RSET
RAJAGIRI SCHOOL OF ENGINEERING & TECHNOLOGY (AUTONOMOUS)

Department of Mechanical Engineering

RSET VISION

To evolve into a premier technological and research institution, moulding eminent professionals with creative minds, innovative ideas and sound practical skill, and to shape a future where technology works for the enrichment of mankind.

RSET MISSION

To impart state-of-the-art knowledge to individuals in various technological disciplines and to inculcate in them a high degree of social consciousness and human values, thereby enabling them to face the challenges of life with courage and conviction.

DEPARTMENT VISION

To evolve into a centre of excellence by imparting professional education in mechanical engineering with a unique academic and research ambience that fosters innovation, creativity and excellence.

DEPARTMENT MISSION

- *To have state-of-the-art infrastructure facilities.*
- *To have highly qualified and experienced faculty from academics, research organizations and industry.*
- *To develop students as socially committed professionals with sound engineering knowledge, creative minds, leadership qualities and practical skills.*

PROGRAMME EDUCATIONAL OBJECTIVES

PEO 1: Demonstrate the ability to analyse, formulate and solve/design engineering/real life problems based on his/her solid foundation in mathematics, science and engineering..

PEO 2: Showcase the ability to apply their knowledge and skills for a successful career in diverse domains viz., industry/technical, research and higher education/academia with creativity, commitment and social consciousness.

PEO 3: Exhibit professionalism, ethical attitude, communication skill, team work, multidisciplinary approach, professional development through continued education and an ability to relate engineering issues to broader social context.

PROGRAMME OUTCOMES

1) **Engineering Knowledge:** Apply the knowledge of Mathematics, Science, Engineering fundamentals, and Mechanical Engineering 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.

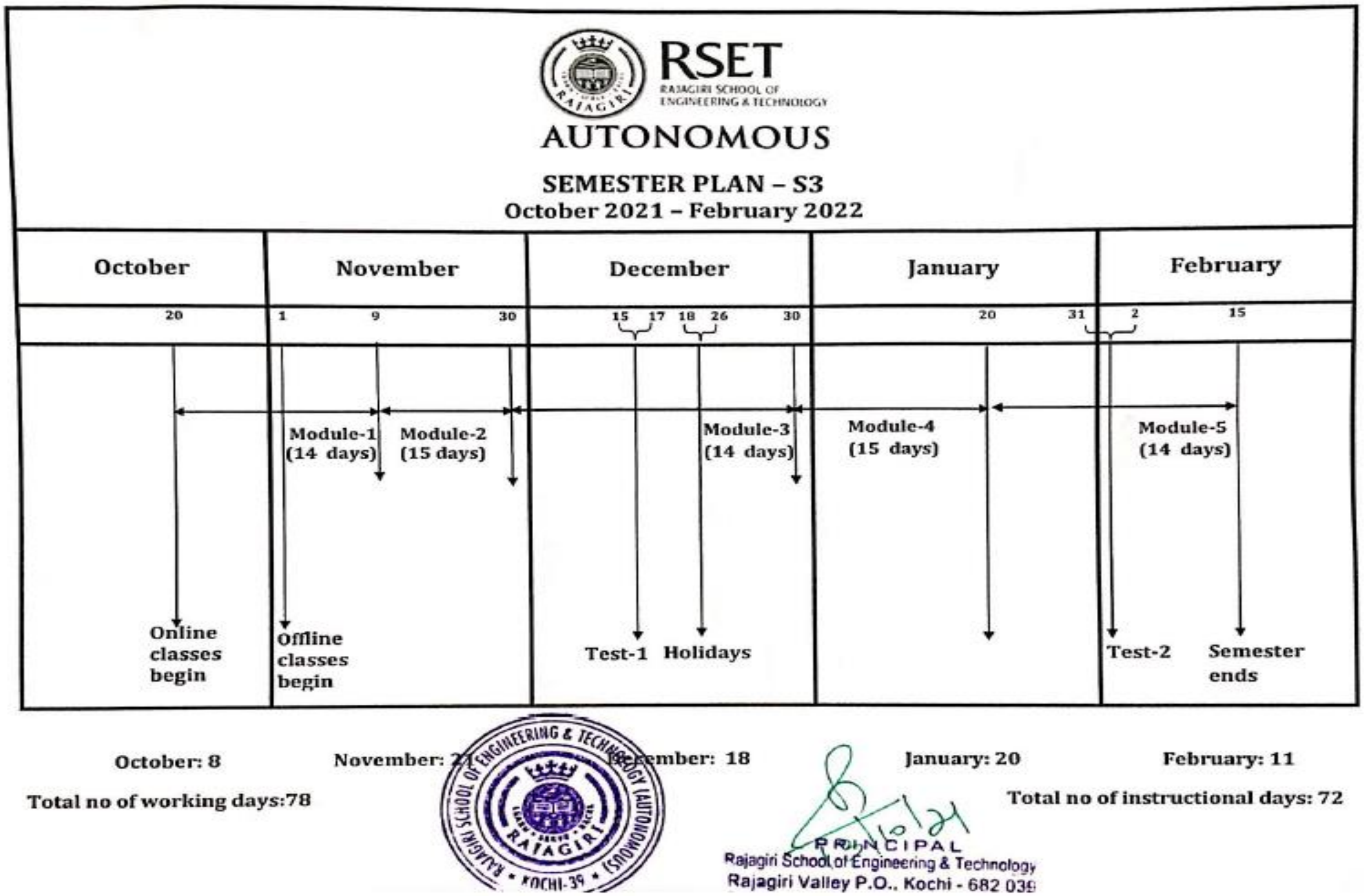
4) **Conduct investigations of complex problems:** Use research based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5) **Modern tool usage:** Create, select, and apply appropriate techniques, 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 the need for sustainable developments.
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 multi-disciplinary 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.

