learning about the selection of different personal protective equipment based on the work environment will enable the students to ensure the safety of those involved.
	PSO1	High correlation is that it helps the student in using the new equipments in safety like PPE kit and helps him in applying those knowledge in solving safety problems.
CO3	**PO1**	Knowledge of different issues in construction industries will help students to solve problems related to the same
	PO2	By understanding major issues in construction industries, students will be able to analyze the issues and reach substantiated conclusions.
	PO3	Design of suitable solutions to different issues in construction industries by identifying the causes of major safety issues in construction industry.
	PO5	Students will be able to select and apply appropriate techniques to solve different issues in construction industry.
	PO6	Knowledge of different issues in construction industries enable the students to assess societal, health, safety, legal issues related to construction industry
	PO7	By learning issues in construction industries, the students will able to understand the impact of the engineering solutions in societal and environmental contexts, and the need for sustainable development
	PO8	Students will be able to commit to professional ethics and responsibilities while dealing with various issues related to construction industries
	PO9	Having in sight on different issues related to construction industry, students can effectively work as an individual, and as a member or leader in diverse team
	PO10	Knowledge of issues in construction industrywillenablethestudentstocommunicateeffectivelywiththeengineeringcommunity and with the society in large on construction activities and enable them to give and receive clear instructions
	PO12	Knowledge of issues in construction industry help the students to engage in lifelong learning which gives in the broadest context of technological change in the industry.
	PSO1	High correlation is that it helps the student in understanding various safety issues in construction and makes him in operating safety equipments to solve problems in construction industry
CO4	**PO1**	Knowledge of various principles in machine guarding help students to solve issues related to mechanical material handling.
	PO2	By understanding various issues in mechanical material handling, students will be able to analyze the machine related hazards and should be able to reach substantiated conclusions.
	PO3	The students will be able to design suitable solutions to issues related to mechanical material handling by identifying the causes of various hazards in machines.
	PO5	Students will be able to apply various mechanical material handling techniques to handle hazard related to the machines in construction industry.
	PO6	Knowledge of different issues in mechanical material handling enable the

		students to assess societal, health, safety, legal issues related to construction industry.
	PO7	By understanding the issues of mechanical material handling in construction industries, the students will able to understand the impact of the engineering solutions in societal and environmental contexts, and the need for sustainable development
	PO8	Understanding various principles in machine guarding, the students will be able to apply ethical principles and commit to professional ethics and responsibilities.
	PO9	Understanding various principles in machine guarding and issues related to mechanical material handling, the students will be able to work as an individual or as a member/leader in a team.
	PO10	Knowledge of issues related to mechanical material handling in construction industrywillenablethestudentstocommunicateeffectivelywiththeengineeringcommunity and with the society in large on construction activities and enable them give and receive clear instructions.
	PO12	Knowledge of various principles in machine guarding and material handling help the students to engage in lifelong learning which gives in the broadest context of technological change in the industry.
	PSO1	By understanding various issues in various mechanical machines helps to solve safety hazard in machines in a sustainable way.
CO5	**PO1**	Knowledge of different hazard identification tools and chemical hazards in different industries will help students to apply in complex engineering problems related to industries.
	PO2	Concepts of different hazard identification tools and chemical hazards will help the students to analyze and formulate different engineering problems from different dimensions.
	PO4	Students will use the risk assessment, inventory analysis, HAZOP, MSDS to analyze, interpret data, and synthesis of information to provide valid conclusions.
	PO5	By understanding hazard identification tools and chemical hazards, students will be able to apply appropriate techniques to handle industrial hazards.
	PO6	In sight on types of hazard identification tools and chemical hazards will enable the students to assess societal health, and safety issues to Professional engineering practice
	PO7	By learning hazard identification and analysis, students will understand. The impact of the engineering solutions in societal and environmental contexts, and the need for sustainable development.
	PO8	Understanding the types of hazards, risks, HAZOP, corrective action, control, etc. will help students to apply ethical principles to engineering. practice.
	PO9	By utilizing different hazard identification tools and understanding Different aspects of chemical hazards, the students will be able to function better as an individual or as a member/leader in a team.
	PO10	Knowledge of hazard identification and analysis tools will enable the students to communicate effectively with the engineering community on complex engineering activities and enable them give and receive clear instructions.

	PO12	Learning, understanding and application of hazard identification and analysis tools will help to engage in lifelong learning which in the broadest context of technological change.
	PSO1	Understanding cause of chemical hazard will helps to solve the hazard issue in a sustainable way

9. Curricular gaps (if any)

Absence of digital safety management systems (like ERP/EHS software tools)
Limited coverage of international safety standards (OSHA, ISO 45001, NFPA, etc.)
Emerging areas like AI in safety, robotics in hazardous environments not included

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	Talk on "Industrial Safety awareness"	Expert talk from interdisciplinary area	PO1, PO6, PO7, PO12
2	Workshop on PPE Selection and Usage	Workshop	PO1, PO8, PO9, PO12

11. Internal Assessment mark allocation (as per university curriculum)

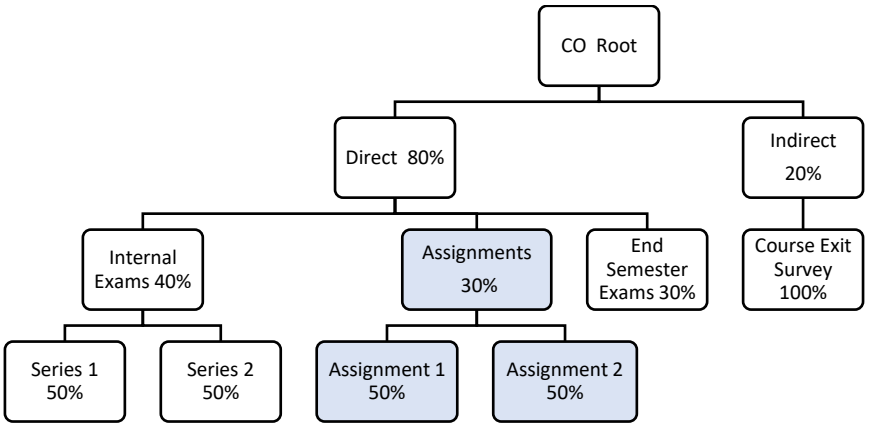
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put' x' if mapping is present)

	Tools		**Weightage#**	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
Direct Assessment Tools**	Internal Exam(s) 40%	Series 1	20%	x	x	x		
		Series 2	20%			x	x	x
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x	x	x		
		Assignment 2	15%				x	x
	End Semester Exam		30%	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hour	Topic Name	Module	Reference (s)	Teaching Pedagogy
1	Need for safety. Safety and productivity. Definitions: Accident, Injury,	1	R1, R2	Lecture
2	Unsafe act, Unsafe Condition, Dangerous Occurrence. Reportable accidents	1	R1, R2	Lecture
3	Theories of accident causation. Safety organization.	1	R1, R2	Lecture
4	Role of management, supervisors, workmen, unions, government and voluntary agencies in safety.	1	R1, R2	Lecture
5	Role of management, supervisors, workmen, unions, government and voluntary agencies in safety.	1	R1, R2	Remedial
6	Safety Officer-responsibilities, authority.	1	R1, R2	Tutorial
7	Safety committee-need, types, advantages.	1	R1, R2	Lecture
8	Types of PPEs, respiratory and non-respiratory equipment.	2	R1, R2	Lecture
9	Standards related to PPEs	2	R1, R2	Remedial
10	Standards related to PPEs	2	R1, R2	Tutorial
11	Monitoring Safety Performance: Frequency rate, severity rate	2	R1, R2	Lecture
12	Monitoring Safety Performance: incidence rate, activity rate.	2	R1, R2	Lecture
13	Housekeeping: Responsibility of management and employees. Advantages of good housekeeping. 5 s of housekeeping.	2	R1, R2	Tutorial
14	Work permit system- objectives, hot work and cold work permits.	2	R1, R2	Lecture
15	Typical industrial models and methodology. Entry into confined spaces.	2	R1, R2	Lecture
16	Monitoring Safety Performance	2	R1, R2	Remedial

17	Excavation and filling â€“ Under-water works â€“ Under-pinning & Shoring	3	R5	Lecture
18	Ladders & Scaffolds â€“ Tunneling	3	R5	Lecture
19	Blasting â€“Demolition â€“ Confined space	3	R5	Lecture
20	Blasting â€“Demolition â€“ Confined space	3	R5	Remedial
21	Familiarization with relevant Indian Standards and the National Building Code provisions on construction safety.	3	R5	Tutorial
22	Relevance of ergonomics in construction safety.	3	R5	Lecture
23	Ergonomics Hazards	3	R5	Lecture
24	Ergonomics Hazards	3	R5	Remedial
25	Musculoskeletal Disorders and Cumulative Trauma Disorders.	3	R5	Tutorial
26	Point-of-Operation, Principle of machine guarding	4	R5	Lecture
27	Types of guards and devices.	4	R5	Lecture
28	Safety in Power Presses, primary & secondary operations - shearing -bending - rolling â€“ drawing.	4	R5	Tutorial
29	Safety in turning, boring, milling, planning and grinding.	4	R5	Lecture
30	Welding and Cutting-Safety Precautions of Gas welding and Arc Welding,	4	R5	Lecture
31	Welding and Cutting-Safety Precautions of Gas welding and Arc Welding,	4	R5	Remedial
32	Cutting and Finishing.	4	R5	Tutorial
33	Material Handling-Classification-safety considerationmanual and mechanical handling. Handling assessments and techniques- lifting, carrying, pulling, pushing, palletizing and stocking.	4	R5	Lecture
34	Material Handling equipment-operation & maintenance. Maintenance of common elements-wire rope, chains slings, hooks, clamps	4	R5	Lecture
35	Material Handling equipment-operation & maintenance. Maintenance of common elements-wire rope, chains slings, hooks, clamps	4	R5	Remedial
36	Hazard and risk, Types of hazards â€“ Classification of Fire	5	R7	Lecture
37	Types of Fire extinguishers fire, explosion and toxic gas release.	5	R7	Lecture
38	Inventory analysis, Fire and explosion hazard rating of process plants	5	R7	Lecture
39	Types of Fire extinguishers fire	5	R7	Remedial
40	The Dow Fire and Explosion Hazard Index.	5	R7	Tutorial
41	Preliminary hazard analysis, Hazard and Operability study (HAZOP)	5	R7	Lecture
42	Chemical hazard- Classifications, Control of Chemical Hazards.	5	R7	Lecture
43	Hazardous properties of chemicals	5	R7	Tutorial
44	Material Safety Data Sheets (MSDS).	5	R7	Lecture

45	Material Safety Data Sheets (MSDS).	5	R7	Remedial

15. Question Bank

Module 1				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1.	Define Industrial Safety, Accident and Injury.	**3**	CO1	**L1**
2.	Describe the personal factors that lead to accidents	**3**	CO1	**L1**
3.	Describe the objectives of industrial safety.	**3**	CO1	**L1**
4.	Define terms: Accident, Reportable accident, Dangerous occurrence.	**4**	CO1	**L1**
5.	Explain any 3 unsafe acts while are responsible for accidents in industries	**3**	CO1	**L1**
6.	List any important six responsibilities of worker/workmen towards the safety measures in an organization.	**3**	CO1	**L1**
7.	Write the importance of safety in organisations	**3**	CO1	**L1**
8.	List out the objectives of Industrial Safety	**4**	CO1	**L1**
9.	List the various accident causation theories and explain any one in details.	**14**	CO1	**L1**
10.	Define an industrial accident. Write a note on economic aspects of accidents.	**7**	CO1	**L1**
11.	Explain objectives and functions of Safety organization	**8**	CO1	**L1**
12.	With suitable schematics, describe the different types of safety organization.	**6**	CO1	**L2**
13.	Differentiate Unsafe act and Unsafe conditions with suitable examples	**3**	CO1	**L2**
14.	Discuss the significance of a safety committee in improving the safety performance of an industry	**3**	CO1	**L2**
15.	How can you describe safety policy	**3**	CO1	**L2**
16.	Discuss the significance of safety policy in reducing the accidents.	**4**	CO1	**L2**
17.	Explain Domino Theory of accident causation	**7**	CO1	**L2**
18.	Explain the responsibilities of safety officer in the implementation of safety in industries.	**8**	CO1	**L2**
19.	Explain the personal factors that lead to accidents	**6**	CO1	**L2**
20.	Explain environmental causes of accidents. What are the corrective actions to eliminate them?	**10**	CO1	**L2**

21.	"Safety is the need of this century". Do you agree with this .If so explain	**10**	CO1	**L2**
22.	Discuss the need of Safety committee- types, and advantages.	**14**	CO1	**L2**
23.	Discuss the Role of management, supervisors, workmen, unions, government and voluntary agencies in safety.	**14**	CO1	**L2**
24.	Discuss on authorities and roles of a safety officer?	**10**	CO1	**L2**
25.	Discuss various Theories of accident causation	**14**	CO1	**L2**
26.	Safety and productivity are the two sides of a coin'. Are you agreeing with this statement? Explain with your arguments.	**10**	CO1	**L3**
27.	List the various accident causation theories and explain any two in detail with relevant schematics.	**14**	CO1	**L2**

Module 2

Sl. No.	Question	Marks	CO	BL
1.	Define (i) Frequency rate, (ii) severity rate, (iii) incidence rate	**3**	**CO2**	**L1**
2.	List the advantages of good housekeeping	**3**	**CO2**	**L1**
3.	What is PPE? Give examples	**3**	**CO2**	**L1**
4.	List the different types of personal protective equipment	**3**	**CO2**	**L1**
5.	What is respiratory protective equipment (RPE)? Explain the features of any one type of RPE.	**3**	**CO2**	**L1**
6.	How does frequency rate and incidence rate support safety analysis?	**3**	**CO2**	**L1**
7.	How can workers' safety be ensured during underpinning work?	**3**	**CO2**	**L1**
8.	What do you mean by confined space? Give examples.	**4**	**CO2**	**L1**
9.	How do you monitor the safety performance in industries	**3**	**CO2**	**L2**
10.	List the steps to be followed in confined space entry to protect the life of a worker?	**4**	**CO2**	**L1**
11.	Briefly explain the standards related to PPE?	**6**	**CO2**	**L1**
12.	Describe the responsibility of management and employees in housekeeping?	**3**	**CO2**	**L1**
13.	Define (i) Activity rate, (ii) incidence rate	**3**	**CO2**	**L1**
14.	Explain the 5 s of housekeeping.	**10**	**CO2**	**L2**
15.	Explain the benefits of good housekeeping? Also, explain the five 'S' (5 S) concept in housekeeping.	**9**	**CO2**	**L2**

16.	Classify the personal protective equipment. List the suitability of at least fifteen types of PPEs.	**10**	**CO2**	**L2**
17.	How will you calculate the frequency rate? Explain with an example.	**4**	**CO2**	**L2**
18.	How will you compare the safety performance of two industries? Explain with suitable example.	**10**	**CO2**	**L2**
19.	Discuss the significance of work permit system in accident prevention.	**4**	**CO2**	**L2**
20.	Give the different types of permit? Highlight its suitability.	**4**	**CO2**	**L2**
21.	Explain the equipments that can be used for protecting the workers from breathing poisonous gases.	**3**	**CO2**	**L2**
22.	Explain the protective equipments that can be used in a noisy environment.	**3**	**CO2**	**L2**
23.	Explain any one protective equipments that could be selected during welding work.	**3**	**CO2**	**L2**
24.	Explain the equipments that can be used for protecting the workers from falling objects.	**3**	**CO2**	**L2**
25.	Explain any 3 equipments that can be used for protection of finger, hand and arm.	**3**	**CO2**	**L2**
26.	Using the following data calculate the frequency rate of accident in an industrial plant. 1. Number of workers=500 2. Number of disabling injuries per year= 5. 3. Average number of hours worked by worker per year=2000.	**3**	**CO2**	**L3**
27.	Using the following data to calculate the severity rate of accident in an industrial plant where only one accident occurred during the year, the type of injury being cutting of the tip of a finger. No: of workers=2000. No: of days lost in a year due to accidents=100 Average no: of hours worked by worker per year=2000.	**3**	**CO2**	**L3**

Module 3

Sl. No.	**Question**	**Marks**	**CO**	**BL**
1.	List the various safety features of ladders.	**3**	**CO3**	**L1**
2.	List any important six safety practices used with ladders in construction sites.	**3**	**CO3**	**L1**
3.	List the various safety features of scaffolds.	**3**	**CO3**	**L1**
4.	Identify any six safety requirements in shoring.	**3**	**CO3**	**L1**
5.	Identify any six hazards in underwater works.	**3**	**CO3**	**L1**
6.	List any four precautions in Scaffolding.	**4**	**CO3**	**L1**

7.	Describe any four safety precautions in the use of a ladder.	**4**	**CO3**	**L2**
8.	How safety of the workers can be ensured during a demolition operation.	**3**	**CO3**	**L2**
9.	How safety of the workers can be ensured during excavation and filling	**3**	**CO3**	**L2**
10.	Explain any important four safety practices in excavation works.	**3**	**CO3**	**L2**
11.	Discuss the safety requirement for a confined space entry	**3**	**CO3**	**L2**
12.	How safety of the workers can be ensured during tunnelling	**3**	**CO3**	**L2**
13.	Discuss the safety requirement for Under-pinning & Shoring	**3**	**CO3**	**L2**
14.	Explain Musculoskeletal Disorders and Cumulative Trauma Disorders in detail	**7**	**CO3**	**L2**
15.	Explain the Relevance of ergonomics in construction safety	**7**	**CO3**	**L2**
16.	Discuss the important types of ergonomic hazards associated with industries.	**7**	**CO3**	**L2**
17.	Identify the various hazards during the different stages of building construction.	**7**	**CO3**	**L2**
18.	Discuss the safety and fire protection facilities required for a high rise building as per National building code.	**14**	**CO3**	**L2**
19.	'Kuthiran' is Kerala's first-ever tunnel for road transport and South India's longest six-lane road tunnel. Illustrate the various safety precautions followed during blasting and tunnelling operations.	**10**	**CO3**	**L3**
20.	"Musculoskeletal Disorder (MSD) and Cumulative Trauma Disorder (CTD) are major occupational diseases." Justify the statement with two examples each.	**10**	**CO3**	**L3**
21.	"Ergonomics is related to the design of workplaces, products and systems to best fit those who use them". Justify this statement for the construction industry.	**10**	**CO3**	**L3**
22.	Illustrate the construction of a multistorey building and apply your knowledge to solve various safety issues. (Hint: Hazards and safety precautions in Excavation & scaffolding)	**10**	**CO3**	**L3**
Module 4				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1.	Define type of Safeguards used in construction industry.	**3**	**CO4**	**L1**
2.	Define point of operation devices used for safeguard of machinery	**3**	CO4	**L1**
3.	Define Slings used for Material handling in industry.	**3**	CO4	**L1**
4.	Define palletizing and stocking technique in material handling	**3**	CO4	**L1**
5.	List any three types of machine guards.	**3**	**CO4**	**L1**

6.	List any three objectives of material handling	**3**	**CO4**	**L1**
7.	Explain the advantage of Chain sling over a wire rope	**3**	CO4	**L2**
8.	Mention any four potential hazards associated with wire rope used for material handling.	**3**	CO4	**L2**
9.	Explain the classification of Material Handling	**3**	CO4	**L2**
10.	Explain Safety Precautions followed in Gas welding	**3**	CO4	**L2**
11.	Explain Safety precautions followed in Arc Welding	3	CO4	**L2**
12.	Discuss the safety issues of Gas welding operations.	3	CO4	**L2**
13.	Explain the hazards associated with manual material handling?	3	CO4	**L2**
14.	Discuss the key elements of a hearing conservation program.	3	CO4	**L2**
15.	What are the various objectives of Maintenance	3	CO4	**L2**
16.	Explain the various principles used in machine guarding.	**9**	CO4	**L2**
17.	Explain the issues in mechanical material handling.	**9**	CO4	**L2**
18.	Explain the various types of machine guarding devices used in industries. Discuss the suitability of each machine guarding devices.	**9**	CO4	**L2**
19.	With suitable sketches briefly explain seven defects of wire ropes.	9	CO4	**L2**
20.	Explain Hearing Conservation Program in Production industries.	9	CO4	**L2**
21.	Explain various Material Handling equipment, its operation & maintenance.	14	CO4	**L2**
22.	Explain various material handling assessments and techniques used in industry.	14	CO4	**L2**
23.	Describe three major factors affecting the selection of material handling equipment and explain any four types of material handling systems.	**14**	**CO4**	**L2**
24.	Explain various classifications and safety considerations in Machine handling	14	CO4	**L2**
25.	Explain the principles of machine guarding and types of guards and devices used for machine safety.	**14**	CO4	**L2**
26.	Explain Safety Precautions followed in Gas welding and Arc Welding	**14**	CO4	**L2**
27.	Suppose you are a section supervisor in a Mechanical industry with many machining operations. Predict the safety precautions in grinding operation.	**3**	**CO4**	**L3**
28.	Suppose you are a section supervisor in a Mechanical industry with many machining operations. Predict the safety precautions in turning operation.	**3**	**CO4**	**L3**

Module 5				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1.	List the types of Fire extinguishers.	3	CO5	L1
2.	MSDS is mandatory for chemical products. Give reasons	3	CO5	L1
3.	What is meant by MSDS	3	CO5	L1
4.	Name the company who developed the F& EI (Fire & explosion Index)	3	CO5	L1
5.	How do you identify chemical hazards.	3	CO5	L1
6.	List the hazardous properties of chemicals.	3	CO5	L1
7.	Enumerate the industries which uses HAZOP analysis	3	CO5	L1
8.	Define(i)Hazard (ii) Risk	3	CO5	L1
9.	Differentiate Hazard and Risk.	3	CO5	L2
10.	What do you meant by Hazard and Risk	3	CO5	L1
11.	Describe any three types of Hazards.	3	CO5	L2
12.	Classify Chemical hazards.	3	CO5	L2
13.	Explain the hierarchy of control of chemical hazards.	3	CO5	L2
14.	Classify different types of Fire.	3	CO5	L2
15.	Why material safety data sheet is mandatory for chemical products?	3	CO5	L2
16.	Explain ABC analysis of inventory control.	6	CO5	L2
17.	Describe the Dow Fire and Explosion Hazard Index.	7	CO5	L2
18.	Explain the structure of hazard identification and risk assessment.	7	CO5	L2
19.	Describe the Selection of different types of fire extinguishers accordance to type of fire.	10	CO5	L2
20.	Explain chemical risk assessment steps in industries.	10	CO5	L2
21.	Describe corrective action and follow-up in HAZOP analysis.	10	CO5	L2
22.	What is Hazard and Operability Analysis? How do you conduct a HAZOP analysis?	14	CO5	L2
23.	Discuss about different types of chemical hazards.	14	CO5	L2
24.	Illustrate the Fire and explosion hazard rating of process plants	10	CO5	L3

25.	Show with a case study example, the Control of Chemical Hazards in industries.	10	CO5	L3

Prepared By : Arun V, Course Faculty

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Course Code & Name: MEL411 MECHANICAL ENGINEERING LAB

1. Prescribed Syllabus

List of Exercises/ Experiments (Lab experiments may be given considering 12 sessions of 3 hours each. Minimum 10 experiments to be performed.)

1. Experiment on Whirling of shaft.
2. Experiment on Gyroscope.
3. Experiment on Universal governor apparatus.
4. Experiment on Free vibration analysis.
5. Experiment on Forced vibration analysis.
6. Experiment on any Non-destructive test.
7. Exercises on Milling Machine - slab milling/gear cutting.
8. Milling forces – Milling parameters – measurement of milling forces in slab milling operations.
9. Exercises on pneumatic circuits using pneumatic trainer unit.
10. Exercises on hydraulic circuits using hydraulic trainer unit.
11. Exercises on electro pneumatic and electro hydraulic circuits using trainer units.
12. Exercises on 3-D printing.
13. Exercises on stepper motor to determine the operating characteristics.
14. Exercises on PC based data acquisition system with any software.
15. Study of SCADA and PLC programming.
16. Interfacing SCADA with PLC and PC.
17. Controlling variable speed drive through PLC/SCADA.