PROGRAMME SPECIFIC OUTCOMES

Mechanical Engineering Programme Students will be able to:

1) Apply their knowledge in the domain of engineering mechanics, thermal and fluid sciences to solve engineering problems utilizing advanced technology.
2) Successfully apply the principles of design, analysis and implementation of mechanical systems/processes which have been learned as a part of the curriculum.
3) Develop and implement new ideas on product design and development with the help of modern CAD/CAM tools, while ensuring best manufacturing practices.

SEMESTER PLAN



ASSIGNMENT SCHEDULE	
Week 4	100905/MA300 A Partial Differential Equation And Complex Analysis
Week 5	100006/ME300B Mechanics of Solids
Week 5	100006/ME300C Mechanics of Fluids
Week 6	100006/ME300D Metallurgy And Material Science
Week 7	100908/CO900E Design And Engineering
Week 8	100908/CO300F Sustainable Engineering
Week 8	100905/MA300 A Partial Differential Equation And Complex Analysis
Week 9	100006/ME300B Mechanics of Solids
Week 9	100006/ME300C Mechanics of Fluids
Week 12	100006/ME300D Metallurgy And Material Science
Week 12	100908/CO900E Design And Engineering
Week 13	100908/CO300F Sustainable Engineering

SCHEME

SEMESTER III

COURSE CODE	COURSE NAME	L-T-P	HOURS	CREDIT
100905/MA300A	PARTIAL DIFFERENTIAL EQUATION AND COMPLEX ANALYSIS	3-1-0	4	4
100006/ME300B	MECHANICS OF SOLIDS	3-1-0	4	4
100006/ME300C	MECHANICS OF FLUIDS	3-1-0	4	4
100006/ME300D	METALLURGY AND MATERIAL SCIENCE	3-1-0	4	4
100908/CO900E	DESIGN AND ENGINEERING	2-0-0	2	2
100908/CO300F	SUSTAINABLE ENGINEERING	2-0-0	2	--
100006/ME322S	COMPUTER AIDED MACHINE DRAWING	0-0-3	3	2
100006/ME322T	MATERIALS TESTING LAB	0-0-3	3	2
TOTAL			**26**	**22**