Sl No	Experiments
1	Experiment on Whirling of shaft
2	Experiment on Gyroscope
3	Experiment on Porter governor apparatus
4	Experiment on Watt governor apparatus
5	Exercises on 3-D printing
6	Experiment on Non-destructive test.
7	Exercises on pneumatic circuits using pneumatic trainer unit
8	Exercises on electro pneumatic circuits using trainer units
9	Measurement of milling forces in slab milling operations
10	Experiment on Forced vibration analysis

2. Text Books (T)

T1. V.P Singh, Dhanpat Rai & Co publications, Theory of machines
T2. A Textbook of Manufacturing Technology (Manufacturing Processes) by Er. R. K. Rajput Higher Education Laxmi Publications.
T3.K.P.Ramachandran, G.K.Vijayaraghavan, M.S.Balasundaram, Mechatronics: Integrated Mechanical Electronic Systems, Wiley India Pvt. Ltd., New Delhi, 2008

3. Reference Books (R)

R1.C.E.Wilson, P. Sadler, Kinematics and Dynamics of Machinery, Pearson Education, 2005
R2.D.H.Myszka, Machines and Mechanisms Applied Kinematic Analysis, Pearson Education, 2013
R3.W.Bolton, Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Person Education Limited, New Delhi, 2007
R4.Serope Kalpakjian, Steven R. Schmid - Manufacturing Engineering and Technology, Pearson

4. Objectives

1. To conduct the various experiments related to machine dynamics, cutting forces in milling machine.
2. To practice exercise using pneumatic trainer units, hydraulic devices, basic concepts of stepper motors.
3. Enable the students to get the basic ideas of data acquisition systems and automation.

5. Course Pre / Co-requisite

Engineering Mechanics, Theory of Machines, Machine Tools

6. Course Outcomes

The students will be able to

CO1: Get practical knowledge on design and analysis of mechanisms in the machines
CO2: Measure the cutting forces associated with milling machining operations.
CO3: Apply the basic concepts of hydraulic and pneumatic actuators and their applications in product and processes
CO4: Use appropriate systems for data acquisition and control of product and processes

7. Mapping of Course Outcomes with Program Outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	**H**	**M**	**M**	**H**	**H**		**M**		**H**	**M**		**M**	**M**		**L**
CO2	**H**	**M**	**M**	**H**	**H**		**M**		**H**	**M**		**M**	**M**		**L**
CO3	**H**	**M**	**M**	**H**	**H**		**M**		**H**	**M**		**M**	**H**		**M**
CO4	**H**	**M**	**M**	**H**	**H**		**M**		**H**	**M**		**M**			**L**

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	PO1	Knowledge in mechanism of respective apparatus to solve engineering problems. High correlation is due to the fact that deep knowledge of science, engineering fundamentals, and an engineering specialization could be used to solve the complex engineering problems.
	PO2	By gaining knowledge students can identify, formulate, and analyse complex engineering problems related to respective machines. Medium correlation is due to the fact that it uses basic principle to identify, formulate, review research literature and analyse complex engineering problems.
	PO3	Study of gyroscope can be useful to design system components for the public. Moderately mapped as the students will be able to solve problems aiming social responsibilities, minimized health impacts and meeting customer requirements.
	PO4	Experiments and interpretation of data using knowledge in theory of machines and working of respective apparatus to find solutions to similar engineering problems. Strongly mapped as Students will be able to conduct experiments, interpret and analyse data, synthesize the information to analyse a current topic of professional interest.
	PO5	High correlation mapped as the students will be able to use the modern tool for to Create, select, and apply relevant approaches, resources, and current engineering and IT tools, such as modelling and prediction, to complicated engineering tasks while understanding their constraints.
	PO7	Moderately mapped as the Students able to demonstrate understanding of, and the need for, sustainable development, and to comprehend the impact of engineering problem solutions in societal and environmental contexts.
	PO9	By completing the experiments in the laboratory students can function effectively as an individual, and as a member or leader in diverse teams. Strongly mapped as the students able to Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools to complex engineering activities with an understanding of the limitations of its function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
	PO10	By analysing the experimental data and interpret the results the students can communicate effectively on complex engineering activities with the engineering community. Moderately mapped the students able to Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools for effective communication on complex engineering activities with the engineering community and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
	PO12	Conducting experiments and analyzing provide professionalism, ethical attitude, communication skill, team work. Moderately mapped the students to able to create, select, and employ relevant approaches, resources, and current engineering and IT technologies in order to engage in independent and lifelong learning in the broadest context of technological change.
	PSO1	Analytical knowledge on the respective experiments helps the students

		to solve some of the mechanical engineering problems.
	PSO3	By applying appropriate techniques and modern engineering tools of respective machines helps the students to synthesize and analyse complex mechanical engineering problems.
CO2	**PO1**	Knowledge of mechanism in the milling machine can complement the study of engineering problems. High correlation is due to the fact that deep knowledge of science, engineering fundamentals, and an engineering specialization could be used to solve the complex engineering problems.
	PO2	By gaining knowledge students can identify, formulate, and analyse complex engineering problems related to milling machines. Medium correlation is due to the fact that it uses basic principle to identify, formulate, review research literature and analyse complex engineering problems.
	PO3	Conducting experiments and analysing in respective apparatus provide professionalism, ethical attitude, communication skill, team work. Moderately mapped as the students will be able to solve problems aiming social responsibilities, minimized health impacts and meeting customer requirements.
	PO4	Conducting experiments and interpretation of data using knowledge in milling machines to solve similar engineering problems. Strongly mapped as Students will be able to conduct experiments, interpret and analyse data, synthesize the information to analyse a current topic of professional interest.
	PO5	Strongly mapped as the students will be able to find the relevant tools to implement the problem stated.
	PO7	By gaining knowledge in milling machines, students can apply ethical principles, responsibilities and norms of the engineering practice related to respective apparatus. Moderately mapped as the Students able to demonstrate understanding of, and the need for, sustainable development, and to comprehend the impact of engineering problem solutions in societal and environmental contexts.
	PO9	By gaining the knowledge in respective apparatus students can function effectively as an individual, and as a member or leader in diverse teams. Strongly mapped as the students able to Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools to complex engineering activities with an understanding of the limitations of its function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
	PO10	By analysing the experimental data and interpret the results the students can communicate effectively on complex engineering activities with the engineering community. Moderately mapped the students able to Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools for effective communication on complex engineering activities with the engineering community and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
	PO12	Conducting experiments and analyzing provide professionalism, ethical attitude, communication skill, team work. Moderately mapped the students to able to create, select, and employ relevant approaches, resources, and current engineering and IT technologies in order to engage

		in independent and lifelong learning in the broadest context of technological change.
	PSO1	Knowledge on respective machines or devices helps the students to solve some of the mechanical engineering problems.
	PSO3	By analysing the experimental data and interpret the results of techniques and modern engineering tools of respective experiments helps the students to synthesize and analyse complex mechanical engineering problems.
CO3	**PO1**	Knowledge of pneumatic actuators can complement the study of engineering problems. High correlation is due to the fact that deep knowledge of science, engineering fundamentals, and an engineering specialization could be used to solve the complex engineering problems
	PO2	By gaining knowledge students can identify, formulate, analyse the complex engineering problems reaching substantiated conclusions related to pneumatic actuator. Medium correlation is due to the fact that it uses basic principle to identify, formulate, review research literature and analyse complex engineering problems.
	PO3	Conducting experiments and analysing provide professionalism, ethical attitude, communication skill, team work. Moderately mapped as the students will be able to solve problems aiming social responsibilities, minimized health impacts and meeting customer requirements.
	PO4	By analysing the experimental data and interpret the results students can provide valid conclusions. Strongly mapped as Students will be able to conduct experiments, interpret and analyse data, synthesize the information to analyse a current topic of professional interest.
	PO5	Strongly mapped to the pneumatic actuators as the students able to Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools with in the timeline, adhering to ethical and professional standards
	PO7	By analysing the experimental data and interpret the results students can apply ethical principles, responsibilities and norms of the engineering practice related to pneumatic trainers. Moderately mapped as the Students able to demonstrate understanding of, and the need for, sustainable development, and to comprehend the impact of engineering problem solutions in societal and environmental contexts.
	PO9	By analysing the experimental data and interpret the results students can function effectively as an individual, and as a member or leader in diverse teams. Strongly mapped as the students able to Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools to complex engineering activities with an understanding of the limitations of its function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
	PO10	By analysing the experimental data and interpret the results the students can communicate effectively on complex engineering activities with the engineering community. Moderately mapped the students able to Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools for effective communication on complex engineering activities with the engineering community and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
	PO12	Conducting experiments and analyzing provide professionalism, ethical

		attitude, communication skill, team work. Moderately mapped the students to able to create, select, and employ relevant approaches, resources, and current engineering and IT technologies in order to engage in independent and lifelong learning in the broadest context of technological change
	PSO1	By analysing the experimental data and interpret the results on the respective machines helps the students to solve some of the mechanical engineering problems.
	PSO3	By analysing the experimental data and interpret the results of techniques and modern engineering tools of respective experiments helps the students to synthesize and analyse complex mechanical engineering problems.
CO4	**PO1**	Knowledge of 3D printer can complement the study of engineering problems. High correlation is due to the fact that deep knowledge of science, engineering fundamentals, and an engineering specialization could be used to solve the complex engineering problems.
	PO2	By gaining knowledge students can identify, formulate, and analyse complex engineering problems related to data acquisition. Medium correlation is due to the fact that it uses basic principle to identify, formulate, review research literature and analyse complex engineering problems.
	PO3	Conducting experiments and analysing in respective apparatus provide professionalism, ethical attitude, communication skill, team work. Moderately mapped as the students will be able to solve problems aiming social responsibilities, minimized health impacts and meeting customer requirements.
	PO4	Conducting experiments and interpretation of data using knowledge in data acquisition to solve similar engineering problems. Strongly mapped as Students will be able to conduct experiments, interpret and analyse data, synthesize the information to analyse a current topic of professional interest.
	PO5	Strongly mapped as the students able to Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools with in the timeline ,adhering to ethical and professional standards
	PO7	By gaining knowledge in respective apparatus, students can apply ethical principles, responsibilities and norms of the engineering practice related to respective apparatus. Moderately mapped as the Students able to demonstrate understanding of, and the need for, sustainable development, and to comprehend the impact of engineering problem solutions in societal and environmental contexts.
	PO9	By gaining the knowledge in respective apparatus students can function effectively as an individual, and as a member or leader in diverse teams. Strongly mapped as the students able to Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools to complex engineering activities with an understanding of the limitations of its function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
	PO10	By analysing the experimental data and interpret the results the students can communicate effectively on complex engineering activities with the engineering community. Moderately mapped the students able to Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools for effective communication on complex

		engineering activities with the engineering community and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
	PO12	Conducting experiments and analyzing provide professionalism, ethical attitude, communication skill, team work. Moderately mapped the students to able to create, select, and employ relevant approaches, resources, and current engineering and IT technologies in order to engage in independent and lifelong learning in the broadest context of technological change.
	PSO3	By documenting of experimentation of appropriate techniques and modern engineering tools in respective experiments helps the students to synthesize and analyse complex mechanical engineering problems.

9. Curricular gaps (if any) : Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	-	-	-

11. Course Plan / Schedule of experiments

Weeks(W)	**Experiments**	**Relevance to COs**
1	Experiment on Whirling of shaft	CO1
2	Experiment on Gyroscope	CO1
3	Experiment on Porter governor apparatus	CO1
4	Experiment on Watt governor apparatus	CO1
5	Exercises on 3-D printing	CO4
6	Experiment on Non-destructive test.	CO4
7	Exercises on pneumatic circuits using pneumatic trainer unit	CO3
8	Exercises on electro pneumatic circuits using trainer units	CO3
9	Measurement of milling forces in slab milling operations	CO2
10	Experiment on Forced vibration analysis	CO4
Total No. of Hours	30	

12. Assessment Pattern (as per curriculum)

Continuous Internal evaluation - 75 marks

End Semester Examination - 75 marks

Total -150 marks

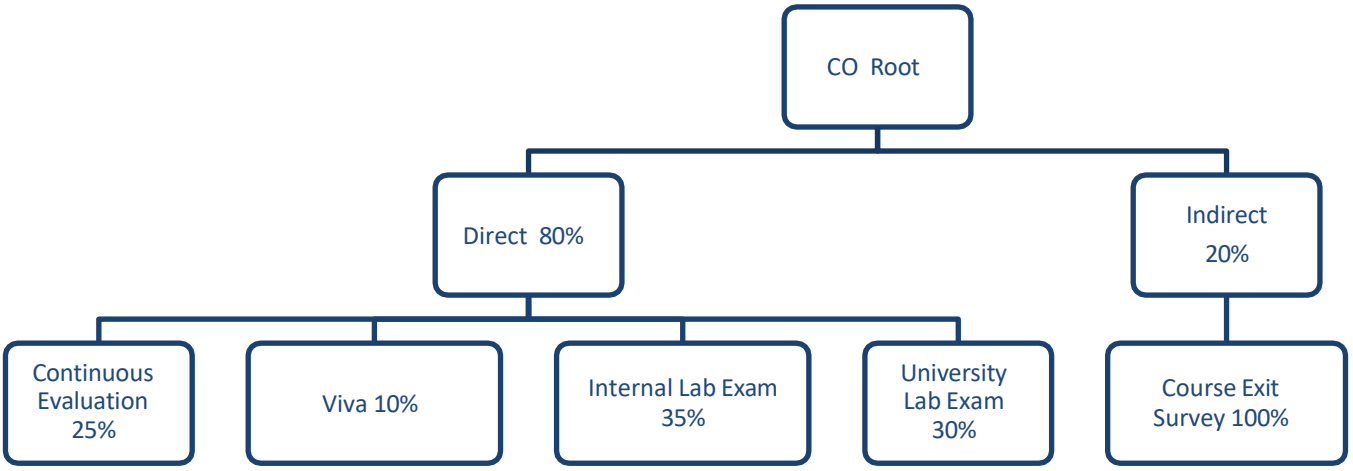
13. Evaluation criteria (as per syllabus)

Sl. No	Nature of Evaluation	Evaluation Pattern	Topics of Evaluation	Duration	Weightage of marks
1.	**Continuous Internal evaluation (75 marks)**				
a.	Attendance	90%-100% - 15 marks 85% -90% - 13.5 marks 75% -85 % - 12 marks 70% - 75% - 10.5 marks 65% - 70% - 9 marks 60% - 65% - 7.5 marks	NA	NA	20%
b.	Continuous Assessment	10 marks for performance Total no. of experiments: 10 Total – 100 marks will be converted to 20 while calculating internals	Each experiment	2.5 hours	26.67%
c.	Viva Voce	10 marks for viva. Total no. of experiments: 10 Total – 100 marks will be converted to 10 while calculating internals	Each experiment	2.5 hours	13.33%
d.	Internal Test	Preliminary Work – 10 marks Conducting Experiment – 10 marks Performance and Result – 5 marks Viva – 5 marks Total – 30 marks	All Experiments	2.5 hours	40%
2.	**End Semester Examination (75 marks)**				
a.	End semester Examination	(a) Preliminary work: 15 Marks (b) Implementing the work/ Conducting the experiment: 10 Marks (c) Performance, result and inference (usage of equipment's and troubleshooting): 25 Marks (d) Viva voce: 20 marks (e) Record: 5 Marks	All Experiments	2.5 hours	100%

14. Assessment – CO Mapping (Put' x' if mapping is present)

	Tools**	Weightage#	CO1	CO2	CO3	CO4
Direct Assessment Tools 80%	Continuous Evaluation Experiment wise CO mapping	25%	x	x	x	x
	Viva – Voce Experiment wise CO mapping	10%	x	x	x	x
	Internal Lab Exam	35%	x	x	x	x
	End Semester Exam	**50%**	x	x	x	x
Indirect Assessment Tool 20%	Course Exit Survey	100%	x	x	x	x

15. Assessment Configuration



Prepared By : Mr. Jaison Joseph (Subject Faculty)

Checked By : Ms. Nisha B Nair (Subject group coordinator)

Approved By : Dr. Ramadas T (HOD - ME)

Course Code & Name: MEQ413 Seminar

1. Prescribed Syllabus

General Guidelines

- The Department shall form an Internal Evaluation Committee (IEC) for the seminar with academic coordinator for that program as the Chairperson/Chairman and seminar coordinator & seminar guide as members. During the seminar presentation of a student, all members of IEC shall be present.
- Formation of IEC and guide allotment shall be completed within a week after the University examination (or last working day) of the previous semester.
- Guide shall provide required input to their students regarding the selection of topic/ paper.
- Choosing a seminar topic: The topic for a UG seminar should be current and broad based rather than a very specific research work. It's advisable to choose a topic for the Seminar to be closely linked to the final year project area. Every member of the project team could choose or be assigned Seminar topics that covers various aspects linked to the Project area.

2. Text Books (T)

Nil

3. Reference Books (R)

Nil

4. Course Objectives

- To do literature survey in a selected area of study.
- To understand an academic document from the literate and to give a presentation about it.
- To prepare a technical report.

5. Course Pre / Co-requisite

Nil

6. Course Outcomes

After successful completion of the course, the students will be able to:
CO1: Identify academic documents from the literature which are related to her/his areas of interest
CO2: Read and apprehend an academic document from the literature which is related to her/ his areas of interest.
CO3 Prepare a presentation about an academic

document.
CO4 Give a presentation about an academic document.
CO5 Prepare a technical report.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	**M**	**M**	**L**	**L**		**M**	**L**					**H**	**M**		
CO2	**H**	**H**	**H**	**H**		**M**	**L**					**H**	**M**		
CO3	**H**	**M**			**H**			**L**		**M**		**H**	**M**		
CO4	**H**				**M**			**L**		**H**		**H**	**M**		
CO5	**H**	**H**	**H**	**H**	**M**	**M**		**M**		**H**		**H**	**M**		

8. Justification for CO-PO-PSO Correlation

CO1	PO1	By identifying academic documents from the literature which are related to his areas of interest, they will understand the new advancement in the field which enable them to apply the knowledge for the solution of complex engineering problems
	PO2	By identifying academic documents from the literature which are related to his areas of interest, they will identify, review research literature and analyze complex engineering problems
	PO3	By identifying academic documents from the literature which are related to his areas of interest, they will understand the new advancement in the field which enable them to design solutions for complex engineering problems and design system components or processes that meet the specified needs
	PO4	By identifying academic documents from the literature which are related to his areas of interest, he will use research based knowledge and research methods to provide valid conclusions
	PO6	By identifying academic documents from the literature which are related to his areas of interest, they will understand the new advancement in the field which enable them to apply reasoning informed by contextual knowledge to assess societal health, safety and the consequent responsibilities relevant to the professional engineering practice
	PO7	By identifying academic documents from the literature which are related to his areas of interest, they will understand the new advancement in the field which are more focused on a sustainable development which will enable them to appreciate the need for sustainable development and its possibilities.
	PO12	By identifying academic documents from the literature which are related to his areas of interest, he will be able to recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological knowledge

CO2	**PSO1**	By identifying academic documents from the literature which are related to his areas of interest, he will be able to demonstrate the knowledge of concurrent technologies to solve the practical problems using the principles of sustainable development.
	PO1	By reading and apprehending an academic document from the literature which is related to her/ his areas of interest, he will understand the new advancement in the field which enable them to apply the knowledge for the solution of complex engineering problems
	PO2	By reading and apprehending an academic document from the literature which is related to her/ his areas of interest, he will identify, review research literature and analyze complex engineering problems
	PO3	By reading and apprehending an academic document from the literature which is related to her/ his areas of interest, he will understand the new advancement in the field which enable them to design solutions for complex engineering problems and design system components or processes that meet the specified needs
	PO4	By reading and apprehending an academic document from the literature which is related to her/ his areas of interest, he will use research based knowledge and research methods to provide valid conclusions
	PO6	By reading and apprehending an academic document from the literature which is related to her/ his areas of interest, he will understand the new advancement in the field which enable them to apply reasoning informed by contextual knowledge to assess societal health, safety and the consequent responsibilities relevant to the professional engineering practice
	PO7	By reading and apprehending an academic document from the literature which is related to her/ his areas of interest, he will understand the new advancement in the field which are more focused on a sustainable development which will enable him to appreciate the need for sustainable development and its possibilities.
	PO12	By reading and apprehending an academic document from the literature which is related to her/ his areas of interest, he will be able to recognize the need for, and have the preparation and ability to engage in independent and lifelong learning in the broadest context of technological knowledge
	PSO1	By reading and apprehending an academic document from the literature which is related to her/ his areas of interest, he will be able to demonstrate the knowledge of concurrent technologies to solve the practical problems using the principles of sustainable development.
	PO1	Preparing a presentation about an academic document which enables the students to apply engineering knowledge.
CO3	**PO2**	Preparing a presentation about an academic document that will help the students to identify, review, research and analyse the engineering problems.

	PO5	Preparing a presentation about an academic document by using a modern tool.
	PO8	Preparing a presentation about an academic document by applying ethical principles and norms of engineering practice.

	PO10	Preparing a presentation about an academic document which enables the student to communicate effectively with the community.
	PO12	Preparing a presentation about an academic document enables them to engage in independent and life-long learning.
	PSO1	By preparing a presentation about an academic document, he will be able to demonstrate the knowledge of concurrent technologies to solve the practical problems using the principles of sustainable development.
CO4	PO1	Giving a presentation about an academic document which enables the students to apply engineering knowledge.
	PO5	Giving a presentation about an academic document by using a modern tool.
	PO8	Giving a presentation about an academic document by applying ethical principles and norms of engineering practice.
	PO10	Giving a presentation about an academic document which enables the student to communicate effectively with the community.
	PO12	Giving a presentation about an academic document enables them to engage in independent and life-long learning.
	PSO1	By Giving a presentation about an academic document, he will be able to demonstrate the knowledge of concurrent technologies to solve the practical problems using the principles of sustainable development.
	PO1	Preparing a technical report which enables the students to apply engineering knowledge.
	PO2	Preparing a technical report that will help the students to identify, review, research and analyse the engineering problems.
	PO3	Preparing a technical report which enables them to design solutions for engineering problems.
	PO4	Preparing a technical report which helps the students to use their research based knowledge.
	PO5	Preparing a technical report by using a modern tool.

CO5	PO6	Preparing a technical report which helps to assess societal safety, legal and cultural issues relevant to engineering practice.
	PO8	Preparing a technical report by applying ethical principles and norms of engineering practice.
	PO10	Preparing a technical report which enables the student to communicate effectively with the community.
	PO12	Preparing a technical report enables them to engage in independent and life-long learning.
	PSO1	By preparing a technical report, he will be able to demonstrate the knowledge of concurrent technologies to solve the practical problems using the principles of sustainable development.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	Nil		

11. Internal Assessment mark allocation (as per university curriculum)

(Provide details as mentioned in syllabus)

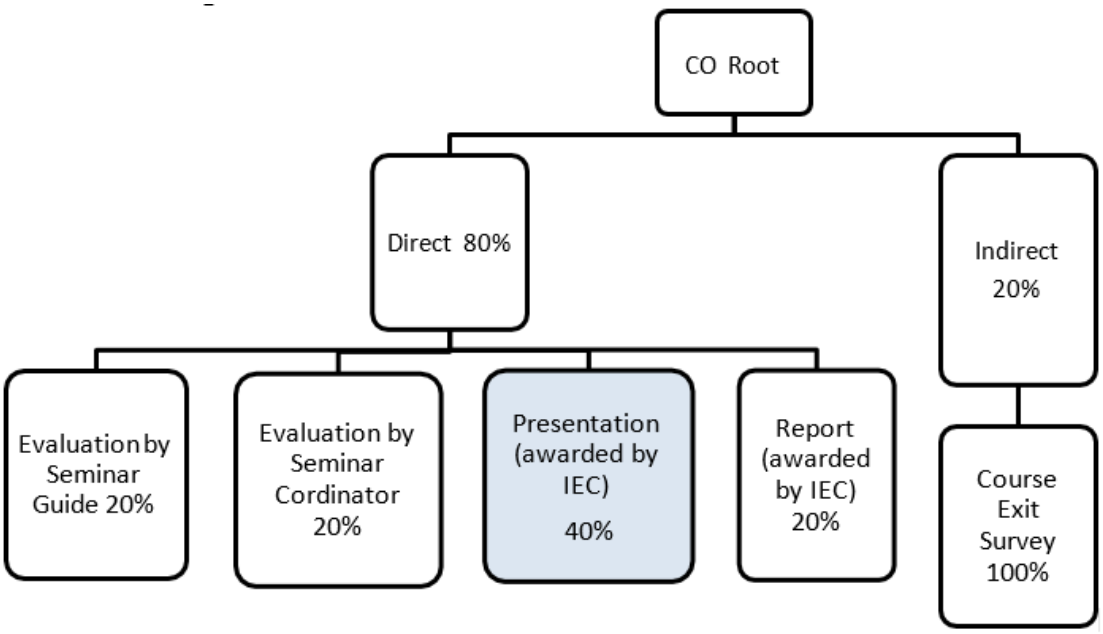
Seminar Guide : 20 marks
Seminar Coordinator : 20 marks
Presentation : 40 marks
Report : 20 marks
Total : 100 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		**Weightage#**	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
	Seminar Guide	Background Knowledge	10%	X	X	X	X	
		Relevance of the paper/topic selected	10%	X	X			

Direct Assessment Tools	Seminar Coordinator	Seminar Diary	10%	X	X			
		Attendance	10%					
	Presentation	Clarity of presentation	10%			X	X	
		Interactions	10%			X	X	
		Overall participation	10%			X	X	
		Quality of the slides	10%				X	
	Report		20%					X
Indirect Assessment Tool	Course Exit Survey		100%	X	X	X	X	X

13. Assessment Configuration



Prepared By : Binju Varghese P

Checked By :

Approved by : Dr. Ramadas T, HoD (ME)

Course Code & Name: MED 415 PROJECT PHASE 1

1. Prescribed Syllabus

Module	Topic	Hours
1	The course 'Project Work' is mainly intended to evoke the innovation and invention skills in a student. The course will provide an opportunity to synthesize and apply the knowledge and analytical skills learned, to be developed as a prototype or simulation. The project extends to 2 semesters and will be evaluated in the 7th and 8th semester separately, based on the achieved objectives. One third of the project credits shall be completed in 7th semester and two third in 8^{th} semester. It is recommended that the projects may be finalized in the thrust areas of the respective engineering stream or as interdisciplinary projects. Importance should be given to address societal problems and developing indigenous technologies. Phase 1 Target • Literature study/survey of published literature on the assigned topic • Formulation of objectives • Formulation of hypothesis/ design/ methodology • Formulation of work plan and task allocation. • Block level design documentation • Seeking project funds from various agencies • Preliminary Analysis/ Modeling/ Simulation/ Experiment/ Design/ Feasibility study • Preparation of Phase 1 report	

2. Text Books (T)

Not specified in syllabus.

3. Reference Books (R)

R1. Minimum 5 SCI Indexed journals
WEB SOURCE REFERENCES:
W1 http://www.sciencedirect.com
W2 https://www.springer.com/in
W3 https://www.asme.org/
W4 https://www.aiaa.org/

4. Course Objectives

- To apply engineering knowledge in practical problem solving.
- To foster innovation in design of products, processes or systems.
- To develop creative thinking in finding viable solutions to engineering problems

5. Course Pre / Co-requisite

NIL

6. Course Outcomes

Upon completion of the course the students will be able to

CO1 Model and solve real-world problems by applying knowledge across domains

CO2. Develop products, processes, or technologies for sustainable and socially relevant applications

CO3: Function effectively as an individual and as a leader in diverse teams and to comprehend and execute designated tasks

CO4: Plan and execute tasks utilizing available resources within timelines, following ethical and professional norms

CO5 Identify technology/research gaps and propose innovative/creative solutions

CO6: Organize and communicate technical and scientific findings effectively in written and oral forms

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO 3
CO1	**M**	**M**	**M**	**L**	**M**	**M**	**M**	**L**	**L**	**L**	**L**	**M**	**H**		
CO2	**M**	**M**	**M**		**L**	**H**	**M**	**L**	**L**		**L**	**L**	**H**		
CO3									**H**	**M**	**M**	**L**		**M**	
CO4					**M**			**H**	**M**	**M**	**H**	**M**	**H**		
CO5	**M**	**H**	**H**	**L**	**M**							**L**			**H**
CO6					**M**			**M**	**M**	**H**	**L**	**L**		**M**	

8. Justification for CO-PO-PSO Correlation

CO	PO	Justification
	PO1	Moderately mapped as the students will be able to use the fundamental knowledge of mathematics, science and engineering to solve the problems related to project work and present it before an audience
	PO2	Moderately mapped as the students will be able to Identify, formulate and research literature to analyze a current topic of professional interest and conduct a detailed study on the evolution of it and suggest alternatives or fresh designs.

CO1	PO3	Moderately mapped as the students will be able to design projects aiming social responsibilities, minimized health impacts and meeting customer requirements.
	PO4	Slightly mapped as Students will be able to conduct experiments, interpret and analyse data, synthesize the information to analyse a current topic of professional interest
	PO5	Moderately mapped as the students will be able to use the modern tool for project to Create, select, and apply relevant approaches, resources, and current engineering and IT tools, such as modelling and prediction, to complicated engineering tasks while understanding their constraints
	PO6	Moderately mapped as the students able to assess societal, health, safety, legal, and cultural issues and the resulting obligations pertinent to the professional practise of engineering project by using reasoning informed by contextual knowledge.
	PO7	Moderately mapped as the students able to demonstrate understanding of, and the need for, sustainable development, and to comprehend the impact of l engineering project solutions in societal and environmental contexts.
	PO8	Slightly mapped as Students able to apply ethical concepts and commit to professional ethics, duties, and engineering practise norms.
	PO9	Slightly mapped as Students can able to work well both independently and as a team member or leader in a variety of project contexts
	PO10	Slightly mapped as Students able to communicate well with other engineers and with the rest of society about complex engineering projects. For example, they should be able to understand and write good reports and design documentation, and can give good presentations.
	PO11	Slightly mapped as Students able to apply knowledge and understanding of engineering and management principle as a team member and leader, to manage projects
	PO12	Moderately mapped as the students able to understand the importance of project, and be prepared for, autonomous, lifelong learning in the fullest sense of technological development.
	PSO1	Knowledge on fundamental principles of engineering will enable students to model and analyse real life civil engineering problems
	PO1	Moderately mapped as the students able to apply the knowledge of mathematics, science and engineering to Develop products, processes or technologies for sustainable and socially relevant projects
	PO2	Moderately mapped as the students will be able to develop design methodologies for the project to be developed
	PO3	Moderately mapped as the students will be able to detailed design for each component in the project system.
	PO5	Slightly mapped as the students will be able to find the relevant tools to implement the problem stated
	PO6	Strongly mapped as the students will be able to find solution for some societal needs.
	PO7	Strongly mapped as the students will be able to finds solutions for environmental safety.

CO2	PO8	Slightly mapped as the students will be able to apply ethical principles and commit to professional ethics
	PO9	Slightly mapped as the students will be able to work as a team and present their work carried out
	PO11	Slightly mapped as the students will be able to manage the various phases of project development
	PO12	Slightly mapped as the students will be able to apply the communication and interpersonal skills acquired in their professional career
	PSO1	Knowledge on fundamental principles of engineering will enable students to develop sustainable products/technology with socially relevant applications.
CO3	PO9	Strongly mapped as the students will be able to work as a team and present their work carried out.
	PO9	Moderately mapped as the students will be able to present their work carried out.
	PO11	Moderately mapped as the students will be able to manage the various phases of project development with financial constraints
	PO12	slightly mapped as the students will be able to apply the communication and interpersonal skills acquired in their professional career.
	PS02	Students will be able to interact effectively with engineers from other disciplines regarding sustainable solutions for the benefit of society.
CO4	PO5	Moderately mapped as the students able to Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools with in the timeline, adhering to ethical and professional standards.
	PO8	Highly mapped as the students able to apply the ethical concepts and adhere to the engineering profession's professional ethics, obligations, and standards
	PO9	Moderately mapped as the students able to Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools to complex engineering activities with an understanding of the limitations of its function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
	PO10	Moderately mapped the students able to Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools for effective communication on complex engineering activities with the engineering community and write effective reports and design documentation, make effective presentations, and give and receive clear instructions
	PO11	Highly mapped the students able to Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools to demonstrate the knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

	PO12	Moderately mapped the students to able to create, select, and employ relevant approaches, resources, and current engineering and IT technologies in order to engage in independent and lifelong learning in the broadest context of technological change.
	PS01	Knowledge of engineering fundamentals helps the students to plan and execute task within the time using professional norms
CO5	PO1	Moderately mapped as the students able Apply the knowledge of mathematics, science, engineering fundamentals to Identify technology/research gaps and propose innovative/creative solutions
	PO2	Highly mapped the students able to Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools to identify the research gap and propose creative solutions
	PO3	Highly mapped as the students able to Design solutions for complex engineering problems and design system components that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations and propose innovative solution
	PO4	Slightly mapped the students able use research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions for the research problem
	PO5	Moderately mapped as the students able to Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools to identify the research gap and propose creative solutions
	PO12	Slightly mapped as students should be able to find research gaps and come up with creative solutions. They should also be able to learn on their own and continue to do so as technology changes.
	PS03	By applying modern engineering tools enable the students to create innovative solutions for complex problems
CO6	PO5	Moderately mapped the students capable to apply appropriate techniques, resources, and current engineering and IT tools to organise and communicate effectively in writing and orally technical and scientific findings.
	PO8	Moderately mapped as the students will be able to apply ethical principles and agree to professional ethics, responsibilities, and norms of engineering practise. This will allow them to effectively organise and communicate technical and scientific findings in written and spoken forms.
	PO9	Moderately mapped students are able to perform effectively as individuals, as members or leaders of varied teams, and in multidisciplinary contexts.
	PO10	Strongly mapped the students able to Communicate effectively on complex engineering activities with the engineering community and with society in general. This includes being able to comprehend and write effective reports and design documentation, making effective presentations, and giving and receiving clear instructions for organising and communicating technical and scientific findings effectively in written and oral forms.
	PO11	Slightly mapped the students will be able to organise and talk about technical and scientific findings in a clear way, both in writing and in person. They will also be able to show that they know and understand engineering and management principles in order to run projects and work in multidisciplinary settings.

	PO12	Slightly mapped Students will be able to organise and talk about technical and scientific findings in a clear way, both in writing and in person. They will also be able to learn on their own and for the rest of their lives in the broadest context of technological change.
	PS02	Enable the students to interact with engineers from other disciplines to organise technical findings effectively.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	NIL		

11. Internal Assessment mark allocation (as per university curriculum)

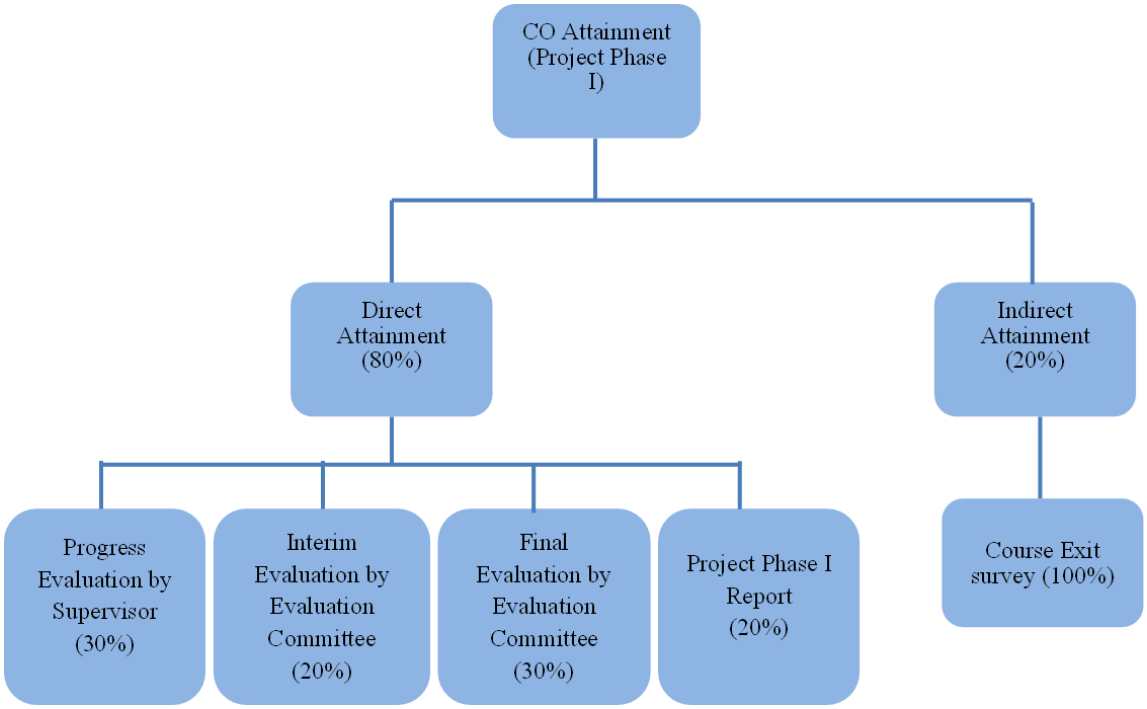
(Provide details as mentioned in syllabus)

Total: 100 marks (Minimum required to pass: 50 marks).
Project progress evaluation by guide: 30 Marks.
Interim evaluation by the Evaluation Committee: 20 Marks.
Final Evaluation by the Evaluation Committee: 30 Marks.
Project Phase - I Report (By Evaluation Committee): 20Marks.

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

Assessment	Tools**	Weightage#	CO1	CO2	CO3	CO4	CO5	CO6
Direct Assessment	**Progress Evaluation**	**30%**	**x**	**x**	**x**	**x**	**x**	**x**
	Interim Evaluation	**20%**	**x**	**x**	**x**	**x**	**x**	**x**
	Final Evaluation	**30%**	**x**	**x**	**x**	**x**	**x**	**x**
	Report	**20%**						**x**
Indirect Assessment Tool	**Course Exit Survey**	**100%**	**x**	**x**	**x**	**x**	**x**	**x**

13. Assessment Configuration



Prepared By : Arun V
Checked By : Dr. Ramadas T
Approved By : Dr. Ramadas T

Semester: 8

Curriculum

SLOT	COURSE NO.	COURSES	L-T-P	HOURS	CREDIT
A	MET402	MECHATRONICS	2-1-0	3	3
B	MET414	QUALITY MANAGEMENT	2-1-0	3	3
	MET464	MICRO AND NANO MANUFACTURING	2-1-0	3	3
C	MET 466	TECHNOLOGY MANAGEMENT	2-1-0	3	3
D	MET 458	ADVANCED ENERGY ENGINEERING	2-1-0	3	3
E	MET404	COMPREHENSIVE VIVA VOCE	1-0-0	1	1
U	MED416	PROJECT PHASE II	0-0-12	12	4
R/M/H	VAC	Remedial/Minor/Honours course	3-1-0	4*	4
TOTAL				25/28	17/21

Course Code & Name: MET 402 MECHATRONICS

1. Prescribed Syllabus

Module	Topic	Hours
1	Introduction to Mechatronics: Structure of Mechatronics system. Sensors - Characteristics - Temperature, flow, pressure sensors. Displacement, position and proximity sensing by magnetic, optical, ultrasonic, inductive, capacitive and eddy current methods. Encoders: incremental and absolute, gray coded encoder. Resolvers and synchros. Piezoelectric sensors. Acoustic Emission sensors. Principle and types of vibration sensors. Actuators: Mechanical actuators, Electrical actuators, Hydraulic and Pneumatic actuators.	**7**
2	Directional control valves, pressure control valves, process control valves. Rotary actuators. Development of simple hydraulic and pneumatic circuits using standard Symbols. Micro Electro Mechanical Systems (MEMS): Fabrication: Deposition, Lithography, Micromachining methods for MEMS, Deep Reactive Ion Etching (DRIE) and LIGA processes. Principle, fabrication and working of MEMS based pressure sensor, accelerometer and gyroscope.	**9**
3	Mechatronics in Computer Numerical Control (CNC) machines: Design of modern CNC machines - Mechatronics elements - Machine structure: guide ways, drives. Bearings: antifriction bearings, hydrostatic bearing and hydrodynamic bearing. Re-circulating ball screws, pre-loading methods. Re-circulating roller screws. Measuring system for NC machines - direct and indirect measuring system. System modelling - Mathematical models and basic building blocks of general mechanical, electrical, fluid and thermal systems	**6**
4	Typical elements of open and closed loop control systems. Adaptive controllers for machine tools. Programmable Logic Controllers (PLC) –Basic structure, input/ output processing. Programming: Timers, Internal Relays, Counters and Shift registers. Development of simple ladder programs for specific purposes. Case studies of Mechatronics systems: Automatic camera, bar code reader, pick and place robot, automatic car park barrier system, automobile engine management system.	**6**
5	Mechatronics in Robotics-Electrical drives: DC, AC, brushless, servo and stepper motors. Harmonic drive. Force and tactile sensors. Range finders: ultrasonic and light-based range finders Robotic vision system - Image acquisition: Vidicon, charge coupled device (CCD) and charge injection device (CID) cameras. Image processing techniques: histogram processing: sliding, stretching, equalization and thresholding.	**8**

2. Text Books (T)

T1. Bolton W., Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering, Person Education Limited, New Delhi, 2007
T2. Ramachandran K. P., G. K. Vijayaraghavan, M. S. Balasundaram, Mechatronics: Integrated Mechanical Electronic Systems, Wiley India Pvt. Ltd., New Delhi, 2008.
T3. Saeed B. Niku, Introduction to Robotics: Analysis, Systems, Applications, Person Education, Inc., New Delhi, 2006.

3. Reference Books (R)

R1. David G. Aldatore, Michael B. Histand, Introduction to Mechatronics and Measurement Systems,
McGraw-Hill Inc., USA, 2003.
R2. Gordon M. Mair, Industrial Robotics, Prentice Hall International, UK, 1998.
R3. HMT, Mechatronics, Tata McGraw-Hill Publishing Company Ltd., New Delhi, 2004.
R4. Vijay K. Varadan, K. J. Vinoy, S. Gopalakrishnan, Smart Material Systems and MEMS: Design and Development Methodologies, John Wiley & Sons Ltd., England, 2006.

4. Course Objectives

This course help students to understand the mechanical systems used in Mechatronics and the Integration of mechanical, electronics, control and computer engineering in the design of mechatronics systems.

5. Course Pre / Co-requisite

NIL

6. Course Outcomes

CO1 Explain the sensors and actuators used in mechatronics.
CO 2 Design hydraulic and pneumatic circuits for automation.
CO 3 Explain the manufacturing processes used in MEMS.
CO 4 Demonstrate the various components of a CNC machine.
CO 5 Create a PLC program.
CO 6 Explain the robotic sensors and vision system.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO 1	H	M	M										H		H
CO 2	H	H	H		H								H		H

CO 3	**H**	**L**	**L**										**H**		**H**
CO 4	**H**	**L**	**L**										**H**		**H**
CO 5	**H**	**H**	**H**		**H**								**H**		**H**
CO 6	**H**	**L**	**L**										**H**		**H**

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	**PO1**	Knowledge of sensors and actuators used in mechatronics can be used to solve engineering problems. High corelation is due to the fact that it uses principles of science and engineering fundamentals.
	PO2	Students can identify, formulate and analyze complex engineering problem using basic knowledge of sensors and actuators. Hence Medium correlation can be obtained.
	PO3	Design solutions for complex engineering problems can be obtained from the basic knowledge of sensors and actuators. Hence Medium correlation is obtained.
	PSO1	Knowledge of sensors and actuators can be used to solve practical problems using the principles of sustainable development. Hence high correlation is obtained.
	PSO3	Concepts of sensors and actuator could be used to design and analyse different systems. Hence high correlation could be obtained.
CO2	**PO1**	Students will be able to understand and design hydraulic and pneumatic circuits for automation. High corelation is due to the fact that it uses principles of science and engineering fundamentals for the solution of complex engineering problems.
	PO2	By analysing hydraulic and pneumatic circuits for automation, complex engineering problems of industries could be solved. High corelation is due to the fact that it uses principles of science and engineering fundamentals.
	PO3	By designing hydraulic and pneumatic circuits, design solution for complex engineering problems could be obtained. Hence high corelation is obtained.
	PO5	Designing of hydraulic and pneumatic circuits uses modern engineering and IT tools. Hence high corelation could be obtained.
	PSO1	Designing of hydraulic and pneumatic circuits demonstrate the knowledge of concurrent technologies to solve practical problems. Hence high corelation could be obtained.
		Principles of mathematics, science and engineering could be used

	PSO3	to design and analyse hydraulic and pneumatic circuits. Hence high correlation could be obtained.
CO3	**PO1**	Knowledge of MEMS can be used to solve engineering problems. High corelation is due to the fact that it uses principles of science and engineering fundamentals. .
	PO2	Understanding of manufacturing processes used in MEMS could be used to analyse complex engineering problems. Low correlation is due to the fact it uses basic principles of engineering to identify and analyse complex problems
	PO3	Manufacturing principles of MEMS will be used to provide design solution for complex engineering problems. Low corelation is due to the fact that it uses basic principles to meet the specified needs.
	PSO1	Understanding of manufacturing principles of MEMS demonstrate the knowledge of concurrent technologies. High corelation is due to the fact that this could be used to solve practical problems.
	PSO3	Principles of mathematics, science and engineering could be used in manufacturing of MEMS. High correlation is due to the fact it can be used to analyze multi- disciplinary system.
CO4	**PO1**	Knowledge of various components of a CNC machine can bring solution to engineering problems. High correlation is due to the fact that it uses knowledge of engineering fundamentals.
	PO2	Understanding of CNC components can be used to analyse complex engineering problems. Low correlation is due to the fact it uses basic principles of engineering to identify and analyse complex problems.
	PO3	Understanding of CNC components will be used to provide design solution for complex engineering problems. Low corelation is due to the fact that it uses basic principles to meet the specified needs.
	PSO1	Knowledge of concurrent technologies can be used to demonstarate various components of a CNC machine. High corelation is due to the fact that this could be used to solve practical problems
	PSO3	Principles of mathematics, science and engineering could be used to understand various components of CNC machine. High correlation is due to the fact it can be used to analyze multi-disciplinary system
CO5	**PO1**	Students will be able to create a PLC program. High corelation is due to the fact that it uses principles of science and engineering fundamentals for the solution of complex engineering problems.
	PO2	By understanding and analysing PLC program, complex engineering problems of industries could be solved. High corelation is due to the fact that it uses principles of science and engineering fundamentals.
		Students will be able to create PLC program which will be used to

	PO3	provide design solution for complex engineering problems. High corelation is due to the fact that it uses principles to meet the specified needs.
	PO5	Designing of PLC program uses modern engineering and IT tools. Hence high corelation could be obtained.
	PSO1	Making of PLC program demonstrate the knowledge of concurrent technologies. High corelation is due to the fact that this could be used to solve practical problems.
	PSO3	Principles of mathematics, science and engineering could be used to understand PLC program. High correlation is due to the fact it can be used to analyze multi- disciplinary system
CO6	**PO1**	Knowledge of robotic sensor and vision system could be used to bring solution to engineering problems. High correlation is due to the fact that it uses knowledge of engineering fundamentals.
	PO2	By understanding and analysing robotic sensors and vision system, complex engineering problems of industries could be solved. Low corelation is due to the fact that it uses basic principles of science and engineering fundamentals.
	PO3	Understanding of robotic sensors and vision system will be used to provide design solution for complex engineering problems. Low corelation is due to the fact that it uses basic principles to meet the specified needs.
	PSO1	Knowledge of robotic sensors and vision system demonstrate the knowledge of concurrent technologies. High corelation is due to the fact that this could be used to solve practical problems.
	PSO3	Principles of mathematics, science and engineering could be used to understand robotic sensors and vision system. High correlation is due to the fact it can be used to analyze multi- disciplinary system.