100905 MA300A PARTIAL DIFFERENTIAL EQUATIONS AND COMPLEX ANALYSIS

4.1 COURSE INFORMATION SHEET

PROGRAMME: ME	***DEGREE:*** BTECH
PROGRAMME: MECHANICAL ENGINEERING	DEGREE: **B.TECH** UNIVERSITY: **A P J ABDUL KALAM TECHNOLOGICAL UNIVERSITY**
COURSE: PARTIAL DIFFERENTIAL EQUATIONS AND COMPLEX ANALYSIS	SEMESTER: **III** CREDITS: **4**
COURSE CODE: *100905 MA300A* ***REGULATION: UG***	COURSE TYPE: **CORE**
COURSE AREA/DOMAIN: ENGINEERING MATHEMATICS	CONTACT HOURS: **3+1 (Tutorial) hours/Week.**

SYLLABUS:

UNIT	***DETAILS***	***HOURS***
I	**PARTIAL DIFFERENTIAL EQUATIONS** 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'smethod,Solution of equation by method of separation of variables.	8
II	**APPLICATION OF PARTIAL DIFFERENTIAL EQUATIONS** 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
III	**COMPLEX VARIABLE-DIFFERENTIATION** Complex function, limit, continuity, derivative, analytic functions, Cauchy-Riemann equations, harmonic functions, finding harmonic conjugate, Conformal mappings .$w = z^2$, $w = e^z$, Linear fractional transformation w =1/z. fixed points, Transformation w=z sin z (From sections 17.1, 17.2 and 17.4 only mappings $w = z^2$, , $w = e^z$, $w = 1$, $w = sinz$ and problems based on these transformation need to be discussed.	9
IV	**COMPLEX VARIABLE-INTEGRATION**	

	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 representationofapath,Contourintegrals,Cauchyintegraltheorem(withoutproof)onsimply connected domain, Cauchy integral theorem (without proof) on multiply connected domain CauchyIntegralformula(withoutproof),CauchyIntegralformulaforderivativesofananalytic function, Taylor's series and Maclaurin series.	9
V	**COMPLEX VARIABLE-RESIDUE INTEGRATION** 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 and rational functions. Improper integrals of the form.	9
	TOTAL HOURS	**45**

TEXT/REFERENCE BOOKS:

T/R	*BOOK TITLE/AUTHORS/PUBLICATION*
T1	B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 44th Edition,2018.
T2	Erin Kreyszig: Advanced Engineering Mathematics, 10th edition, Wiley
R1	Peter V. O'Neil, Advanced Engineering Mathematics, Cengage, 7th Edition, 201

COURSE PRE-REQUISITES:

C.CODE	*COURSE NAME*	*DESCRIPTION*	*SEM*
	A basic course in partial differentiation and complex numbers	To develop basic ideas on partial differentiation and Complex numbers.	

COURSE OBJECTIVES:

1	To equip the students with methods of solving partial diff. equation with first order
2	To familiarize them with the concept of boundary value problems which have many applications in engineering like heat and wave equations
3	To understand the basic theory of functions of a complex variable, calculus of complex valued functions and conformal transformations

COURSE OUTCOMES:

SNO	*DESCRIPTION*	*Bloom's Taxonomy Level*
CO 1	**Identify the** concept and the solution of partial differential equation.	Remember (Level 1)
CO 2	**Analyze** and solve one dimensional wave equation and heat equation.	Analyse (Level 4)
CO 3	**Understand** complex functions, its continuity differentiability with the use of Cauchy- Riemann equations.	Understand (Level 2)
CO 4	**Evaluate** complex integrals using Cauchy's integral theorem and Cauchy's integral formula, understand the series expansion of	Evaluate (Level 5)

	analytic function	
CO 5	Understand the series expansion of complex function about a singularity and **apply** residue theorem to compute several kinds of real integrals.	Apply (Level 3)

CO-PO AND CO-PSO MAPPING

	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	3	3	3	3	2	1				2		2	3	2	
CO 2	3	3	3	3	2	1				2		2	3		
CO 3	3	3	3	3	2	1				2		2	2		
CO 4	3	3	3	3	2	1				2		2			
CO 5	3	3	3	3	2	1				2		2			