9. Curricular gaps (if any)

NIL

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	PLC Programmi ng	Expert Session	PO1,PO2,PO3,PSO1,POS 3

11. Internal Assessment mark allocation (as per university curriculum)

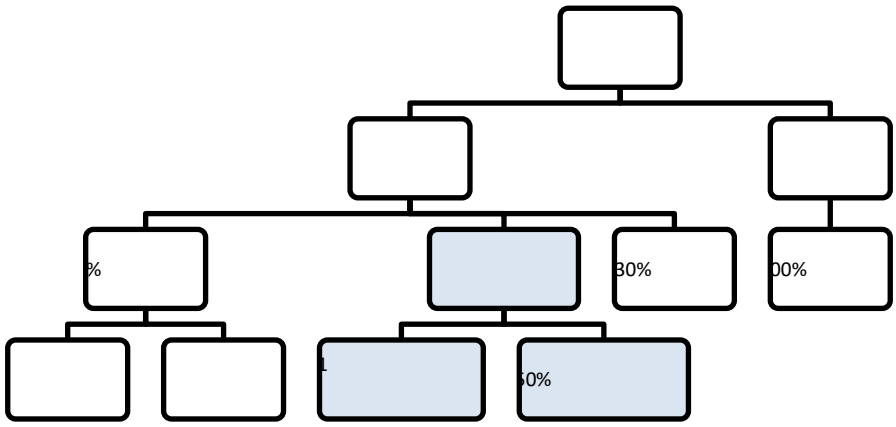
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		**Weightage#**	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**
Direct Assessment Tools**	Internal Exam(s) 40%	Series 1	20%	x	x		x		
		Series 2	20%		x	x	x	x	x
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x					
		Assignment 2	15%		x	x	x	x	x
	University Exam		30%	x	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x	x

13. **Assessment Configuration**



14. Course Plan

Hour	**Topic**	**Module**	**Reference(s)**	**Teaching Pedagogy**

1	Introduction	1	T1,R1	Lectur e
2	Sensors - Characteristics	1	T1,R1	Lecture
3	Temperature,	1	T1,R1	Lecture
4	Pressure	1	T1,R1	Tutorial
5	Pressure	1	T1,R1	Remedial
6	Displacement,	1	T1,R1	Lecture
7	Displacement,	1	T1,R1	Lecture
8	Displacement sensor,	1	T1,R1	Lecture
9	Encoders: incremental and absolute, gray coded encoder.	1	T1,R1	Lecture
10	Resolvers and synchros. Piezoelectric sensors. Acoustic Emission sensors.	1	T1,R1	Lecture
11	Principle and types of vibration sensors.	1	T1,R1	Tutorial
12	Principle and types of vibration sensors.	1	T1,R1	Remedial
13	Actuators: Mechanical actuators, Electrical actuators, Hydraulic and Pneumatic actuators	1	T1,R1	Lecture
14	Actuators: Mechanical actuators, Electrical actuators, Hydraulic and Pneumatic actuators	1	T1,R1	Lecture
15	Typical elements of open and closed loop control systems. Adaptive controllers for machine tools.	4	T1,R1	Lecture
	Programmable Logic Controllers (PLC) Ã¢Â€Â“Basic structure, input/ output processing. Programming: Timers, Internal Relays, Counters and Shift registers.	4		

16			T1,R1	Tutorial
17	Programmable Logic Controllers (PLC) Ã¢Â€Â“Basic structure, input/ output processing. Programming: Timers, Internal Relays, Counters and Shift registers.	4	T1,R1	Remedial
18	Development of simple ladder programs	4	T1,R1	Lecture
19	Development of simple ladder programs	4	T1,R1	Lecture
20	Development of simple ladder programs	4	T1,R1	Lecture
21	Development of simple ladder programs	4	T1,R1	Tutorial
22	Automatic camera,	4	T1,R1	Remedial
23	bar code reader,	4	T1,R1	Lecture
24	pick and place robot, automatic car park barrier system,	4	T1,R1	Lecture
25	automatic car park barrier system, automobile engine management system.	4	T1,R1	Lecture
17	Programmable Logic Controllers (PLC) Ã¢Â€Â“Basic structure, input/ output processing. Programming: Timers, Internal Relays, Counters and Shift registers.	4	T1,R1	Remedial
18	Development of simple ladder programs	4	T1,R1	Lecture
19	Development of simple ladder programs	4	T1,R1	Lecture
20	Development of simple ladder programs	4	T1,R1	Lecture
29	Mathematical Modelling of hydraulic system	4	T1,R1	Lecture
30	Mathematical Modelling of pneumatic and thermal system	4	T1,R1	Lecture
31	Mechatronics in Computer Numerical Control (CNC) machines: Design of modern CNC machines - Mechatronics elements	4	T1,R1	Lectur e

32	Machine structure: guide ways, drives. Bearings: anti- friction bearings, hydrostatic bearing and hydrodynamic bearing.	4	T1,R1	Lectur e
34	Re-circulating ball screws, pre- loading methods.	3	T1,R1	Remed ial
35	Re-circulating roller screws. Measuring system for NC machines - direct and indirect measuring system.	3	T1,R1	Lectur e
36	Re-circulating roller screws. Measuring system for NC machines - direct and indirect measuring system.	3	T1,R1	Tutori al
37	Directional control valves,	2	T1,R1	Lectur e
38	Directional control valves,	2	T1,R1	Remed ial
39	Pressure control valves,	2	T1,R1	Lectur e
39	Pressure control valves,	2	T1,R1	Lectur e
40	Process control valves.	2	T1,R1	Tutori al
41	Development of simple hydraulic and pneumatic circuits using standard Symbols.	2	T1,R1	Lectur e
42	Micro Electro Mechanical Systems (MEMS): Fabrication: Deposition,	2	T1,R1	Lectur e
43	Development of simple hydraulic and pneumatic circuits using standard Symbols.	2	T1,R1	Remed ial
44	Development of simple hydraulic and pneumatic circuits using standard Symbols.	2	T1,R1	Lectur e
45	Micro Electro Mechanical Systems (MEMS): Fabrication: Deposition,	2	T1,R1	Tutori al

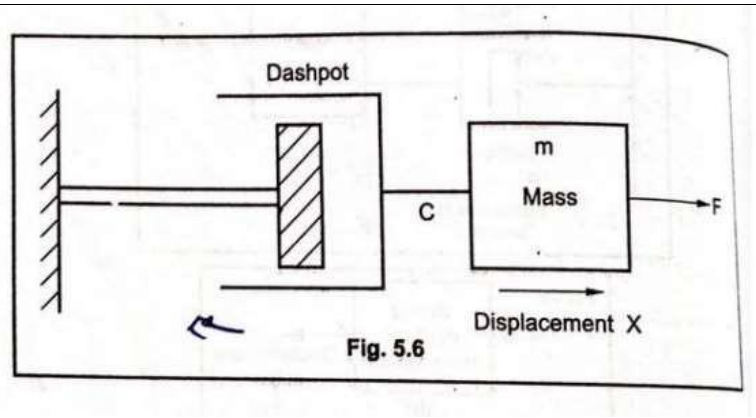
46	Micro Electro Mechanical Systems (MEMS): Fabrication: Deposition,	2	T1,R1	Lectur e
47	Lithography, Micromachining methods for MEMS,	2	T1,R1	Lectur e
48	Lithography, Micromachining methods for MEMS,	2	T1,R1	Lectur e
49	Micromachining methods for MEMS, Deep Reactive Ion Etching (DRIE)	2	T1,R1	Lectur e
50	Range finders: ultrasonic and light- based range finders	5	T1,R1	Lectur e
51	brushless, servo and stepper motors.	5	T1,R1	Tutori al
52	Mechatronics in Robotics-Electrical drives: DC, AC,	5	T1,R1	Lectur e
52	Harmonic drive. Force and tactile sensors.	5	T1,R1	Lectur e
53	Robotic vision system - Image acquisition:	5	T1,R1	Lectur e
54	Image processing techniques: histogram processing: sliding, stretching, equalization and thresholding.	5	T1,R1	Lectur e
55	Vidicon, charge coupled device (CCD) and chargeinjection device (CID) cameras.	5	T1,R1	Lectur e
56	Range finders: ultrasonic and light- based range finders	5	T1,R1	Lectur e

15. Question Bank

Module 1				
Sl. No	**Question**	**Marks**	**CO**	**BL**
1	List the importance of mechatronics	3	CO1	L1
2	Define mechatronics	3	CO1	L1
3	Describe the terms hysteresis error and non-linearity error.	3	CO1	L1
3	Suggest any three applications of Hall effect sensor in mechatronic systems.	3	CO1	L1
4	Differentiate between absolute and incremental encoders	3	CO1	L1
5	Draw the structure of mechatronics system.	3	CO1	L1
6	Define sensors. List types of sensors	3	CO1	L1
7	Explain the term sensitivity of a measuring instrument	3	CO1	L1
8	Define system. Give an example of system.	3	CO1	L1
9	List any six applications of mechatronics.	3	CO1	L1
10	List any two merits and demerits of potentiometer.	3	CO1	L1
11	Differentiate between RTD and thermocouple.	3	CO1	L1
12.	Define actuators. List types of actuators.	3	CO1	L1
13	List any two merits and demerits of electrical actuators.	3	CO1	L1
14	List any two merits and demerits of pneumatic actuators.	3	CO1	L1
15	List any two merits and demerits of hydraulic actuators	3	CO1	L1
16	Explain principle of vibration sensor.	9	CO1	L2
17	List and explain in detail the static and dynamic characteristics of a sensor.	9	CO1	L2
18	With a neat sketch explain bimetallic strip sensors	9	CO1	L2
19	With a neat sketch explain thermocouple sensors	9	CO1	L2
20	Explain the working of RTD sensor	9	CO1	L2
21	Explain the working of any one type each of flow and pressure sensors.	9	CO1	L2
22	With a neat diagram, explain flow sensor	9	C	L2

			O1	
23	With a neat sketch explain principle & working of potentiometer.	9	C O1	L2
24	With a neat sketch explain LVDT sensor.	9	C O1	L2
25	Explain the working of eddy current and capacitance type proximity sensors	9	C O1	L2
26	With neat sketches explain the working of i) resolver ii) Synchros	9	C O1	L2
27	Differentiate between hydraulic and electric actuator.	9	C O1	L2
28	With a neat sketch explain capacitive sensors.	9	C O1	L2
29	With a neat sketch explain strain gauge sensors.	9	C O1	L2
30	Explain any one type of vibration sensor with a neat figure.	9	C O1	L2
31	With a neat sketch explain working of encoders.	9	C O1	L2
32	With a neat sketch explain hall effect sensor	9	C O1	L2
Module 2				
1	List types of control valve used in hydraulic system.	3	C O2	
2	Define direction control valve. List types of direction control valve.	3	C O2	L1
3	Explain with a neat sketch working of a poppet valve	3	C O2	L1
4	What is a 4/3 Direction control valve? When is it used in place of 4/2 way valves	3	C O2	L1
5	Describe how pressure relief valve limit the maximum pressure.	3	C O2	L1
6	List types of pressure relief valve. What are the functions of pressure relief valve.	3	C O2	L1
7	List different methods to fabricate MEMS.	3	C O3	L1
8	Define Lithography	3	C O3	L1
9	List any two advantages and disadvantages of Deep Reactive Ion Etching.	3	C O3	L1
10	List any six applications of Micro Electro Mechanical Systems.	3	C O3	L1
11	With a neat figure explain any two types of direction control valve.	9	C O3	L2
12	With a neat sketch explain any two types of pressure control valve.	9	C O3	L2

13	Explain types of deposition process used in Micro Electro Mechanical System	9	C O3	L2
14	Summarize Deep Reactive Ion Etching.	9	C O3	L2
15	Summarize accelerometer	9	C O3	L2
16	Explain lithography	9	C O3	L2
17	With a neat sketch explain any two types of process control valve	9	C O3	L2
18	Explain LIGA process.	9	C O3	L2
19	Explain principle, fabrication and working of MEMS based Gyroscope.	9	C O3	L2
20	Develop a hydraulic circuit for the sequencing operation A+B+A-B-?	9	C O3	L2
	Module 3			
1.	List any six factors to be considered while designing guideways.	3	C O4	L1
2.	Recall any six advantages of recirculating ball screw.	3	C O4	L1
3.	Explain Recirculating ball screw	3	C O4	L1
4.	Recall different types of loads acting on the structure of CNC machine	3	C O4	L1
5.	Draw figure for stick slip phenomenon.	3	C O4	L1
6.	List functions of guideways or slideways	3	C O4	L1
7.	List merits of hydrostatic bearing.	3	C O4	L1
8.	List merits of hydrodynamic bearing.	3	C O4	L1
9.	Explain Preloading.	3	C O4	L1
10.	Sketch close loop control system.	3	C O4	L1
11.	With a neat sketch explain stick slip phenomenon.	9	C O4	L2
12.	With a neat sketch explain different types of recirculating ball screw.	9	C O4	L2
8.	List merits of hydrodynamic bearing.	3	C O4	L1
13.	Derive mathematical expression for building blocks of translation system with figure.	9	C O4	L2
	Derive mathematical equation for following system.	9	C O4	L2

14.	 Fig. 5.6			
	Module 4			
1	Summarize Lean Manufacturing. List the principles of Lean Manufacturing. Explain any two principles of lean manufacturing.	CO4	L2	3
2	Give the advantages of lean manufacturing.	CO4	L1	3
3.	What are the different tools of lean manufacturing? Explain any four lean manufacturing tools.	CO4	L1	3
4.	Explain Agile Manufacturing	CO4	L1	3
5.	Compare the difference between lean and agile manufacturing.	CO4	L2	3
6.	List and explain different types of waste.	CO4	L1	3
7.	Explain 5 S System.	CO4	L2	7
8.	Explain characteristics of agile manufacturing.	CO4	L2	7
9.	List all the advantages of agile manufacturing?	CO4	L1	7
10.	Compare conventional manufacturing and lean manufacturing.	CO4	L2	7
11.	Explain need of agile manufacturing in business.	CO4	L2	7
12.	Explain conceptual framework of agile manufacturing.	CO4	L2	7
13.	Discuss all principles of lean manufatcuring	CO4	L2	7
14.	Describe all types of waste considerd in lean manufacturing.	CO4	L2	7
15.	Discuss methods to eliminate waste in lean manufacturing	CO4	L2	7
Module V				
1	Explain the concept of enterprise with reference to ERP system.	CO5	L2	7
2	Describe any three success for implementing ERP system.	CO5	L2	7

3	Describe the key processes of "Customer Relationship Management.	CO5	L2	7
4	Explain ERP technology.	CO5	L2	7
5	Discuss common myths related to ERP system.	CO5	L2	7
6	Explain Business Process Re-engineering. List different failure factors of BPR and also list different phases of BPR.	CO5	L2	7
7	Explain Business Intelligence. List the benefits of Business Intelligence.	CO5	L2	7
8	Explain Data Mining.	CO5	L2	7
9	Explain E business and E commerce.	CO5	L2	7
10	Explain different phases of Business Process Reengineering	CO5	L2	7
11.	Define online analytical processing.	CO5	L2	7
12.	Describe any three failure factors for implementing ERP system.	CO5	L2	7
13.	Compare E commerece and E business	CO5	L2	7
14.	Discuss product cyle management.	CO5	L2	7
15	Describe datawarehousing with figure	CO5	L2	7

Prepared By : Nisha B Nair

Checked By : Dr. Monoj Jose Kalathil

Approved by : Dr. Ramadas T, HoD (ME)

Course Code & Name: MET414 QUALITY MANAGEMENT

1. Prescribed Syllabus

Module	Topic	Hours
1	Introduction to Quality Engineering - Definitions of the terms - quality, quality planning, quality control, quality assurance, quality management, Total Quality Management (TQM)-overview on TQM - the TQM axioms - consequences of total quality- Barriers to TQM Deming approach to TQM – Juran's quality trilogy- Crosby's fourteen steps for quality improvement.	7
2	Strategic Quality Management: Cost of Quality- Customer satisfaction- Quality Function Deployment (QFD)- Integrating quality into strategic management - obstacles to achieving successful strategic quality management- Concepts of 5S, Six Sigma, Kaizen	8
3	Human dimensions of TQM – Top management commitment- Leadership for TQM- Change management- resources for quality activities - training for quality –Employee involvement, motivation empowerment- teamwork- self managing teams - role of the quality director	7
4	Supporting Tools, Activities and Techniques in TQM Projects: Affinity diagram -brainstorming - cause and effect analysis - process flow chart – check sheets- Scatter diagram - Pareto chart- Histogram and fundamentals of statistics - Control charts for improving process capability- Taguchi's robust design- Total Productive maintenance- Failure Mode and Effect Analysis	9
5	Quality System: ISO 9000 family of standards- ISO 9001:2000 model, quality management system- management responsibility- resource management- product realization- measurement analysis and improvements- ISO 14000 family of standards- Quality auditing- types and benefits	5

2. Text Books (T)

1 Besterfield Dale H. , Besterfield Carol, Besterfield Glen H., Besterfield Mary, Urdhwareshe Hemant, Urdhwareshe Rashmi, "Total Quality Management (TQM) 5e", Pearson Education, 2018.
2. Subburaj Ramasamy, "Total Quality Management", McGraw Hill Education, 2017.
3. Dr. K.C. Arora, "Total Quality Management", S K Kataria and Sons, 2013.
4. Suganthi, L and Anand A Samuel, "Total Quality Management", Prentice Hall India Learning Private Limited, 2009

3. Reference Books (R)

1 Logothetics N, "Managing for Total Quality - From Deming to Taguchi and SPC", Prentice Hall Ltd., New Delhi, 1997.
2. Deming W E, “Out of the Crisis," MIT Press, Cambridge, MA, 1982.
3. Juran J M and Juran on “Leadership for Quality" An Executive Handbook, The Free Press, New York, 1989.
4. Salor J H, "TQM-FIeld Manual," McGraw Hill, New York, 1992.
5. Crosby P B, "Quality is Free" McGraw Hill, New York, 1979.

4. Course Objectives

This course is designed to facilitate the students to understand the concept and culture of total quality management. It empowers the students by inculcating the skills to use quality control techniques and other quality tools in solving quality-related problems and apply these principles in an industry. This course will also amalgamate their knowledge about the importance of customer satisfaction through desired quality at a competitive price.

5. Course Pre / Co-requisite

NIL

6. Course Outcomes

CO1: To be conversant with important terms for quality management in organisations
CO2: Have a complete theoretical and practical understanding of the contributions of Quality Gurus
CO3: Demonstrate knowledge of the underlying principles of strategic quality management
CO4: Identify various human dimensions of TQM
CO5: Implement different tools and techniques in TQM
CO6 : Identify core and extended modules of ISO 9000 family of standards

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO 1	H					M					H	H			H
CO 2	M										M	M			M
CO 3	M	M	M						H		H	H		M	
CO 4	H					H			H		H	H		M	

CO 5	**M**	**H**	**H**	**M**	**M**				**M**		**H**	**M**		**M**	
CO 6					**M**	**M**	**L**	**L**	**M**	**H**	**H**	**L**		**M**	

8. Justification for CO-PO-PSO Correlation

CO1	**PO1**	Highly mapped as the students will be able to use the fundamental knowledge of quality engineering to solve the problems related to quality management in organisations
	PO6	Moderately mapped as the students able to identify the important of quality management to assess organisational issues and demonstrate the consequent responsibilities relevant to the professional engineering practice.
	PO11	Highly mapped as the students able to use the project management and finance terms for quality management in organisation
	PO12	Highly mapped as the students able to understand the importance of quality, and be prepared for, lifelong learning in the fullest sense of technological development in quality management
	PSO3	Highly mapped as the students able to apply principles of quality engineering to design and analyze multi-disciplinary systems
CO2	**PO1**	Moderately mapped as the students will be able to use the fundamental knowledge of quality concepts and theories to find out the solution for problem related to quality in organisation
	PO11	Moderately mapped as the students will able to use the project management and finance terms for complete theoretical and practical understanding of the contributions of Quality Gurus
	PO12	Moderately mapped as the students able to understand the importance of theoretical and practical understanding of quality, and be prepared for, lifelong learning in the fullest sense of technological development in quality management.
	PSO3	Moderately mapped as the students as the students able to apply principles of quality engineering to design and analyze multi-disciplinary systems
CO3	**PO1**	Moderate mapped as the students able to use the fundamental knowledge of strategic quality management to solve the problems related to quality management in organisations
	PO2	Moderately mapped as the students able to identify, formulate and analyse principle of strategic quality to solve the problems related to quality management in organisations
	PO3	Moderately mapped as the students able to design solution for complex engineering problem using strategic quality management and design the process that meets specific needs with appropriate engineering consideration

	PO9	Highly mapped as the students able to use the principle of strategic quality management can perform effectively as a member or leader in diverse team and in multidisciplinary setting
	PO11	Slightly mapped as the students can able to use the strategic quality management principle and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
	PO12	Highly mapped as the students able to recognise the need of strategic quality management and ability to engage in independent and lifelong learning in the broadest context of technological change.
	PS02	Moderately mapped as the students able to Manage engineering projects as a professional team with ethical attitude by applying principles of quality management.
CO4	**PO1**	Highly mapped as the students able to identify the various human dimension of TQM to solve the problems related to quality management in organisations
	PO6	Highly mapped as the students able to identify the various dimension and knowledge of TQM to assess organisational issues and demonstrate the consequent responsibilities relevant to the professional engineering practice.
	PO9	Highly mapped as the students the principle of TQM and can perform effectively as a member or leader in diverse team and in multidisciplinary setting
	P011	Slightly mapped as the students can able to use the TQM principle and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
	PO12	Highly mapped as the students able to recognise the need of TQM and ability to engage in independent and lifelong learning in the broadest context of technological change.
	PSO2	Moderately mapped as the students able to Manage engineering projects as a professional team with ethical attitude by applying principles of quality management.
CO5	**PO1**	Moderately mapped as the students will be able to use different tools and techniques in TQM to solve the problems related to quality management in organisations
	PO2	Highly mapped as the students able to identify, formulate and analyse tools and techniques in TQM to solve the problems related to quality management in organisations
	PO3	Highly mapped as the students able to design solution for complex engineering problem using tools and techniques in TQM and design the process that meets specific needs with appropriate engineering consideration
	PO4	Moderately mapped as the student's able use research-based knowledge and research methods in TQM including design of experiments, analysis and interpretation of data to solve the problems related to quality management in organisations

	PO5	Moderately mapped as the student's able use different tools and techniques in TQM create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities
	PO9	Moderately mapped as the students the principle of different tools and techniques in TQM and can perform effectively as a member or leader in diverse team and in multidisciplinary setting
	PO11	Moderately mapped as the students can able to use the TQM principle and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
	PO12	Moderately mapped as the students able to recognise TQM principle and ability to engage in independent and lifelong learning in the broadest context of technological change.
	PSO2	Moderately mapped as the students able to Manage engineering projects as a professional team with ethical attitude by applying principles of quality management
CO6	**PO5**	Moderately mapped as the student's able use different statistical quality control techniques and modern engineering and IT tools including prediction and modelling to complex engineering activities
	PO6	Moderately mapped as the students able to use Engineer and society concept to identify core and extended modules of ISO 9000 family of standards
	PO7	Slightly mapped as the students able to Environment and sustainability concept to identify core and extended modules of ISO 9000 family of standards
	PO8	Slighly mapped the students can use concepts of ethics to identify core and extended modules of ISO 9000 family of standards
	PO9	Moderately mapped as the students the principle of different statistical quality control techniques and can perform effectively as a member or leader in diverse team and in multidisciplinary setting
	PO11	Moderately mapped as the students can able to use different statistical quality control techniques and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
	PO12	Moderately mapped as the students able to recognise use different statistical quality control technique and ability to engage in independent and lifelong learning in the broadest context of technological change.
	PSO2	Moderately mapped as the students able to Manage engineering projects as a professional team with ethical attitude by applying principles of quality management

9. Curricular gaps (if any)

Quality Engineering in the context of Industry4.0

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	bridge the gap between industry academia	NPTEL VIDEOS https://archive.nptel.ac.in/courses/106/105/106105195/	P10, P05

11. Internal Assessment mark allocation (as per university curriculum)

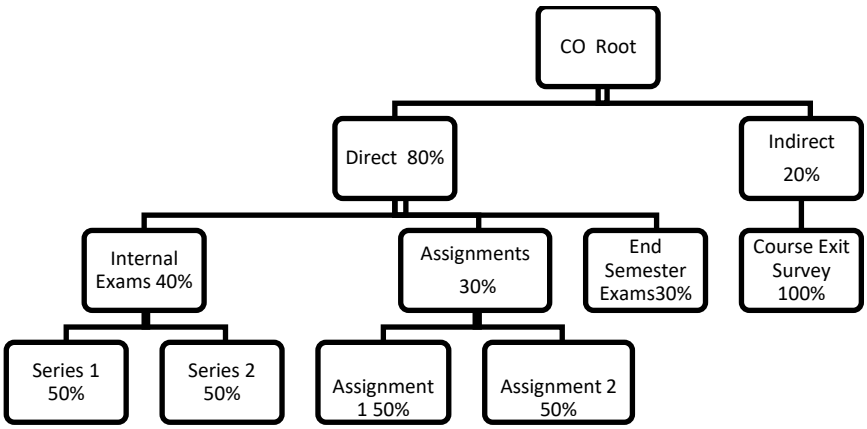
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put' x' if mapping is present)

	Tools		**Weightage#**	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**	**CO6**
Direct Assessment Tools**	Internal Exam(s) 40%	Series 1	20%	x	x	x			
		Series 2	20%				x	x	x
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x					
		Assignment 2	15%						x
	University Exam		30%	x	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Sl.no	Topic Name	Reference	Module	Teaching Pedagogy
1	Definitions of the terms - quality, quality planning,	T1,T2,T3	1	Lecture
2	Deming approach to TQM	T1,T2,T3	1	Lecture
3	Juran quality trilogy- Crosby's	T1,T2,T3	1	Lecture
4	Concepts of 5S,	T1,T2,T3	2	Lecture
5	Cost of Quality- Customer satisfaction-	T1,T2,T3	2	Lecture
6	Quality Function Deployment (QFD)	T1,T2,T3	2	Lecture
7	Integrating quality into strategic management -	T1,T2,T3	2	Lecture
8	obstacles to achieving successful strategic quality management	T1,T2,T3	2	Lecture
9	Six Sigma	T1,T2,T3	2	Lecture
10	Top management commitment-	T1,T2,T3	3	Lecture
11	Cause and effect analysis -	T1,T2,T3	3	Lecture
12	Taguchiâ€™s robust design- Total Productive maintenance- Failure	T1,T2,T3	3	Lecture
13	Productive maintenance- Failure	T1,T2,T3	3	Lecture
14	process flow chart â€“ check sheets	T1,T2,T3	3	Lecture
15	Scatter diagram - Pareto chart	T1,T2,T3	4	Lecture

16	Histogram and fundamentals of statistics	T1,T2,T3	4	Lecture
17	quality control, quality assurance, quality management	T1,T2,T3	4	Lecture
18	Control charts	T1,T2,T3	4	Lecture
19	process capability-	T1,T2,T3	4	Lecture
20	Failure Mode and Effect Analysis	T1,T2,T3	4	Lecture
21	ISO 9000 family of standards	T1,T2,T3	5	Lecture
22	ISO 9001 model	T1,T2,T3	5	Lecture
23	resource management- product realization measurement analysis and improvements	T1,T2,T3	5	Lecture
24	ISO 14000 family of standards	T1,T2,T3	5	Lecture
25	the TQM axioms	T1,T2,T3	5	Lecture
26	consequences of total quality-	T1,T2,T3	5	Lecture
27	Barriers to TQM	T1,T2,T3	5	Lecture
28	Quality Auditing	T1,T2,T3	5	Lecture
29	quality and the management cycle	T1,T2,T3	5	Lecture
30	Quality auditing- types and benefits	T1,T2,T3	5	Lecture
31	quality management system- management responsibility-	T1,T2,T3	5	Lecture

15. Question Bank

Module 1				
Sl. No.	Question	**Marks**	**CO**	**BL**
1	Define Quality	**3**	**CO1**	**L1**
2	Define Total Quality Management.	**3**	**CO2**	**L1**
3	Mention the basic features of TQM	**3**	**CO1**	**L1**
4	What are the major benefits of TQM?	**3**	**CO1**	**L1**
5	What are some major obstacles to TQM implementation?	**3**	**CO1**	**L1**
6	What are the major dimensions of product quality?	**3**	**CO1**	**L1**
7	Mention the names of some major contributors to the quality movement.	**3**	**CO2**	**L1**
8	What is Deming Cycle?	**3**	**C02**	**L1**

9	What is Deming's "System of Profound Knowledge"?	**3**	**CO2**	**L1**
10	Explain the Dimensions of service quality	**3**	**CO1**	**L1**
11	Explain dimensions of quality	**8**	**CO1**	**L2**
12	Explain the evolution of TQM.	**6**	**CO1**	**L2**
13	Write basic concepts of TQM?	**3**	**CO1**	**L1**
14	Explain the contributions of Deming to TQM.	**8**	**CO2**	**L2**
15	Explain the contributions of Juran to TQM	**6**	**CO2**	**L2**
16	Explain the contributions of Crossby to TQM.	**6**	**CO2**	**L2**
17	Explain the TQM framework.	**8**	**CO1**	**L2**
18	State and explain the barriers to TQM implementation in an organization.	**8**	**CO1**	**L2**
	Module 2			
19	Why should suppliers be treated as partners?	**6**	**CO3**	**L2**
20	What are Quality Circles?	**3**	**CO3**	**L1**
21	What are the Japanese 5S principles?	**3**	**CO3**	**L1**
22	What is meant by 'Cost of quality'?	**3**	**CO3**	**L1**
23	What are the four categories of quality costs?	**8**	**CO3**	**L2**
24	Mention some benefits of implementing 5S principles	**3**	**CO3**	**L1**
25	Explain Kaizen	**3**	**CO3**	**L1**
26	Explain Supplier Rating.	**3**	**CO3**	**L2**

27	Explain all the elements in 5'S principle and also the implementation procedure of 5'S in a manufacturing company	**8**	**CO3**	**L3**
28	What is six sigma?	**3**	**CO3**	**L1**
29	Why do we need six sigma?	**3**	**CO3**	**L1**
	Module 3			
30	What is qfd?	**3**	**CO3**	**L1**
30	Briefly explain the steps involved in QFD.	**6**	**CO3**	**L2**
31	Explain each section of the basic structures of house of quality	**6**	**CO3**	**L3**
32	Discuss objectives of quality function deployment.	**8**	**CO3**	**L3**
33	Write about the system of recognition a reward followed in an organisation.	**6**	**CO4**	**L1**
34	What are steps involved in continuous improvement process	**6**	**CO4**	**L1**
35	List the seven tools of quality.	**8**	**CO4**	**L2**
36	Explain the different types of Teams	**3**	**CO4**	**L1**
37	What are major functions of statistical analysis? Write down the applications of statistical techniques?	**6**	**CO4**	**L2**
	Module 4			

38	What are the steps involved in developing a team	**5**	**CO5**	**L2**
39	What is meant by employee empowerment with respect to total quality management?	**6**	**CO5**	**L2**
40	What are self-managing teams?	**3**	**CO5**	**L1**
41	Describe the importance of leadership in TQM	**3**	**CO5**	**L1**
42	Explain the FAILURE MODE AND EFFECT ANALYSIS (FMEA)	**6**	**CO5**	**L3**
43	What are the eight pillars of TPM?	**6**	**CO5**	**L1**
44	Explain about TAGUCHI'S QUALITY LOSS FUNCTION	**5**	**CO5**	**L2**
45	What are the essential features of Total Productive Maintenance (TPM)?	**6**	**CO5**	**L2**
Module 5				
Sl. No.	Question	**Marks**	**CO**	**BL**
46	What is ISO 9000 quality standards?	**4**	**CO6**	**L2**
47	Give any five elements of ISO 9000	**4**	**CO6**	**L2**
48	What are the eight quality principles underlying ISO 9000: 2000?	**5**	**CO6**	**L2**
49	What are the different types of audits?	**5**	**CO6**	**L1**
50	What are the documentation requirements of quality management systems?	**5**	**CO6**	**L2**
51	What is quality manual?	**5**	**CO6**	**L2**
52	Explain the management's responsibility for ISO	**5**	**CO6**	**L2**
53	What are the benefits of ISO 14001?	**5**	**CO6**	**L2**
54	What are the requirements of ISO 14001?	**3**	**CO6**	**L1**

55	Explain the elements of ISO 9000 standards.	**6**	**CO6**	**L2**
56	Discuss about implementation of ISO 9000	**4**	**CO6**	**L3**
57	Explain Quality Audits in detail	**4**	**CO6**	**L2**

Prepared By: .Dr. Ramadas.T

Checked By : Dr Manoj Jose Kalathil (Course committee convener)

Approved By : Dr Ramadas,T (HOD)

Course Code & Name: MET464 MICRO AND NANO MANUFACTURING

1. Prescribed Syllabus

Module	Topic	Hours
1	Introduction to principles of micro and nano fabrication techniques- microfabrication of semi- conductor devices- standard micro machining flow chart- basics of micro fabrication- manipulative techniques. Introduction to mechanical micro machining: Micro drilling-process, tools and applications, Micro turning- principle, process, tools and applications, Diamond micro turning- principle, process, tools and applications, Micro milling and Micro grinding- processes, tools and applications, Micro extrusion- principle, process and applications.	**9**
2	Introduction to Non-conventional micro-nano manufacturing: Abrasive Jet Micro-machining, WAJMM- principle, process and applications. Micro EDM, Micro WEDM, Micro EBM- principle, process and applications. Micro ECM, Micro LBM, Focused Ion Beams- process, principle and applications. Micro moulding processes: Injection moulding, Reaction injection moulding, hot embossing, injection compression moulding- micromolding tools-applications.	**7**
3	Introduction to micro-nano finishing processes: Magnetorheological Finishing (MRF) processes, Magneto-rheological Abrasive Flow Finishing (MRAFF) processes- Principle, equipment and applications- Force analysis for MRAFF process. Magnetic float polishing (MFP), Elastic Emission machining (EEM), Ion Beam Machining (IBM), Chemical Mechanical Polishing (CMP)- principle, equipment and applications	**5**
4	Introduction to Nano Fabrication: Nano fabrication using soft lithography- principle and applications. Introduction to Carbon nano materials- CN tubes- properties and applications. CN tube transistors-Diamonds- properties and applications- CVD Diamond technology- LIGA process. Laser micro welding- Electron Beam Micro welding.	**7**
5	Introduction to micro-nano inspection and metrology: Scanning electron microscopy, Scanning white light interferometry, Optical Microscopy, Scanning probe Microscopy, Scanning tunnelling	**6**

	microscopy, Confocal microscopy, Atomic force microscopy. Introduction to On- machine metrology.	

2. Text Books (T)

T1. Mark J. Jackson, Micro and Nanomanufacturing, Springer, 2007.

T2. V.K. Jain, Micromanufacturing Processes, Taylor and Francis- CRC press, 2012

3. Reference Books (R)

R1. N.P.Mahalik, Micromanufacturing and nanotechnology, Springer, 2006.
R2. Mark J. Jackson, Microfabrication and Nanomanufacturing, Taylor and Francis-CRC press, 2006.

4. Course Objectives

This course aims to equip learners with a comprehensive understanding of the foundational principles, intricate processes, and diverse applications within the domains of micro manufacturing and nanotechnology. Additionally, it seeks to impart knowledge on the dimensional metrology aspects and various tools pertinent to micro and nanoscale manufacturing, enabling learners to proficiently analyze and implement advanced manufacturing techniques.

5. Course Pre / Co-requisite

Manufacturing technology

6. Course Outcomes

On successful completion of this course students shall be able to

CO 1: Explain different techniques used in micro and nano manufacturing

CO 2: Describe conventional techniques used in micro manufacturing.

CO 3: Describe non-conventional micro-nano manufacturing approaches.

CO 4: Outline the working principle and applications of micro and nano finishing processes

CO 5: Explain the basics of micro and nano fabrication techniques.

CO 6: Apply and select metrology systems in micro and nano manufacturing.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3
CO1	H	-	-	-	-	-	L	-	M	L	L	-			
CO2	M	-	-	-	-	-	L	-	M	L	L	-			
CO3	M	-	-	M	-	-	L	-	M	L	L	-			
CO4	H	-	-	-	-	-	L	-	M	L	L	-			
CO5	M	-	-	-	-	-	L	-	M	L	L	-			
CO6	H	-	-	-	L	-	M	-	M	L	M	L	-		

8. Justification for CO-PO-PSO Correlation

CO1	**PO1**	This CO requires students to apply fundamental engineering principles to understand various micro and nano manufacturing techniques.
	PO7	Understanding various manufacturing techniques is crucial for developing environmentally friendly and sustainable practices in micro and nano manufacturing.
	PO9	This knowledge helps individuals function effectively in teams by providing insights into different techniques and fostering collaboration.
	PO10	Communicating the complexities of various manufacturing techniques requires clear and effective communication skills.
	PO11	Knowledge of different techniques aids in project management by selecting the most suitable manufacturing methods and managing resources effectively.
CO2	**PO1**	Students must apply their engineering knowledge to describe conventional micro manufacturing techniques.
	PO7	Conventional techniques often have well-established environmental impacts, making it important to understand their sustainability aspects.
	PO9	Describing conventional techniques enhances teamwork by providing a common foundation of knowledge for team members.
	PO10	Effectively describing conventional techniques involves clear and precise communication.
	PO11	Understanding conventional techniques helps in project planning and resource allocation.
CO3	**PO1**	Students need to apply engineering fundamentals to describe non-conventional approaches.
	PO4	Understanding and describing non-conventional micro-nano manufacturing approaches require the application of research-based knowledge and methods, which align with the principles of conducting investigations of complex problems.
	PO7	Non-conventional approaches can offer more sustainable solutions, making their understanding crucial for environmental impact assessments.

	PO9	Knowledge of non-conventional approaches fosters innovation and collaboration within teams.
	PO10	Clearly describing these advanced techniques requires strong communication skills.
	PO11	Non-conventional approaches may require unique project management strategies, emphasizing the importance of understanding these techniques.
CO4	**PO1**	Students must use their engineering knowledge to understand the principles and applications.
	PO7	Understanding the working principles and applications of these processes helps assess their environmental impact and sustainability.
	PO9	Effective teamwork benefits from a shared understanding of these processes.
	PO10	Outlining these principles and applications necessitates clear and effective communication.
	PO11	Knowledge of finishing processes aids in planning and managing manufacturing projects efficiently.
CO5	**PO1**	Understanding fabrication techniques requires a solid foundation in engineering principles.
	PO7	Basic knowledge of fabrication techniques is essential for developing sustainable manufacturing solutions.
	PO9	This foundational knowledge supports teamwork by providing a common understanding of fabrication techniques.
	PO10	Explaining the basics of these techniques involves clear and concise communication.
	PO11	Understanding fabrication techniques is vital for project planning and resource management.
CO6	**PO1**	Applying metrology systems requires a deep understanding of engineering principles.
	PO5	Applying and selecting metrology systems in micro and nano manufacturing inherently involves using modern engineering tools and techniques which includes advanced measurement instruments, software for data analysis, and modeling tools that predict system performance.
	PO7	Selecting appropriate metrology systems contributes to sustainable manufacturing practices.
	PO9	Effective application and selection of metrology systems require collaboration and teamwork.
	PO10	Communicating the selection and application of metrology systems involves clear and precise communication.
	PO11	Knowledge of metrology systems aids in efficient project management and quality control.
	PO12	The field of metrology in micro and nano manufacturing is constantly evolving with new technologies and methodologies which requires a commitment to continuous learning and staying updated with the latest advancements.

9. Curricular gaps (if any)

NIL

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
	NIL		

11. Internal Assessment mark allocation (as per university curriculum)

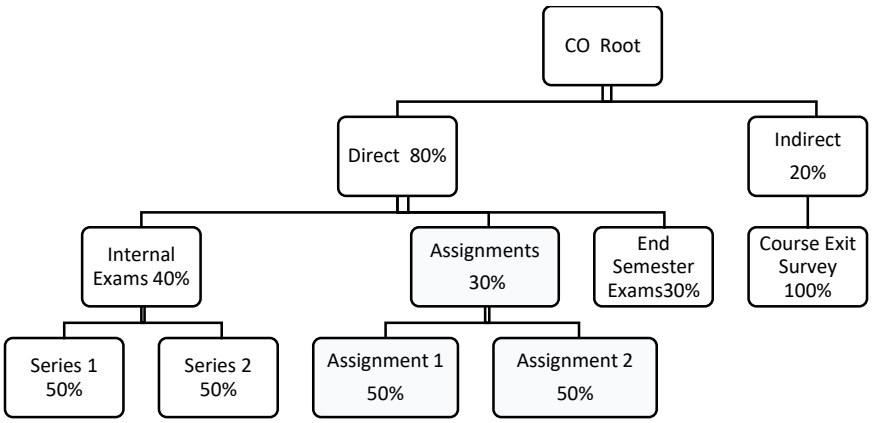
(Provide details as mentioned in syllabus)

Attendance - 10 marks
Continuous Assessment Test - 25 marks
Assignment (s)/ Course Project - 15 marks
Total - 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		Weightage#	CO 1	CO 2	CO 3	CO 4	CO 5	CO 6
Direct Assessment Tools**	Internal Exam(s) - 40%	Series 1	20%	x	x	x	x		
		Series 2	20%				x	x	x
	Assignment (s)/ Course Project /Quiz etc. -30%	Assignment1	15%		x	x	x		
		Assignment2	15%	x	x		x	x	x
	End Semester Exam		30%	x	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hour	Topic	Module	Reference(s)	Teaching Pedagogy
1.	Introduction to micro-nano fabrication techniques- principles and evolution.	1	T1, T2	Lecture
2.	Overview of microfabrication of semiconductor devices- example- Integrated Chip.	1	T1, T2	Lecture
3.	Standard micro machining flow chart and basics of microfabrication- manipulative techniques.	1	T1, T2	Lecture
4.	Introduction to mechanical micro machining. Micro drilling-principle, process, description and applications.	1	T1, T2	Lecture
5	Micro turning- principle, process, description and applications.	1	T1, T2	Tutorial
6	Diamond micro turning- principle, process, description and applications.	1	T1, T2	Lecture
7	Micro milling and Micro grinding- principle, process, description and applications.	1	T1, T2	Lecture
8	Micro grinding- principle, process, description and applications.	1	T1, T2	Lecture
9	Micro extrusions- principle, process, description and applications.	1	T1, T2	Lecture
10	Introduction to non-conventional micro-nano manufacturing- Abrasive jet micro machining, WAJMM- principle, process, description and applications.	2	T1, T2	Lecture
11	Micro EDM, Micro WEDM, Micro EBM- process, principle, description and applications.	2	T1, T2	Tutorial
12	Micro ECM, Micro LBM- process, principle, description and applications.	2	T1, T2	Lecture
13	Focused Ion Beams-process, principle and applications.	2	T1, T2	Lecture
14	Micromolding process- Injection molding, reaction Injection molding- process, principle, description and applications.	2	T1, T2	Lecture
15	Hot embossing, injection compression molding- description	2	T1, T2	Lecture
16	Micromolding tools- applications.	2	T1, T2	Lecture
17	Introduction to micro-nano finishing processes- magnetorheological finishing (MRF)- process, principle, description,	3	T1, T2	Lecture

	application.			
18	Magnetorheological abrasive flow finishing (MRAFF)- process, principle- Force analysis- description and applications.	3	T1, T2	Lecture
19	Magnetic float polishing (MFP)- process, principle, description and applications.	3	T1, T2	Lecture
20	Elastic emission machining (EEM), Ion beam machining (IBM)- process, principle, description and applications.	3	T1, T2	Tutorial
21	Chemical mechanical polishing (CMP)- process, principle, description and applications.	3	T1, T2	Lecture
22	Introduction to Nanofabrication- Nanofabrication using soft lithography- principle and applications- examples- field effect transistor, elastic stamp.	4	T1, T2	Lecture
23	Manipulative techniques- principle and description, applications.	4	T1, T2	Lecture
24	Introduction to Carbon nano materials- CN tubes- properties and applications- CN tube transistors.	4	T1, T2	Lecture
25	Diamonds- properties and applications-	4	T1, T2	Lecture
26	CVD diamond technology.	4	T1, T2	Tutorial
27	LIGA process.	4	T1, T2	Lecture
28	Laser micro welding- Electron beam micro welding.	4	T1, T2	Lecture
29	Introduction to micro-nano inspection and metrology- Scanning electron microscopy- principle and description.	5	T1, T2	Lecture
30	Scanning white light interferometry- principle and description.	5	T1, T2	Lecture
31	Optical microscopy- principle and description.	5	T1, T2	Lecture
32	Scanning probe microscopy, Scanning tunnelling microscopy- principle, description and applications.	5	T1, T2	Lecture
33	Confocal microscopy, Atomic force microscopy- principle and description.	5	T1, T2	Tutorial
34	Introduction to On-machine metrology.	5	T1, T2	Lecture

15. Question Bank

Module 1

Sl. No	Question	Marks	CO	BL
1	Discuss the differences between macro and micro machining.	3	CO1, CO2	L2
2	Describe the features of micro grinding process.	3	CO1, CO2	L1
3	Describe the features of micro drilling process.	3	CO1, CO2	L1
4	Define microgrinding.	3	CO1, CO2	L1
5	Point out any 3 differences between macro-turning and micro-turning.	3	CO1, CO2	L2
6	Explain the various steps in the micro fabrication of semiconductor devices.	6	CO1, CO2	L2
7	Enumerate the key principles of Micro and nano fabrication manipulative techniques	6	CO1, CO2	L2
8	With a neat sketch, discuss the process, tooling, applications & advantages of Diamond micro turning. Or Illustrate the process, tool requirements, advantages & applications of a technique for producing ultra-precision parts for advanced medical applications, with a neat sketch.	14	CO1, CO2, CO5	L3
9	With a neat sketch, explain the process of Micro milling. Mention its tooling, advantages and applications. Or Illustrate the process that is used in creating micro-scale features on printed circuit boards (PCBs) with high precision and fine details. Mention its tooling, advantages and applications.	14	CO1, CO2, CO5	L3
10	a) With neat sketches explain about micro drilling process. b) List down the applications of micro milling process.	14	CO1, CO2	L2
11	What are the challenges in micro-turning? Discuss in detail the design requirements of micro-turning machines.	14	CO1, CO2	L3
12	Discuss in detail the design requirements of microturning machines.	14	CO1, CO2	L2
13	Discuss the outcomes of microgrinding of ceramic materials.	14	CO1, CO2	L2
Module 2				

1	List the applications of Water abrasive jet micro machining.	3	CO3	L1
	List few applications of Micro ECM process.			
2	Why are high speed air turbine spindles useful for micromachining? High-speed air turbine spindles are particularly useful for micromachining due to several key advantages: 1. High Speed: They can achieve rotational speeds exceeding 100,000 RPM, which is essential for precision micromachining tasks. 2. Low Heat Generation: Air turbine spindles generate minimal heat due to their design, which helps in maintaining the integrity of the workpiece and the cutting tool. 3. Compact and Lightweight: These spindles are small and lightweight, making them ideal for use in desktop and ultra-precision machine tools. 4. High Efficiency: They offer high mechanical power output and efficiency, often exceeding 50%. 5. Durability and Reliability: With only a few moving parts and air-cooled ceramic bearings, they are highly durable and reliable. These features make high-speed air turbine spindles an excellent choice for micromachining applications, where precision and efficiency are paramount	3	CO3	L2
3	What are the process parameters influencing material removal in Abrasive jet micro- machining?	3	CO3	L2
4	Mention few applications of micro-moulding process.	3	CO3	L2
5	With neat sketches explain nano plastic forming process in detail.	3	CO3	L2
6	What is hot embossing? Why is it particularly suited for manufacturing of optical components? □ Precision: It allows for the replication of microstructures with high precision, which is essential for optical components like micro-lens arrays and micro-prism arrays. □ Complex Geometries: Hot embossing can produce components with complex geometries and high aspect ratios, which are often required in optical systems.	6	CO3	L2

	□ Material Versatility: It can be used with a variety of materials, including thermoplastic polymers, glass, metals, and ceramics. This versatility is beneficial for creating different types of optical components. □ Cost-Effective: Compared to other methods like injection molding, hot embossing is more cost-effective, especially for low-volume production. □ High Quality: It ensures high-quality replication with excellent surface finish and dimensional accuracy, which are crucial for optical performance.			
7	With a neat sketch, explain micro electric discharge machining (EDM) and discuss the merits and demerits.	14	CO3	L3
8	Describe various methods available for manufacturing of micro-molding tools.	14	CO3	L2
9	Discuss micro injection molding and its applications.	14	CO3	L2
10	Explain the working principle of abrasive water jet micro-machining process. Comment on the major process parameters influencing material removal in Abrasive water jet micro-machining (AWJMM).	14	CO3	L2
11	a) Explain the role of Carbonyl Iron particles in MR finishing process b) Explain the influence of process parameters in MR jet finishing process	14	CO3	L2
12	a) With neat sketches explain the working principle of chemical mechanical polishing. Also list a few applications of CMP process.	14	CO3	L2
13	Discuss the Focused Ion Beam system	14	CO3	L2
14	a) With neat sketches explain the working principle of abrasive jet micro machining b) Explain the advantages, disadvantages and applications of micro-EBM process.	14	CO3	L2
15	a) With neat sketches explain the working principle of focused ion beam machining process b) List few applications of Micro ECM process.	14	CO3	L2

16	Compare Micro ECM and Micro LBM in terms of their precision, material removal rates, and surface finish quality	14	CO3	L2
Module 3				
1	Describe Magneto rheological finishing process.	3	CO4	L1
2	Discuss Chemical mechanical polishing.	3	CO4	L3
3	Draw the schematic of Chemical Mechanical Polishing process.	3	CO4	
4	Illustrate the mechanism of material removal in Ion beam machining.	3	CO4	L1
5	Explain the role of carbonyl iron particles in Magnetorheological finishing process.	3	CO4	L1
6	Explain Elastic emission machining process.	14	CO4	L2
7	Write short notes about micro fabrication.	3	CO4	L1
8	Explain the process of Magneto rheological abrasive flow finishing with a neat sketch.	14	CO4	L2
9	Discuss about ion beam machining with a neat sketch and list the process parameters.	14	CO4	L2
10	a) Explain the process of Magneto rheological abrasive flow finishing (MRAFF) with a neat sketch. b) Describe Magnetic float polishing with a neat diagram.	14	CO4	L2
11	Describe the principle of reaction injection moulding (RIM). How does it differ from traditional injection moulding?	14	CO4	L2
Module 4				
1	Describe CVD diamond technology. Or What is CVD diamond technology?	3	CO5, CO6	L1
2	Explain LIGA process	3	CO5, CO6	L2
3	Write the advantages of Laser beam micro welding	3	CO5, CO6	L1
4	List out various materials used in semi-conductor industry	3	CO5, CO6	L1
5	Show by a schematic how an elastic stamp is manufactured using soft lithography?	3	CO5, CO6	L2
6	Why silicon is used as a substrate material in microfabrication of semiconductor devices?	3	CO5, CO6	L2

7	Write the applications of Electron beam micro-welding.	3	CO5, CO6	L1
8	Write the advantages of Electron beam micro welding	3	CO5, CO6	L2
9	Describe the physical properties of Carbon Nanotubes.	3	CO5, CO6	L2
10	Explain the process of micro fabrication of semiconductor devices.	8	CO5, CO6	L2
11	Discuss Laser Beam Micro welding and its applications.	14	CO5, CO6	L2
12	a) Discuss Electron beam micro welding and its applications b) Explain LIGA process with the help of a neat sketch.	8 6	CO5, CO6	L2
13	Explain the significance of Carbon Nano tubes. List the properties and applications.	14	CO5, CO6	L2
14	a) Explain the properties of Carbon nanotubes (CNT's) which enabled them to find significant application in industries. b) Describe any three industrial applications of CNT	10 4	CO5, CO6	L3
15	a) Explain how a Field effect transistor is fabricated by the process of soft lithography? b) Explain CVD diamond technology and its advantages.	7 7	CO5, CO6	L2
16	a) With a neat sketch explain the working of a field effect transistor. b) Write short notes about micro fabrication.	8 6	CO5, CO6	L2
17	a) Discuss the working of carbon nanotube transistors. b) List any four applications of manipulation techniques.	10 4	CO5, CO6	L3
18	a) With neat sketches explain laser micro welding process. b) Write the advantages, disadvantages and applications of electron beam micro welding.	7 7	CO5, CO6	L3
19	a) Explain soft lithography techniques. Mention its advantages. b) Explain the working of carbon nanotube transistors	8 6	CO5, CO6	L3
20	a) Draw and explain the fabrication steps involved in LIGA process b) With neat sketch explain laser micro welding process.	7 7	CO5, CO6	L3
21	a) Explain how a field effect transistor is fabricated by the process of soft lithography. b) Describe the properties of Carbon nanotubes.	7 7	CO5, CO6	L3
22	Explain the significance of Carbon Nano tubes. List the properties and applications.	14	CO5, CO6	L3

23	Discuss Laser Beam Micro welding and its applications.	14	CO5, CO6	L3
Module 5				
1	What are the merits and demerits of On-machine metrology?	3	CO5, CO6	L1
2	Explain the On-machine metrology.	3	CO5, CO6	L2
3	What are the limitations of Scanning white light interferometry technology?	3	CO5, CO6	L1
4	Draw the schematic of typical scanning white light interferometry set up.	3	CO5, CO6	L1
5	Describe the working principle of Scanning white light interferometry.	3	CO5, CO6	L2
6	Explain the principle of Scanning Electron Microscopy (3)	3	CO5, CO6	L2
7	Discuss the principle and working of confocal microscope.	3	CO5, CO6	L2
8	What is Atomic force microscope? Explain its modes of operation	14	CO5, CO6	L2
9	With a neat sketch, explain the principle and working of Scanning probe microscopy. Mention any two applications.	14	CO5, CO6	L2
10	With a neat sketch explain the principle and working of Scanning tunnelling microscope (STM). What are the advantages of using STM for surface imaging and analysis?	14	CO5, CO6	L3
11	Explain the operation of scanning tunneling microscope.	14	CO5, CO6	L2
12	a) Differentiate between constant height method and constant current method used in scanning tunnelling microscopy.	10	CO5, CO6	L3
13	a) Explain Scanning Probe Microscopy with a neat sketch. b) Discuss the principle and working of Scanning tunnelling microscope	8 6	CO5, CO6	L2
14	With neat sketches differentiate between scanning probe microscopy and scanning tunnelling microscopy.	14	CO5, CO6	L3
15	Discuss the working principle of Confocal microscopy. What are the advantages of using confocal microscopy for imaging biological samples?	14	CO5, CO6	L3
16	Discuss the principle and applications of Scanning White-light Interferometry	8	CO5, CO6	L2

17	With a neat diagram explain the working principle of Scanning electron microscopy. What are the advantages of using SEM for imaging and analysis compared to optical microscopy?	14	CO5, CO6	L3
18	Discuss the principle of Scanning White-light Interferometry (SWLI). What are the main advantages of using SWLI compared to other surface measurement techniques?	14	CO5, CO6	L3
19	Discuss about on-machine metrology. On-machine metrology refers to the practice of measuring parts directly on the machine tool that is used for manufacturing them, without moving the part to a separate measurement device. This method offers several advantages: 1. Increased Efficiency: Since measurements are taken directly on the machine, there is no need to move parts to a separate measurement station, saving time and reducing the risk of errors. 2. Improved Accuracy: By measuring parts in their final machining environment, on-machine metrology can account for any changes or deformations that might occur during the machining process. 3. Cost-Effective: Reducing the need for additional measurement equipment and the time spent on moving parts can lead to cost savings in the manufacturing process. 4. Real-Time Feedback: On-machine metrology allows for real-time monitoring and adjustments during the machining process, ensuring higher quality and precision. However, there are also challenges associated with on-machine metrology, such as the potential for environmental factors (like temperature and vibrations) to affect measurement accuracy. Despite these challenges, the benefits often outweigh the drawbacks, making on-machine metrology a valuable tool in modern manufacturing.	6	CO5, CO6	L2
20	Outline unique metrological challenges faced in micro-nano manufacturing?	6	CO5, CO6	L2

Prepared By : Prof. Asha K R, Course faculty

Checked By: Prof. Dr Manoj Jose Kalathil, Subject committee Chairperson (Production)

Approved By: Prof. Dr. Ramadas T., HoD, ME Dept.

Course Code & Name: MET466 Technology Management

1. Prescribed Syllabus

Module	Topic	Hours
1	Technology and Technology Management - Technology- evolution and growth of technology, technology management: concepts and definitions, role and significance of technology management, impact of technology on society and business. Technology and competition, organizing technology at the enterprise level, key issues in managing technological innovation and forms of technology- process technology, product technology	6
2	Technology Acquisition and Technology Forecasting - Technology acquisition, new technology, alternatives for acquiring new technologies, management of acquired technology, technology forecasting, characteristics of technology forecasting, technology forecast methods, principles of technology forecasting, technology forecasting process, need and role of technology forecasting, forecasting methods and techniques, planning and forecasting. Technology generation and development, technology generation, process, technology development, importance of technology generation and development	7
3	Technology strategy and management - Need for technology strategy, technology adoption, diffusion, absorption and competitiveness, elements of technology strategy, role of technology absorption, benefits of technology absorption, constraints in technology absorption, technology package and technological dependence, Indian experience in technology absorption efforts, issues involved in the management of technology absorption and government initiatives, technology policies, science and technology policy in India	7
4	Management of R&D and innovation - Importance of Research and Development (R&D), corporate research and product lifecycle, production costs and R&D, translation of R&D efforts to technology, innovation, types of innovation, difference between innovation and invention, framework for management of innovation, organizational characteristics that facilitate innovation, trademarks, copyrights, patents and their use in innovation management, remedy against infringement, the role of technology transfer in innovation and new product development, role of government in innovation, globalisation and innovations, technology and innovation management - case studies about management of R&D and innovation	9
5	Human Aspects in Technology Management - Integration of people and technology, human factors to be considered in technology management - organisational factors and psychological factors, organisational structure and technology, implications of technological change, implementation of rationalization and automation in India, impact of technological change, human resource	7

	management issues in R&D and innovation, technology assessment and environmental impact analysis	

2. Text Books (T)

T1. P N Rastogi, Management of Technology and Innovation: Competing Through Technological Excellence, SAGE Publications, 2009
T2. Tushman, M.L. and Anderson, P., Managing Strategic Innovation & Change, Oxford University Press, New York, 2004.
T3. Khurana, V. K., Management of Technology and Innovation, Ane Books New Delhi, 2012
T4. Narayanan, V. K, Managing Technology and Innovation for Competitive Advantage, Pearson Education, 2002
T5. Ettile, J. E, Managing Innovation: New technology, New Products and New Services in a Global Economy, A Butterworth-Heinemann Title, 2006

3. Reference Books (R)

R1. Afuah, A, Innovation Management, Strategies, Implementation and Profits, Oxford University Press, 2009
R2. Paul Trott, Innovation Management and New Product Development, Pearson Education, 2004.
R3. Robert A Burgelman, Clayton. M. Christensen, Steven. C. Wheelright, Strategic Management of Technology and Innovation (Fifth Edition), McGraw-Hill Education, 2009.

4. Course Objectives

Management of innovation and technology is important an organisation. This course is designed to facilitate the students to understand the concept of technology management, Key issues in managing technology. This course will also help the students to gain a fair understanding on contemporary topics in technology and innovation management.

5. Course Pre / Co-requisite

Nil

6. Course Outcomes

After the successful completion of the course, the students will be able to
CO1: Be conversant with important terms for technology management in organisations
CO2: Explain the need of technology forecasting
CO3: Understand the essence of technology acquisition
CO4: Describe the elements of technology strategy
CO5: Outline the basics of innovation
CO6 Identify human factors in technology management.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	H					M					M	L	H	H	
CO2	M		M								M	M	H	H	
CO3	M					M						M	H	H	
CO4	H					M						M	H	H	
CO5	H					M					M	M	H	H	
CO6	M					M						M	H	H	

8. Justification for CO-PO-PSO Correlation

CO	PO/PSO	Justification
CO1	PO1	Conversant with important terms for technology management in organisations contributes to skills in solving engineering problems. High correlation is due the fact that this involves in-depth knowledge of science and engineering fundamentals to solve engineering problems.
	PO6	Apply reasoning informed by the important terms for technology management in organisations will help the students to assess societal health, safety, legal and cultural issues. Medium correlation is due to the fact that this involves standard and moderate professional engineering practice.
	PO11	Understanding the important terms for technology management in organisations will help the students to apply these to one's own work, as a member or leader in a team, to manage projects, and in multidisciplinary environments. Medium correlation is due to the fact that this involves standard and moderate knowledge and understanding of the engineering and management principles.
	PO12	Continuous learning about the important terms for technology management in organisations will help the students for engaging in independent and lifelong learning in the broadest context of technological knowledge. Low correlation is due to the fact that this involves basic technical knowledge.
	PSO1	Knowledge about the concurrent technologies used in important terms for technology management in organisations contributes to solving the practical problems using the principles of sustainable development. High correlation is due the fact that this involves in-depth knowledge on concurrent technologies.
	PSO2	Applying the principles of scientific management for the important terms of technology management in organisations will help the students to manage engineering projects as a professional team with ethical attitude. High correlation is due the fact that this involves in-depth knowledge on principles of scientific management.
CO2	PO1	Describing the need of technology forecasting contributes to skills in solving engineering problems. Medium correlation is due to the fact that this involves standard knowledge of mathematics, science and engineering fundamentals in explaining technology forecasting.

	PO3	Explaining the need of technology forecasting will help the students to design solutions for complex engineering problems that meet the specified needs with appropriate consideration for public safety and environmental considerations. Medium correlation is due to the fact that this involves standard and moderate knowledge on technology forecasting.
	PO11	Understanding the need of technology forecasting in organisations will help the students to apply these to one's own work, as a member or leader in a team, to manage projects, and in multidisciplinary environments. Medium correlation is due to the fact that this involves standard and moderate knowledge and understanding of the technology forecasting.
	PO12	Continuous learning about the need of technology forecasting in organisations will help the students for engaging in independent and lifelong learning in the broadest context of technological knowledge. Medium correlation is due to the fact that this involves standard and moderate technical knowledge on technology forecasting.
	PSO1	Knowledge about the concurrent technologies used in the need of technology forecasting in organisations contributes to solving the practical problems using the principles of sustainable development. High correlation is due the fact that this involves in-depth knowledge on concurrent technologies.
	PSO2	Applying the principles of scientific management for the need of technology forecasting in organisations will help the students to manage engineering projects as a professional team with ethical attitude. High correlation is due the fact that this involves in-depth knowledge on principles of scientific management.
CO3	**PO1**	Understanding the essence of technology acquisition will help the students to apply the knowledge to solve complex engineering problems. Medium correlation is due to the fact that this involves standard knowledge of mathematics, science and engineering fundamentals.
	PO6	Understanding the essence of technology acquisition in organisations will help the students to assess societal health, safety, legal and cultural issues. Medium correlation is due to the fact that this involves standard and moderate professional engineering practice.
	PO12	Understanding the essence of technology acquisition in organisations contributes towards lifelong learning in the broadest context of technological knowledge. Medium correlation is due to the fact that this involves standard technical knowledge.
	PSO1	Knowledge about the essence of technology acquisition in organisations contributes to solving the practical problems using the principles of sustainable development. High correlation is due the fact that this involves in-depth knowledge on concurrent technologies.
	PSO2	Applying the principles of scientific management for the essence of technology acquisition in organisations will help the students to manage engineering projects as a professional team with ethical attitude. High correlation is due the fact that this involves in-depth knowledge on principles of scientific management.
CO4	**PO1**	Describing the elements of technology strategy will help the students to apply the knowledge to solve complex engineering problems. High correlation is due to the fact that this involves in-depth knowledge of mathematics, science and engineering fundamentals.

	PO6	Understanding the elements of technology strategy will help the students to assess societal health, safety, legal and cultural issues. Medium correlation is due to the fact that this involves standard and moderate professional engineering practice.
	PO12	Understanding the elements of technology strategy in organisations contributes towards lifelong learning in the broadest context of technological knowledge. Medium correlation is due to the fact that this involves standard technical knowledge.
	PSO1	Knowledge about the elements of technology strategy in organisations contributes to solving the practical problems using the principles of sustainable development. High correlation is due the fact that this involves in-depth knowledge on concurrent technologies.
	PSO2	Applying the principles of scientific management for the elements of technology strategy in organisations will help the students to manage engineering projects as a professional team with ethical attitude. High correlation is due the fact that this involves in-depth knowledge on principles of scientific management.
CO5	**PO1**	Outlining the basics of innovation contributes to skills in solving engineering problems. High correlation is due the fact that this involves in-depth knowledge of science and engineering fundamentals to solve engineering problems.
	PO6	Apply reasoning informed by the basics of innovation in organisations will help the students to assess societal health, safety, legal and cultural issues. Medium correlation is due to the fact that this involves standard and moderate professional engineering practice.
	PO11	Outlining the basics of innovation will help the students to apply these to one's own work, as a member or leader in a team, to manage projects, and in multidisciplinary environments. Medium correlation is due to the fact that this involves standard and moderate knowledge and understanding of the engineering and management principles.
	PO12	Continuous learning about the basics of innovation will help the students for engaging in independent and lifelong learning in the broadest context of technological knowledge. Medium correlation is due to the fact that this involves standard and moderate technical knowledge.
	PSO1	Knowledge about the concurrent technologies used in the basics of innovation contributes to solving the practical problems using the principles of sustainable development. High correlation is due the fact that this involves in-depth knowledge on concurrent technologies.
	PSO2	Applying the principles of scientific management for the basics of innovation will help the students to manage engineering projects as a professional team with ethical attitude. High correlation is due the fact that this involves in-depth knowledge on principles of scientific management.
PO6	**PO1**	Identifying the human factors in technology management will help the students to apply the knowledge to solve complex engineering problems. Medium correlation is due to the fact that this involves standard and moderate knowledge of mathematics, science and engineering fundamentals.
	PO6	Understanding the human factors in technology management will help the students to assess societal health, safety, legal and cultural issues. Medium correlation is due to the fact that this involves standard and moderate professional engineering practice.

	PO12	Understanding the human factors in technology management in organisations contributes towards lifelong learning in the broadest context of technological knowledge. Medium correlation is due to the fact that this involves standard technical knowledge.
	PSO1	Knowledge about the human factors in technology management contributes to solving the practical problems using the principles of sustainable development. High correlation is due the fact that this involves in-depth knowledge on concurrent technologies.
	PSO2	Applying the principles of scientific management for the human factors in technology management will help the students to manage engineering projects as a professional team with ethical attitude. High correlation is due the fact that this involves in-depth knowledge on principles of scientific management.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	Case study on the management of R&D	Group Discussion	PO11, PSO2

11. Internal Assessment mark allocation (as per university curriculum)

(Provide details as mentioned in syllabus)

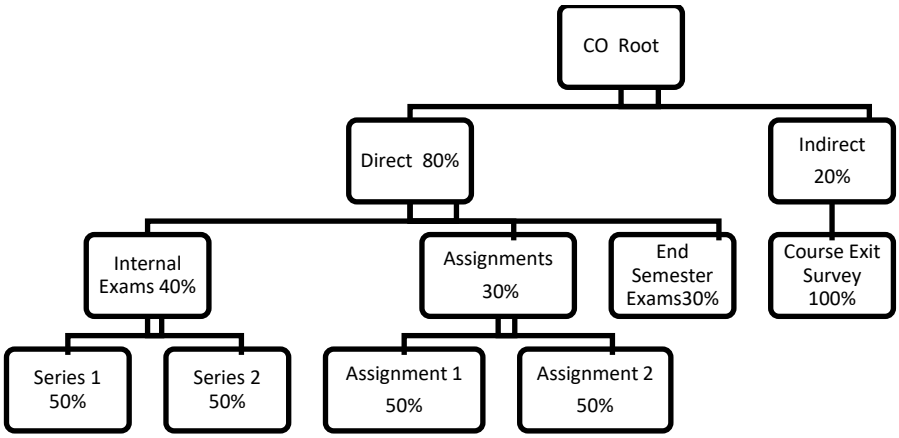
Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. Assessment – CO Mapping (Put‘ x’ if mapping is present)

	Tools		Weightage	CO1	CO2	CO3	CO4	CO5	CO6
Direct Assessment Tools	Internal Exam(s) 40%	Series 1	20%	x	x	x	x		
		Series 2	20%					x	x
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	15%	x	x	x	x		
		Assignment 2	15%					x	x

	End Semester Exam	30%	x	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey	100%	x	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Hour	Topic	Module	Reference	Teaching Pedagogy
1	Technology- evolution and growth of technology	1	T4, R3	Lecture
2	Technology management: concepts and definitions, role and significance of technology management	1	T4, R3	Tutorial
3	Impact of technology on society and business.	1	T4, R3	Lecture
4	technology and competition, organizing technology at the enterprise level	1	T4, R3	Lecture
5	Key issues in managing technological innovation	1	T4, R3	Lecture
6	Forms of technology- process technology, product technology	1	T4, R3	Tutorial
7	Technology acquisition, new technology	2	T4, R3	Lecture

8	alternatives for acquiring new technologies, management of acquired technology	2	T4, R3	Tutorial
9	Technology forecasting, characteristics of technology forecasting, technology forecast method	2	T4, R3	Lecture
10	principles of technology forecasting, technology forecasting process	2	T4, R3	Lecture
11	need and role of technology forecasting, forecasting methods and techniques, planning and forecasting.	2	T4, R3	Tutorial
12	Technology generation and development	2	T4, R3	Lecture
13	importance of technology generation and development.	2	T4, R3	Lecture
14	Need for technology strategy, technology adoption, diffusion	3	T4, R3	Lecture
15	absorption and competitiveness, elements of technology strategy	3	T4, R3	Tutorial
16	Role of technology absorption, benefits of technology absorption, constraints in technology absorption	3	T4, R3	Lecture
17	technology package and technological dependence	3	T4, R3	Lecture
18	Indian experience in technology absorption efforts	3	T4, R3	Lecture
19	Issues involved in the management of technology absorption, government initiatives	3	T4, R3	Lecture
20	technology policies - science and technology policy in India.	3	T4, R3	Tutorial
21	Importance of Research and Development (R&D), corporate research and product lifecycle	4	T4, R3	Lecture
22	production costs and R&D, translation of R&D efforts to technology.	4	T4, R3	Lecture
23	Innovation, types of innovation	4	T4, R3	Tutorial

24	difference between innovation and invention	4	T4, R3	Lecture
25	Framework for management of innovation, organizational characteristics that facilitate innovation,	4	T4, R3	Tutorial
26	Trademarks, copyrights, patents and their use in innovation, management, remedy against infringement,	4	T4, R3	Lecture
27	The role of technology transfer in innovation and new product development, role of government in innovation	4	T4, R3	Lecture
28	globalization and innovations, technology and innovation management.	4	T4, R3	Tutorial
29	Case studies about management of R&D and innovation	4	T4, R3	Group Discussion
30	Integration of people and technology, factors to be considered in technology management	5	T4, R3	Tutorial
31	organizational factors and psychological factors	5	T4, R3	Lecture
32	Organisational structure and technology	5	T4, R3	Lecture
33	implications of technological change	5	T4, R3	Lecture
34	Implementation of rationalization and automation in India, impact of technological change	5	T4, R3	Lecture
35	Human resource management issues in R&D and innovation	5	T4, R3	Tutorial
36	technology assessment and environmental impact analysis	5	T4, R3	Lecture

15. Question Bank

Module 1				
Sl. No	**Question**	**Marks**	**CO**	**BL**
1	Define technology innovation.	3	CO1	L1
2	Outline the importance of data privacy in technology management.	3	CO1	L1
3	List down the advantages of technological competition.	3	CO1	L1
4	List down the disadvantages of technological competition.	3	CO1	L1
5	List down the key elements of technology management.	3	CO1	L1
6	Define process technology.	3	CO1	L1
7	Define product technology.	3	CO1	L1
8	List out some effects of technological changes in recent times, due to global competition in industrial sector	3	CO1	L1
9	What is Industry 4.0? List the three major milestones in industrial development prior to it.	3	CO1	L1
10	What are the major factors, requiring organisations to focus in Technology management?	7	CO1	L2
11	Discuss the major interdependent aspects of manufacturing technology	7	CO1	L2
12	Detail the national level issues in Technology management	7	CO1	L2
13	Distinguish between product technology and process technology	7	CO1	L2
14	Describe the various roles and significance of technology management.	7	CO1	L2
15	Illustrate the correlation between technology and competition in an industry.	7	CO1	L2
16	What is the importance of Enterprise Technology Management?	7	CO1	L2
17	Explain the evolution and growth of technology.	10	CO1	L2
18	With the aid of examples describe the influence of technology on society?	10	CO1	L2

19	Explain with examples the advantages & disadvantages of technological competition.	14	CO1	L2
20	Explain the positive and negative impacts of technology on (a) Society (b) Business	14	CO1	L2
21	Describe technology innovation with an example. How technology innovation drives economic growth? Also explain what are the key issues in managing technological innovation.	14	CO1	L2

Module 2

Sl. No	Question	Marks	CO	BL
1	Recall any three characteristics of technology forecasting.	3	CO2	L1
2	Give some examples of new technology available today in the world.	3	CO2	L1
3	Define technology forecasting.	3	CO2	L1
4	Define technology development.	3	CO3	L1
5	Recall the different processes involved in technology acquisition.	3	CO3	L1
6	Define technology generation.	3	CO3	L1
7	What is the different process of technology generation?	3	CO3	L1
8	What is 'Technology acquisition'?	3	CO3	L1
9	Explain 'technoware' in Technology acquisition	3	CO3	L2
10	Explain the new technologies introduced in the society with the help of examples.	7	CO3	L2
11	Describe the processes involved in the management of acquired technology.	7	CO3	L2
12	Describe the various contents of a Technology transfer agreement	7	CO3	L2
13	How Technology acquisition is justified in an organisation?	7	CO3	L2
14	Explain the need of Technology planning.	7	CO2	L2
15	List out and detail technology forecasting methods	7	CO2	L2
16	Explain Delphi and quantitative methods of forecasting.	10	CO2	L2

17	Explain in detail patent analysis.	10	CO3	L2
18	Describe the different technology forecasting methods and techniques used in industry. Also write down its advantages and disadvantages.	14	CO2	L2
19	Discuss the characteristics and need of technology forecasting.	14	CO2	L2
20	Discuss the steps involved in technology forecasting process. Also illustrate the need and role of technology forecasting.	14	CO2	L2
21	Describe the alternatives for acquiring new technologies.	14	CO3	L2

Module 3

Sl. No	Question	Marks	CO	BL
1	Mention the different factors affecting technology diffusion.	3	CO3	L1
2	Mention the key elements of technology strategy.	3	CO4	L1
3	Outline the importance of technology policies in a country.	3	CO4	L1
4	List down the need for technology strategy in an industry.	3	CO4	L1
5	Discuss the constraints in technology absorption.	3	CO3	L1
6	List out the benefits of technology package	3	CO4	L1
7	List and explain three major needs of an organisation for a technology strategy	3	CO3	L1
8	Name three areas where government approval is required for technology transfer from abroad.	3	CO4	L1
9	What are the issues involved in the management of technology absorption and government initiatives?	7	CO3	L2
10	Differentiate between technology package and technology dependence.	7	CO4	L2
11	What is 'Technology strategy' for an organisation? Explain its needs.	7	CO4	L2
12	Explain the various steps in creating a Technology strategy	7	CO4	L2
13	Describe the organizational level issues in Technology acquisition	7	CO3	L2

14	What are the advantages and disadvantages of Technology acquisition, on a national level?	7	CO3	L2
15	Explain the different stages of technology adoption. Also illustrate the factors affecting the speed and extent of technology adoption.	14	CO3	L2
16	Explain the different stages of technology absorption. Also illustrate the factors affecting the speed and extent of technology absorption.	14	CO3	L2
17	Explain what you mean by technology absorption. Describe the benefits and constraints associated with technology absorption.	14	CO3	L2
18	Describe the key highlights and challenges of the Indian experience in technology absorption.	14	CO3	L2
19	Discuss the different elements of technology strategy with the help of suitable examples.	14	CO4	L2
20	Distinguish between technology adoption and technology diffusion.	14	CO3	L2
21	Name with examples the efforts made by India in technology absorption.	14	CO3	L2

Module 4

Sl. No	Question	Marks	CO	BL
1	List down the importance of Research and Development (R&D) in driving innovation and progress in an industry.	3	CO5	L1
2	List down the importance of corporate research in driving innovation and growth of an organization.	3	CO5	L1
3	Define innovation. Outline the various stages involved in the innovation process.	3	CO5	L1
4	Recall the impact of research and development (R&D) and production cost on the financial performance of a company.	3	CO5	L1
5	Define technology transfer. Identify the primary goals of technology transfer.	3	CO5	L1
6	What is meant by corporate research?	3	CO5	L1
7	How does the production cost and R&D in an organization interrelated?	3	CO5	L1
8	Outline the differences between innovation and invention.	3	CO5	L1

9	List the types of intellectual properties, which can be legally protected	3	CO5	L1
10	Name the categories of products, which are excluded from patent protection	3	CO5	L1
11	Explain the different types of innovations introduced in an organization.	7	CO5	L2
12	Explain the different types of production costs incurred in an organization.	7	CO5	L2
13	Discuss the common remedies against: - (a) trademarks, (b) copyrights and (c) patents.	7	CO5	L2
14	Compare trademarks, copyrights and patents with the help of suitable examples.	7	CO5	L2
15	Summarize any three recent case studies on the management of innovation.	7	CO5	L3
16	Summarize any three case studies on the management of Research and Development (R&D).	7	CO5	L3
17	Explain the role of technology transfer in new product development.	7	CO5	L2
18	Explain the different ways in which a government can support innovation.	7	CO5	L2
19	Describe the different forms of technology transfer.	7	CO5	L2
20	What is product life cycle? Explain the different stages of product life cycle in research.	7	CO5	L2
21	Explain the importance of R&D in an organization.	7	CO5	L2
22	Describe the organizational level issues in R&D management.	7	CO5	L2
23	Which are the focus areas of R&D, in product development?	7	CO5	L2
24	What are the criteria to qualify a new technology for implementation in developing a new product?	7	CO5	L2
25	Discuss the risks associated with innovation.	7	CO5	L2
26	Explain the organizational characters that facilitates innovation.	10	CO5	L2
Module 5				

Sl. No	Question	Marks	CO	BL
1	Name the common elements of the organizational structure in an IT firm.	3	CO6	L1
2	Identify the key human aspects which to be considered in technology management.	3	CO6	L1
3	Outline the implementation of automation process in India.	3	CO6	L1
4	Outline the implementation of rationalization process in India.	3	CO6	L1
5	Write a short note on Environmental Impact Analysis (EIA)	3	CO6	L1
6	Write a short note on technology assessment.	3	CO6	L1
7	What is the role of organization structure in technology management?	3	CO6	L1
8	Which are the important phases, for an effective technology change, in an organisation.	3	CO6	L1
9	Describe the reasons for employee resistance in change initiatives	3	CO6	L2
10	Describe the different organizational factors that influence the success of technology integration.	7	CO6	L2
11	Describe the various psychological factors involved in technology integration.	7	CO6	L2
12	List and narrate the factors necessitating an organisation to go for technological changes.	7	CO6	L1
13	Describe the various steps in effectively managing technological changes	7	CO6	L2
14	Discuss the types of employee resistance and ways to mitigate their effects, during the implementation of technology changes, in an organisation	7	CO6	L2
15	Describe the reasons and advantages of industrial automation	7	CO6	L2
16	Illustrate the various positive and negative implications of technology change on the workforce.	7	CO6	L3
17	Illustrate the different types of organizational structures with the help of examples.	7	CO6	L3

18	Explain the different key Human Resource Management (HRM) issues in R&D organizations.	7	CO6	L2
19	Discuss the impact of technological change in India.	7	CO6	L2
20	What are the psychological implications of technology change at work place?	7	CO6	L2
21	Explain how Environmental Impact Analysis (EIA) and technology assessment are related.	7	CO6	L2

Prepared By: Mr. Avinesh Pyarilal (Subject Faculty)

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Course Code & Name: MET458 Advanced Energy Engineering

1. Prescribed Syllabus

Module	Topic	Hours
1	Introduction to the course, Global and Indian energy resources. Energy demand and supply components, layout and working principles of steam, hydro, nuclear, gas turbine and diesel power plants.	**7**
2	Solar Energy- passive and active solar thermal energy, solar collectors, solar thermal electric systems, solar photovoltaic systems, economics of solar power Wind Energy-Principle of wind energy conversion system, wind turbines, aerodynamics of wind turbines, wind power economics, Introduction to solar-wind hybrid energy	**11**
3	Biomass Energy – Biomass as a fuel, thermo-chemical, bio-chemical and agro-chemical conversion of biomass- pyrolysis, gasification, combustion and fermentation, trans-esterification, economics of biomass power generation, future prospects	**6**
4	Other Renewable Energy sources – Brief account of Geothermal, Tidal, Wave, and MHD power generation. Fuel cells – general description, types, applications. Hydrogen energy conversion systems, hybrid systems- Economics and technical feasibility	**6**
5	Environmental impact of energy conversion – ozone layer depletion, global warming, greenhouse effect, loss of biodiversity, eutrophication, acid rain, air and water pollution, land degradation, thermal pollution, Sustainable energy, promising technologies, development pathways.	**6**

2. Text Books (T)

T1. P K Nag, Power Plant Engineering, TMH, 2002
T2. Jefferson W Tester, Sustainable Energy Choosing among options, PHI, 2006
T3. Tiwari G N, Ghosal M K, Fundamentals of renewable energy sources, Alpha Science International Ltd., 2007

3. Reference Books (R)

R1. David Merick, Richard Marshall, Energy, Present and Future Options, Vol.I & II, John Wiley & Sons, 2001
R2. Godfrey Boyle, Renewable Energy: Power for a Sustainable Future, Oxford University Press, 2012
R3. HerbertE.Merritt, Hydraulic control systems, JohnWiley&Sons, 2012
R4. Roland Wengenmayr, Thomas Buhrke, 'Renewable Energy: Sustainable energy concepts for the future, Wiley – VCH, 2012
R5. Twidell J W and Weir A D, Renewable Energy Resources, UK, E&F.N. Spon Ltd., 2006

4. Course Objectives

a) To give an idea about global energy scenario and conventional energy sources.

b) To understand solar, wind and Biomass energy.

c) To know concepts of other renewable energy sources.

d) To create awareness on the impacts of energy conversion and importance of sustainable energy

5. Course Pre / Co-requisite

Nil

6. Course Outcomes

After completion of the course, student will be able to

CO1: Explain the concept of various types of power generation

CO2: Explain solar and wind power generation and its economics

CO3: Explain biomass energy sources and its economics

CO4: Explain various renewable energy sources

CO5: Explain environmental impacts of various energy generation

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO 3
CO1	**H**	**L**											**M**		
CO2	**H**	**L**			**M**		**M**						**H**		**M**
CO3	**H**	**L**			**M**		**M**						**H**		
CO4	**H**	**M**			**M**		**M**						**H**		
CO5	**H**	**L**	**H**			**M**	**M**						**H**		

8. Justification for CO-PO-PSO Correlation

CO1	PO1	The concept of various types of power generation is used to improve the engineering knowledge. High correlation is due to the fact that this involves the deep knowledge of science, engineering fundamentals, and an engineering specialization to solve the complex engineering problems.
	PO2	The concept of various types of power generation used to identify, formulate and analyse the complex engineering problems. Low correlation is due to the fact that this involves the basic knowledge using first principles of mathematics, science and engineering.

	PSO1	The concept of various types of power generation used to demonstrate the knowledge of concurrent technologies. The medium correlation is due the fact that this involve the practical problems using the principles of sustainable development.
CO2	PO1	The concept of solar and wind power generation is used to improve the engineering knowledge. High correlation is due to the fact that this involves the deep knowledge of science, engineering fundamentals, and an engineering specialization to solve the complex engineering problems.
	PO2	The concept of solar and wind power generation used to identify, formulate and analyse the complex engineering problems. Low correlation is due to the fact that this involves the basic knowledge using first principles of mathematics, science and engineering.
	PO5	The concept of solar and wind power generation used to select, and apply appropriate techniques. The medium correlation is due to the fact that this including prediction and modelling to complex engineering activities with an understanding of the limitations.
	PO7	The concept of solar and wind power generation used to develop sustainable development. The medium correlation is due to the fact that the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
	PSO1	The concept of solar and wind power generation used to demonstrate the knowledge of concurrent technologies. The high correlation is due the fact that this involve the practical problems using the principles of sustainable development.
	PSO3	The concept of solar and wind power generation used to apply principles of modern energy technologies to support multi-disciplinary systems. The medium correlation is due the fact that this involve the principles of mathematics, science and engineering to design and analyse multi-disciplinary systems..
CO3	PO1	The concept of biomass energy resources is used to improve the engineering knowledge. High correlation is due to the fact that this involves the deep knowledge of science, engineering fundamentals, and an engineering specialization to solve the complex engineering problems.
	PO2	The concept of biomass energy resources used to identify, formulate and analyse the complex engineering problems. Low correlation is due to the fact that this involves the basic knowledge using first principles of mathematics, science and engineering.
	PO5	The concept of biomass energy resources used to select, and apply appropriate techniques. The medium correlation is due to the fact that this including prediction and modelling to complex engineering activities with an understanding of the limitations.
	PO7	The concept of biomass energy resources used to develop sustainable development. The medium correlation is due to the fact that the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

	PSO1	The concept of biomass energy resources used to demonstrate the knowledge of concurrent technologies. The high correlation is due the fact that this involve the practical problems using the principles of sustainable development.
CO4	PO1	The concept of various renewable energy sources is used to improve the engineering knowledge. High correlation is due to the fact that this involves the deep knowledge of science, engineering fundamentals, and an engineering specialization to solve the complex engineering problems.
	PO2	The concept of various renewable energy sources used to identify, formulate and analyse the complex engineering problems. Medium correlation is due to the fact that this involves the basic knowledge using first principles of mathematics, science and engineering.
	PO5	The concept of various renewable energy sources used to select, and apply appropriate techniques. The medium correlation is due to the fact that this including prediction and modelling to complex engineering activities with an understanding of the limitations.
	PO7	The concept of various renewable energy sources used to develop sustainable development. The medium correlation is due to the fact that the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
	PSO1	The concept of various renewable energy sources used to demonstrate the knowledge of concurrent technologies. The high correlation is due the fact that this involve the practical problems using the principles of sustainable development.
CO5	PO1	The concept of environmental impacts of various energy generation is used to improve the engineering knowledge. High correlation is due to the fact that this involves the deep knowledge of science, engineering fundamentals, and an engineering specialization to solve the complex engineering problems.
	PO2	The concept of environmental impacts of various energy generation used to identify, formulate and analyse the complex engineering problems. Low correlation is due to the fact that this involves the basic knowledge using first principles of mathematics, science and engineering.
	PO3	The concept of environmental impacts of various energy generation is used to design/development of solutions for complex engineering problems. Medium correlation is due to the fact that this involves the only basic knowledge that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
	PO6	The concept of environmental impacts of various energy generation is relevant to the professional engineering practice. Medium correlation is due to the fact that this involves the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice
	PO7	The concept of environmental impacts of various energy generation used to develop sustainable development. The medium correlation is due to the fact that the impact of the professional engineering solutions in societal and

	environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PSO1	The concept of environmental impacts of various energy generation used to demonstrate the knowledge of concurrent technologies. The high correlation is due the fact that this involve the practical problems using the principles of sustainable development.

9. Curricular gaps (if any)

The concepts explained in this Syllabus is conventional methods only.

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	Renewable energy resources, energy conversion methods and their environmental imapcts	Conduct Seminars	PO1

11. Internal Assessment mark allocation (as per university curriculum)

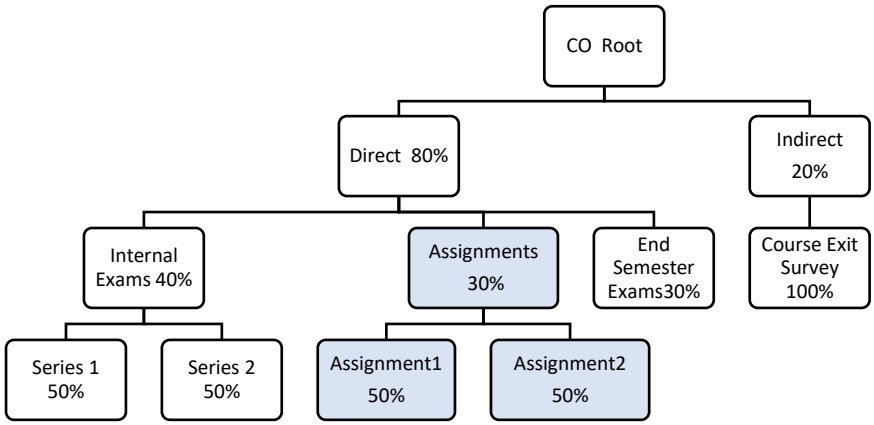
(Provide details as mentioned in syllabus)

Attendance	- 10 marks
Continuous Assessment Test	- 25 marks
Assignment (s)/ Course Project	- 15 marks
Total	- 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools		Weightage#	CO1	CO2	CO3	CO4	CO5
Direct Assessment Tools**	Internal Exam(s) 40%	Series 1	50%	X	X			
		Series 2	50%			X	X	X
	Assignment (s)/ Course Project /Quiz etc. 30%	Assignment 1	50%	X	X		X	
		Assignment 2	50%			X	X	X
	End Semester Exam		30%	x	x	x	x	x
Indirect Assessment Tool	Course Exit Survey		100%	x	x	x	x	x

13. Assessment Configuration



14. Course Plan

Sl.no	Topic Name	Reference	Module	Teaching Pedagogy
1	Introduction to the course, Global and Indian energy resources. Energy Demand and supply.	T1, R1, R5	1	Lecture
2	Components, layout and working principles of steam power plant Site selection of steam power plant	T1, R1, R5	1	Lecture
3	Coal and ash circuit, Air and Flue gas circuit, feed water and steam flow circuit, cooling water circuit of steam power plant	T1, R1, R5	1	Lecture
4	Diesel engine used for diesel power plant, selection of engine	T1, R1, R5	1	Lecture
5	Components, layout and working principles of hydroelectric power plant, site selection	T1, R1, R5	1	Lecture
6	Components, layout and working principles of nuclear power plant, site selection	T1, R1, R5	1	Tutorial
7	Components, layout and working principles of gas turbine power plant,	T1, R1, R5	1	Lecture
8	Classification, site selection of gas turbine power plant, Fuels, Materials , open and closed cycles	T1, R1, R5	1	Tutorial
9	Solar Energy- introduction, geometry, radiation	T3, R4	2	Lecture
10	passive and active solar thermal energy, measurement of solar radiation	T3, R4	2	Lecture
11	solar collectors,	T3, R4	2	Lecture
12	solar thermal electric systems	T3, R4	2	Tutorial
13	solar photovoltaic systems	T3, R4	2	Lecture
14	Economics of solar power	T3, R4	2	Tutorial

15	Wind Energy-Principle of wind energy conversion system, application of wind power, Wind Characteristics, availability and measurement	T3, R4	2	Lecture
16	wind turbines	T3, R4	2	Lecture
17	aerodynamics of wind turbines	T3, R4	2	Lecture
18	wind power economics	T3, R4	2	Tutorial
19	Introduction to solar-wind hybrid energy	T3, R4	2	Tutorial
20	Biomass Energy â€“ Biomass as a fuel	T3, R4	3	Lecture
21	thermo-chemical, bio-chemical and agro-chemical conversion of biomasspyrolysis	T3, R4	3	Lecture
22	thermo-chemical, bio-chemical and agro-chemical conversion of biomasspyrolysis	T3, R4	3	Lecture
23	gasification, combustion and fermentation, transesterification	T3, R4	3	Tutorial
24	economics of biomass power generation	T3, R4	3	Lecture
25	future prospects	T3, R4	3	Tutorial
26	Other Renewable Energy sources â€“ Geothermal	T3, R4	4	Lecture
27	Other Renewable Energy sources â€“ Tidal , Wave	T3, R4	4	Lecture
28	MHD power generation.	T3, R4	4	Lecture
29	Fuel cells â€“ general description, types, applications.	T3, R4	4	Lecture
30	Hydrogen energy conversion systems	T3, R4	4	Tutorial
31	hybrid systems	T3, R4	4	Lecture
32	Economics and technical feasibility	T3, R4	4	Tutorial
33	Environmental impact of energy conversion Sources and effects of air pollution	T3, R2	5	Lecture
34	ozone layer depletion, global warming, greenhouse effect, Acid rain, petro chemical smog	T3, R2	5	Lecture
35	Water pollution , land degradation, biodiversity, loss of biodiversity	T3, R2	5	Lecture
36	Thermal pollution	T3, R2	5	Lecture
37	Control of atmospheric pollution by thermal power plants-control devices for particulate contaminants	T3, R2	5	Tutorial

38	Boiler act, inspection , performance, boiler safety regulations	T3, R2	5	Lecture
39	Control of atmospheric pollution by thermal power plants- automatic controls of feed water, instruments to monitor pollution	T3, R2	5	Lecture
40	Sustainable energy, promising technologies, development pathways`	T3, R2	5	Tutorial
41	Nuclear waste disposal and safety	T3, R2	5	Tutorial

15. Question Bank

Module 1				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	What are the renewable energy resources? Discuss their importance in India's power requirement contest.	3	CO1	L2
2	Explain briefly global energy resources.	3	CO1	L1
3	What are the three main factors for power output of hydroelectric plant?	3	CO1	L1
4	What are the difference between a pressurized water reactor nuclear power plant and boiling water reactor nuclear power plant?	3	CO1	L2
5	What are the advantages and disadvantages of nuclear power plant?	3	CO1	L2
6	Explain the various types of cooling system used in diesel power plant. Name and explain briefly the various types of fuel injection system.	3	CO1	L2
7	Discuss the essential factors which should be considered while selecting a site for a hydroelectric power plant?	4	CO1	L2
8	Mention any two drawbacks of a stationary gas turbine power plant for generation of electricity.	4	CO1	L1
9	What is the purpose of air intake system in a diesel engine power plant?	4	CO1	L1
10	List the factors which should be considered while designing a power plant.	4	CO1	L2
11	Discuss the various factors to be considered while selecting the site for nuclear power station.	4	CO1	L2
12	Draw an explanatory line diagram of an ash handling system employed in steam power plants and also explain the difficulties encountered in the handling of ash in a thermal power station. Explain the difficult types of coal handling process.	4	CO1	L2

13	Discuss the components and working of Thermal Power Plant with a layout. Also explain the advantages and disadvantages of Thermal power plant?	10	CO1	L2
14	Give the schematic layout of a gas turbine power plant and explain it's working with the help of Brayton cycle.	10	CO1	L2
15	17. Sketch the layout of hydroelectric power plant and explain the functions of each component in it. Discuss the advantages and limitations of this plant.	10	CO1	L2
16	Explain the components construction and working of Nuclear Power Plant with a layout. What are the advantages and disadvantages of nuclear power plant?	10	CO1	L2
17	What are the methods used for improving the efficiency of a gas turbine plant? Explain the working of any one type of combustion chamber used in gas turbine plant?	10	CO1	L2
18	Give the layout of diesel engine power plant. What are the advantages and disadvantages of diesel power plants? Describe briefly the commonly used starting system in large and medium size engines.	10	CO1	L2
19	Describe the auxiliary equipment of a diesel engine power plant. What are the disadvantages of this plant? Auxiliary equipment area. Pneumatic starter b. Air compressor. c. Air conditions and d. coolant circulation pump.	10	CO1	L2
20	How do Industry Nation and Globe would benefit from energy efficiency programs.	10	CO1	L3

Module 2

Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	Mention the applications of solar energy.	3	CO2	L1
2	State the various characteristics features of a solar collector system.	3	CO2	L1
3	State any advantages and disadvantages of solar air heaters.	3	CO2	L2
4	Differentiate between solar beam radiation and diffuse radiation.	3	CO2	L2
5	How are solar air heaters classified?	3	CO2	L1
6	State the advantages of photovoltaic solar energy conversion.	3	CO2	L1
7	Briefly discuss any three applications of solar PV systems.	3	CO2	L2
8	Distinguish between active and passive solar energy systems.	3	CO2	L2
9	What do you mean by coefficient of performance and tip speed ratio of wind turbines?	3	CO2	L2

10	What range of wind speed is considered favourable for wind power generation?	3	CO2	L2
11	Explain aerodynamics of wind turbines?	3	CO2	L2
12	Explain any two hybrid wind power plants mainly used these days.	3	CO2	L2
13	Mention the various environmental impacts of wind energy systems.	3	CO2	L2
14	Briefly discuss wind data and wind data measurement.	3	CO2	L1
15	In a wind energy power plant, how the wind energy estimation is done?	3	CO2	L2
16	List the components of a wind energy conversion system and explain its working.	3	CO2	L1
17	Differentiate between passive and active solar energy systems with neat sketches.	4	CO2	L2
18	Explain the working of low temperature thermal power generation plant with neat sketch.	4	CO2	L2
19	What are the advantages and disadvantages of concentrating collectors over flat plate type collectors?	4	CO2	L2
20	Briefly explain the temperature system with flat plate collector in solar power plants	4	CO2	L2
21	Explain the analysis of a central receiver system?	4	CO2	L2
22	Write short note on sustainability attributes of solar power.	4	CO2	L1
23	Explain the construction and configuration of solar cells	4	CO2	L2
24	Briefly explain solar PV systems.	4	CO2	L2
25	Explain the principle of wind energy conversion	4	CO2	L1
26	What are the main considerations while selecting a site for wind energy converters?	4	CO2	L1
27	Explain the construction and working of horizontal axis wind turbine with the help of neat sketches	4	CO2	L2
28	Write notes on solar wind hybrid systems	4	CO2	L2
29	Discuss the environmental impacts of wind turbines	4	CO2	L2
30	Define lift and drag forces of wind energy	4	CO2	L2
31	What are the types of wind turbines	4	CO2	L1
32	Write down the factors to be considered for selecting the site to install wind mills.	4	CO2	L2
33	What are the advantages and disadvantages of wind power? Discuss the industrial applications of wind power systems.	4	CO2	L2
34	Enumerate working of wind energy systems for community centres, schools and health clinic.	4	CO2	L3

35	List the different methods used to estimate wind speed at a location.	4	CO2	L1
36	What do you mean by (1) Yaw control (2) Rated wind speed with respect to wind turbines?	4	CO2	L2
37	Describe the economics of solar power.	5	CO2	L2
38	Explain the advantages and disadvantages of wind energy conversion system	6	CO2	L2
39	Discuss the advantages of vertical axis wind turbines over horizontal axis wind turbines	6	CO2	L2
40	Explain the working of photo voltaic systems with neat sketches. List out the advantages and disadvantages of photovoltaic cells.	10	CO2	L2
41	Illustrate commonly used solar thermal energy systems and its applications.	10	CO2	L2
42	Explain with neat sketch working of a distributed trough solar power plant	10	CO2	L2
43	Explain the working of solar flat plate collector. Also explain the factors affecting the performance of flat plate collector.	10	CO2	L2
44	What are vertical axis wind turbines? Explain the construction and working of any one type of vertical axis wind turbine with the help of neat sketches	10	CO2	L2
45	Discuss the various components of wind energy systems	10	CO2	L2
46	Explain the working of Horizontal axis and vertical axis wind turbine with neat sketch.	10	CO2	L2
47	With neat sketch explain the working of Solar wind hybrid energy systems.	10	CO2	L2
Module 3				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	Explain the process Photosynthesis. What are the conditions necessary for it?	3	CO3	L2
2	Explain the methods used for ethanol production.	3	CO3	L1
3	"Energy released from biomass, comes from sun', elaborate on this point.	3	CO3	L2
4	What is the advantage of converting bio mass to other forms over methods, where it is burnt directly?	3	CO3	L2
5	Biomass can be considered as a form of solar energy'. Discuss	4	CO3	L2
6	Explain the category of biomass resources	4	CO3	L2
7	What are bio-fuels? Explain the classification of bio-fuels	4	CO3	L2

8	List the advantages and disadvantages of a floating drum biogas plant	4	CO3	L2
9	Explain the biochemical and thermochemical methods of biomass conversion	4	CO3	L2
10	What is the difference between biomass and biogas?	4	CO3	L2
11	List the advantages and disadvantages of a fixed dome biogas plant	4	CO3	L1
12	Explain trans esterification	4	CO3	L1
13	Explain fermentation and pyrolysis	4	CO3	L1
14	What is gasification and liquefaction?	4	CO3	L1
15	Describe the steps involved in designing a digester for biogas production. Enumerate the factors affecting digestion process.	4	CO3	L2
16	Explain the process a. Gasification of biomass b. Commercial production of ethanol from biomass c. Production of biogas from biomass.	4	CO3	L2
17	Explain the working of continuous process biogas plant with neat sketch?	4	CO3	L2
18	Explain thermo-chemical, bio-chemical and agro-chemical conversion of biomass?	4	CO3	L2
19	Explain the difference between fixed dome type and floating dome type biogas plant.	4	CO3	L2
20	Explain with neat sketch the working of steam turbine cogeneration systems.	4	CO3	L2
21	What is the difference between biomass and biogas?	4	CO3	L2
22	What are the biomass energy conversion process? Also explain the advantages and disadvantages?	5	CO3	L2
23	Discuss any two methods of biodiesel production with their neat sketches.	5	CO3	L2
24	How does the production of biomass and ethanol affect the environment?	5	CO3	L2
25	Explain the constructional details and working of a floating gas holder digester with the help of a neat sketch	7	CO3	L2
26	Explain the constructional details and working of a fixed dome digester with the help of a neat sketch	7	CO3	L2
27	Write short note on future prospects of biomass power generation.	7	CO3	L1
28	Explain the construction and working of KVIC (floating type) bio gas plant	7	CO3	L2
29	Write a short note on gasification of biomass?	7	CO3	L1
Module 4				

Sl. No.	Question	Marks	CO	BL
1	Describe the working of polymer electrolyte membrane fuel cell with a neat sketch.	3	CO4	L2
2	Explain the advantages and disadvantages of Hydropower?	3	CO4	L2
3	Name the different process used for hydrogen production.	3	CO4	L1
4	Discuss briefly about the different geo thermal energy resources	3	CO4	L2
5	Comment on the possibilities of hydrogen as a potential energy carrier in future.	4	CO4	L2
6	List out the various environmental impacts of setting up hydroelectric power plant.	4	CO4	L1
7	What are the disadvantages of using geothermal energy?	4	CO4	L2
8	What are the chemical reactions involved in hydrogen-oxygen fuel cells?	4	CO4	L2
9	List any four applications of fuel cells	4	CO4	L1
10	Explain the working of any two wave energy conversion devices.	7	CO4	L2
11	Give the working of geothermal power plant. What are the environmental impacts of geothermal energy?	7	CO4	L2
12	Write a short note on a. Problems in tidal power generation. b. Impact of tidal energy on environment. c. Site selection for tidal power plants.	7	CO4	L2
13	Describe the various fuels used in fuel cells along with chemical reactions involved?	7	CO4	L2
14	Explain the working of any one type of wave energy conversion system with the help of a neat sketch.	7	CO4	L2
15	With a neat sketch explain the working of a liquid dominated geothermal power plant.	7	CO4	L2
16	With a schematic layout describe hot dry rock system of geothermal energy?	7	CO4	L2
17	Explain the components of a Tidal power plants.	7	CO4	L2
18	Briefly explain different components of small, mini and micro hydroelectric power system and their design consideration.	10	CO4	L2
19	Explain the different types of geothermal energy systems? What are the merits and demerits?	10	CO4	L2
20	What are the different tidal energy technologies? What are the advantages and limitations of tidal power generation?	10	CO4	L2

21	Discuss the combined MHD gas turbine power plant with neat sketch?	10	CO4	L2
22	How does fuel cells work? What are the advantages and disadvantages? Also explain Hydrogen energy conversion systems?	10	CO4	L2
23	With the help of a neat sketch explain the working principle of fuel cells and also its different applications.	10	CO4	L2
Module 5				
Sl. No.	**Question**	**Marks**	**CO**	**BL**
1	Describe the environment impact of energy utilization in India?	3	CO5	L2
2	Discuss the cause and effect of eutrophication.	3	CO5	L2
3	Explain the pollution and pollution control technologies for thermal (coal) power plant.	3	CO5	L2
4	Explain how eutrophication affects aquatic life	3	CO5	L2
5	Elaborate on the phenomenon of ozone depletion.	3	CO5	L2
6	What are eutrophication? Why is it undesirable?	3	CO5	L2
7	What is sustainable energy?	4	CO5	L1
8	What do you mean by smog?	4	CO5	L1
9	List some of the common sources of land degradation	4	CO5	L1
10	Explain global environmental issues.	7	CO5	L2
11	Explain the harmful effect of CO2, CO, compounds of sulphur and oxides of nitrogen.	7	CO5	L2
12	Explain the effect and impact of greenhouse effect.	7	CO5	L2
13	How acid rain is formed? Explain its impact on environment.	7	CO5	L2
14	Explain the aftereffects of land filling?	7	CO5	L2
15	Describe causes for the loss of bio-diversity due to energy conversion process.	7	CO5	L2
16	Explain briefly about the conditions which will lead to acid rain and also the harmful effects of acid rain.	7	CO5	L2
17	What is cause for the loss of biodiversity and how is biodiversity protected?	7	CO5	L2
18	What is thermal pollution? List the harmful effects of thermal pollution.	7	CO5	L1
19	Describe the actions to be taken for sustainability of energy.	7	CO5	L2
20	Describe any six causes for the loss of biodiversity	7	CO5	L2
21	Explain the causes and effects of enhanced greenhouse effect	7	CO5	L2

22	Describe the following terms a. Ozone layer depletion b. Global warming and Greenhouse effect c. Land degradation d. Acid rain and air pollution	10	CO5	L2
23	What are the major causes of air pollutants? Explain Water Act and Air act? Enumerate various methods to control air pollution.	10	CO5	L2
24	Define Global warming. What are the reasons for Global warming?	10	CO5	L2

Prepared By : Arun V, Course Faculty

Checked By : Asha K R, Subject Group Coordinator

Approved by : Dr. Ramadas T, HoD (ME)

Course Code & Name: MET404 Comprehensive Course Viva

1. Prescribed Syllabus

Nil

2. Text Books (T)

Nil

3. Reference Books (R)

Nil

4. Course Objectives

The objective of this Course viva is to ensure the basic knowledge of each student in the most fundamental core courses in the curriculum. The viva voce shall be conducted based on the core subjects studied from third to eighth semester. This course helps the learner to become competent in placement tests and other competitive examinations

5. Course Pre / Co-requisite

Nil

6. Course Outcomes

Students will be able to
CO1: Effectively comprehend the knowledge gained in the specified courses.
CO2: Comprehend the question asked and answer them with confidence.

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	H	H							M	M		M	M	M	
CO2	H	H							M	H		M	M	M	

8. Justification for CO-PO-PSO Correlation

CO	PO	Justification
CO1	PO1	Comprehensive knowledge gained from mathematics and engineering fundamentals contribute to solving complex engineering problems

	PO2	Comprehensive knowledge gained in basic courses relevant to the computer science branch contribute to identify, formulate, review research literature, and analyze complex engineering problems
	PO9	Comprehensive knowledge gained in basic computer science courses will enable the student to become a productive member of a design team
	PO10	Comprehensive knowledge gained in basic courses in computer science contribute to demonstrate knowledge and understanding of the engineering principles and apply these to one's own work.
	PO12	The student will become aware of the need for lifelong learning and the continued upgrading of technical knowledge
	PSO1	Comprehensive knowledge in various domains of computer science helps the student to design and develop computer programs based on the demands of the society
	PSO2	Comprehensive knowledge in various domains of computer science helps the student to identify a suitable career path
CO2	**PO1**	Comprehensive knowledge gained from mathematics and engineering fundamentals contribute to interpret engineering problems and communicate solutions convincingly
	PO2	Students will have the ability to understand complex questions, analyze the given scenario, and respond effectively with confidence.
	PO9	Comprehensive knowledge gained in basic computer science courses will enable the student to effectively interpret and address challenges, whether working independently or collaboratively
	PO10	Students will be able to articulate ideas clearly and effectively in professional and societal contexts using the knowledge gained in basic courses in computer science
	PO12	Students will be able to seek new knowledge, engage in problem-solving, and adapt to emerging challenges throughout their careers
	PSO 1	Comprehensive knowledge in various domains of computer science helps the student to design and develop computer programs based on the demands of the society
	PSO 2	Comprehensive knowledge in various domains of computer science helps the student to identify a suitable career path

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Nil

11. Internal Assessment mark allocation (as per university curriculum)

(Provide details as mentioned in syllabus)

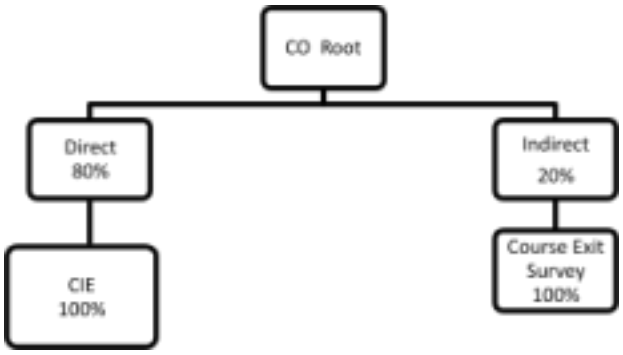
Continuous Internal Evaluation - 50 marks

Total - 50 marks

12. **Assessment – CO Mapping** (Put‘ x’ if mapping is present)

	Tools	**Weightage #**	**CO1**	**CO2**
Direct Assessment Tools	Continuous Internal Evaluation	100%	x	x
Indirect Assessment Tool	Course Exit Survey	100%	x	x

13. Assessment Configuration



Prepared By : Kuriakose V Thundiyil

Checked By : Prof. Arun V, Chairperson

Approved By : Prof. Kanaka Xavier, VP Academics

Course Code & Name: MED416 PROJECT PHASE 2

1. Prescribed Syllabus

Module	Topic	Hours
1	Identify suitable project relevant to the branch of study. Form project team (not exceeding four students). The students can do the project individually also. Identify a project supervisor. Present the project proposal before the assessment board (excluding the external expert) and get it approved by the board. (1) Literature survey (2) Formulation of objectives (3) Formulation of hypothesis/design/methodology (4) Formulation of work plan (5) Seeking funds (6) Detailed Analysis/ Modeling / Simulation/ Design/ Problem Solving/Experiment as needed. (7) Final development of product/ process, testing, results, conclusions and future Directions (8) Preparing a report in the standard format for being evaluated by the Department	**12 per Week**

2. Text Books (T)

Not specified in syllabus.

3. Reference Books (R)

R1. Minimum 5 SCI Indexed journals
WEB SOURCE REFERENCES:
W1 http://www.sciencedirect.com
W2 https://www.springer.com/in
W3 https://www.asme.org/
W4 https://www.aiaa.org/

4. Course Objectives

- To apply engineering knowledge in practical problem solving.
- To foster innovation in design of products, processes or systems.
- To develop creative thinking in finding viable solutions to engineering problems

5. Course Pre / Co-requisite

Nil

6. Course Outcomes

Upon completion of the course the students will be able to

CO1: Model and solve real world problems by applying knowledge across domains (Cognitive knowledge level: Apply).

CO2: Develop products, processes or technologies for sustainable and socially relevant applications (Cognitive knowledge level: Apply).

CO3: Function effectively as an individual and as a leader in diverse teams and to comprehend and execute designated tasks (Cognitive knowledge level: Apply).

CO4: Plan and execute tasks utilizing available resources within timelines, following ethical and professional norms (Cognitive knowledge level: Apply).

CO5: Identify technology/research gaps and propose innovative/creative solutions (Cognitive knowledge level: Analyse).

CO6: Organize and communicate technical and scientific findings effectively in written and oral forms (Cognitive knowledge level: Apply).

7. Mapping of Course Outcomes with Program Outcomes and Program Specific Outcomes

PO/ CO	PO 1	PO 2	PO 3	PO 4	PO5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO 3
CO1	M	M	M	L	M	M	M	L	L	L	L	M	H		
CO2	M	M	M		L	H	M	L	L		L	L	H		
CO3									H	M	M	L		M	
CO4					M			H	M	M	H	M	H		
CO5	M	H	H	L	M							L			H
CO6					M			M	M	H	L	L		M	

8. Justification for CO-PO-PSO Correlation

CO	PO	Justification
	PO1	Moderately mapped as the students will be able to use the fundamental knowledge of mathematics, science and engineering to solve the problems related to project work and present it before an audience
	PO2	Moderately mapped as the students will be able to Identify, formulate and research literature to analyze a current topic of professional interest and conduct a detailed study on the evolution of it and suggest alternatives or fresh designs.

CO1	PO3	Moderately mapped as the students will be able to design projects aiming social responsibilities, minimized health impacts and meeting customer requirements.
	PO4	Slightly mapped as Students will be able to conduct experiments, interpret and analyse data, synthesize the information to analyse a current topic of professional interest
	PO5	Moderately mapped as the students will be able to use the modern tool for project to Create, select, and apply relevant approaches, resources, and current engineering and IT tools, such as modelling and prediction, to complicated engineering tasks while understanding their constraints
	PO6	Moderately mapped as the students able to assess societal, health, safety, legal, and cultural issues and the resulting obligations pertinent to the professional practise of engineering project by using reasoning informed by contextual knowledge.
	PO7	Moderately mapped as the students able to demonstrate understanding of, and the need for, sustainable development, and to comprehend the impact of l engineering project solutions in societal and environmental contexts.
	PO8	Slightly mapped as Students able to apply ethical concepts and commit to professional ethics, duties, and engineering practise norms.
	PO9	Slightly mapped as Students can able to work well both independently and as a team member or leader in a variety of project contexts
	PO10	Slightly mapped as Students able to communicate well with other engineers and with the rest of society about complex engineering projects. For example, they should be able to understand and write good reports and design documentation, and can give good presentations.
	PO11	Slightly mapped as Students able to apply knowledge and understanding of engineering and management principle as a team member and leader, to manage projects
	PO12	Moderately mapped as the students able to understand the importance of project, and be prepared for, autonomous, lifelong learning in the fullest sense of technological development.
	PSO1	Knowledge on fundamental principles of engineering will enable students to model and analyse real life civil engineering problems
	PO1	Moderately mapped as the students able to apply the knowledge of mathematics, science and engineering to Develop products, processes or technologies for sustainable and socially relevant projects
	PO2	Moderately mapped as the students will be able to develop design methodologies for the project to be developed
	PO3	Moderately mapped as the students will be able to detailed design for each component in the project system.
	PO5	Slightly mapped as the students will be able to find the relevant tools to implement the problem stated
	PO6	Strongly mapped as the students will be able to find solution for some societal needs.
	PO7	Strongly mapped as the students will be able to finds solutions for environmental safety.

CO2	PO8	Slightly mapped as the students will be able to apply ethical principles and commit to professional ethics
	PO9	Slightly mapped as the students will be able to work as a team and present their work carried out
	PO11	Slightly mapped as the students will be able to manage the various phases of project development
	PO12	Slightly mapped as the students will be able to apply the communication and interpersonal skills acquired in their professional career
	PSO1	Knowledge on fundamental principles of engineering will enable students to develop sustainable products/technology with socially relevant applications.
CO3	PO9	Strongly mapped as the students will be able to work as a team and present their work carried out.
	PO9	Moderately mapped as the students will be able to present their work carried out.
	PO11	Moderately mapped as the students will be able to manage the various phases of project development with financial constraints
	PO12	slightly mapped as the students will be able to apply the communication and interpersonal skills acquired in their professional career.
	PS02	Students will be able to interact effectively with engineers from other disciplines regarding sustainable solutions for the benefit of society.
CO4	PO5	Moderately mapped as the students able to Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools with in the timeline, adhering to ethical and professional standards.
	PO8	Highly mapped as the students able to apply the ethical concepts and adhere to the engineering profession's professional ethics, obligations, and standards
	PO9	Moderately mapped as the students able to Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools to complex engineering activities with an understanding of the limitations of its function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
	PO10	Moderately mapped the students able to Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools for effective communication on complex engineering activities with the engineering community and write effective reports and design documentation, make effective presentations, and give and receive clear instructions
	PO11	Highly mapped the students able to Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools to demonstrate the knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments

	PO12	Moderately mapped the students to able to create, select, and employ relevant approaches, resources, and current engineering and IT technologies in order to engage in independent and lifelong learning in the broadest context of technological change.
	PS01	Knowledge of engineering fundamentals helps the students to plan and execute task within the time using professional norms
CO5	PO1	Moderately mapped as the students able Apply the knowledge of mathematics, science, engineering fundamentals to Identify technology/research gaps and propose innovative/creative solutions
	PO2	Highly mapped the students able to Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools to identify the research gap and propose creative solutions
	PO3	Highly mapped as the students able to Design solutions for complex engineering problems and design system components that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations and propose innovative solution
	PO4	Slightly mapped the students able use research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions for the research problem
	PO5	Moderately mapped as the students able to Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools to identify the research gap and propose creative solutions
	PO12	Slightly mapped as students should be able to find research gaps and come up with creative solutions. They should also be able to learn on their own and continue to do so as technology changes.
	PS03	By applying modern engineering tools enable the students to create innovative solutions for complex problems
CO6	PO5	Moderately mapped the students capable to apply appropriate techniques, resources, and current engineering and IT tools to organise and communicate effectively in writing and orally technical and scientific findings.
	PO8	Moderately mapped as the students will be able to apply ethical principles and agree to professional ethics, responsibilities, and norms of engineering practise. This will allow them to effectively organise and communicate technical and scientific findings in written and spoken forms.
	PO9	Moderately mapped students are able to perform effectively as individuals, as members or leaders of varied teams, and in multidisciplinary contexts.
	PO10	Strongly mapped the students able to Communicate effectively on complex engineering activities with the engineering community and with society in general. This includes being able to comprehend and write effective reports and design documentation, making effective presentations, and giving and receiving clear instructions for organising and communicating technical and scientific findings effectively in written and oral forms.
	PO11	Slightly mapped the students will be able to organise and talk about technical and scientific findings in a clear way, both in writing and in person. They will also be able to show that they know and understand engineering and management principles in order to run projects and work in multidisciplinary settings.

	PO12	Slightly mapped Students will be able to organise and talk about technical and scientific findings in a clear way, both in writing and in person. They will also be able to learn on their own and for the rest of their lives in the broadest context of technological change.
	PS02	Enable the students to interact with engineers from other disciplines to organise technical findings effectively.

9. Curricular gaps (if any)

Nil

10. Course Enrichment Activities*

Sl No	Description	Proposed Activities **	Relevance to POs and PSOs
1	Nil		

11. Evaluation Criteria (as per university curriculum)

(Provide details as mentioned in syllabus)

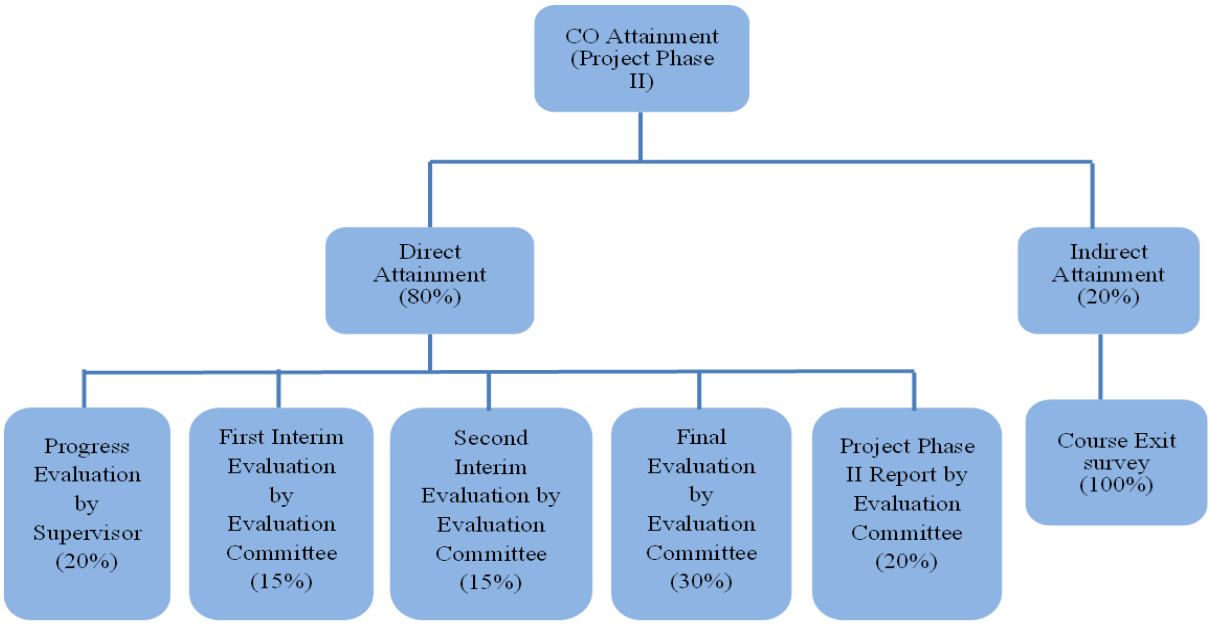
Total: 150 marks (Minimum required to pass: 75 marks).

- Project progress evaluation by guide: 30 Marks.
- Two interim evaluations by the Evaluation Committee: 50 Marks (25 marks for each evaluation).
- Final evaluation by the Final Evaluation committee: 40 Marks
- Quality of the report evaluated by the evaluation committee: 30 Marks

12. Assessment – CO Mapping (Put‘ x’ if mapping is present)

Assessment	Tools**	Weightage#	CO1	CO2	CO3	CO4	CO5	CO6
Direct Assessment	**Progress Evaluation**	**20%**	**x**	**x**	**x**	**x**	**x**	**x**
	Interim Evaluation	**30%**	**x**		**x**	**x**	**x**	**x**
	Final Evaluation	**30%**	**x**	**x**	**x**	**x**	**x**	**x**
	Report	**20%**						**x**
Indirect Assessment Tool	**Course Exit Survey**	**100%**	**x**	**x**	**x**	**x**	**x**	**x**

13. Assessment Configuration



Prepared By : Arun V , Course Faculty

Checked By : Dr. Ramadas T , Subject Group Coordinator

Approved by : Dr. Ramadas T, HoD (ME)