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	*LOW/MEDIUM/ HIGH*	*JUSTIFICATION*
CO 1-PO 1	3	Fundamental knowledge in PDE will help to analyse the Engineering problems very easily
CO 1-PO 2	3	Basic knowledge for the solution of PDE will help to model various problems in engineering fields
CO 1-PO 3	3	Solution of PDE will help to simplify problems with high complexity in Engineering
CO 1-PO 4	3	Non-linear partial differential equations will help to design solutions to various complex engineering problems
CO 1-PO 5	2	Find the difference between complete integral and singular integral of a partial differentialequation
CO 1-PO 6	1	Variable separable form will help to enrich the analysis of engineering problem
CO 1-PO 10	2	Analyse the method of separation of variables for solving PDE
CO 1-PO 12	2	Methods for the solutions of PDE will give a thorough knowledge in the application problem
CO 2-PO 1	3	Will able to analyse various methods of solutions of boundary value problems
CO 2-PO 2	3	Will able to analyse various methods of solutions of initial value problems
CO 2-PO 3	3	Analyse one dimensional wave equation
CO 2-PO 4	3	Analyse one dimensional heat equation
CO 2-PO 5	2	Analyse D-Alembert's solution of wave equation
CO 2-PO 6	1	Analyse Fourier solution of heat equation
CO 2-PO 10	2	Apply the concept of above in boundary application
CO 2-PO 12	2	Apply the concept in the solution of heat equation
CO 3-PO 1	3	Understand the idea of complex variable and functions

CO 3-PO 2	3	Understand the idea of continuity of complex valued functions
CO 3-PO 3	3	Understand the idea of differentiability of complex valued function
CO 3-PO 4	3	Understand the concept of Differentiability and Cauchy Riemann equations
CO 3-PO 5	2	Understand the engineering application of analytic function in fluid mechanics
CO 3-PO 6	1	Understand the idea about stream and potential function
CO 3-PO 10	2	Understand the idea about harmonic function
CO 3-PO 12	2	Understand the idea about harmonic conjugate
CO 4-PO 1	3	Evaluation Cauchy's integral theorem
CO 4-PO 2	3	Evaluation of complex integration
CO 4-PO 3	3	Evaluation of Cauchy's integral formula
CO 4-PO 4	3	Evaluation of complex integral using Cauchy's integral formula
CO 4-PO 5	2	Understanding of the idea of complex integration
CO 4-PO 6	1	Understanding of idea about multi connected region
CO 4-PO 10	2	Series expansion of analytic function
CO 4-PO 12	2	Understand the significance of series expansion in practical problems
CO 5-PO 1	3	Knowledge about the singularities
CO 5-PO 2	3	Understanding of residues and its evaluation
CO 5-PO 3	3	Apply the residue theorem for evaluation of real integrals
CO 5-PO 4	3	Apply the residue theorem for evaluation of integrals
CO 5-PO 5	2	Derivation of residue theorem
CO 5-PO 6	1	Analyse the application of residue theorem
CO 5-PO 10	2	Apply the residue theorem for evaluation of improper integrals
CO 4-PO 12	2	Apply the residue theorem for evaluation of trigonometric functions

JUSTIFICATIONS FOR CO-PSO MAPPING

MAPPING	***LOW/MEDIUM/ HIGH***	***JUSTIFICATION***
CO1 – PSO1	3	Partial differential equations can be used to model problems in mechanics, fluid and thermal sciences
CO2-PSO1	3	Solving problems in thermal engineering requires a working knowledge of the heat equation and methods of solution
CO3-PSO1	3	Solutions of the Laplace equation, and harmonic conjugates have applications in fluid mechanics
CO1-PSO2	2	The various methods for solving partial differential equations can be used to analyze mechanical systems

GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSIONAL REQUIREMENTS:

SNO	***DESCRIPTION***	***RELEVENCE TO PO***	***PROPOSED ACTIONS***

1	Basic concepts on complex analysis	1	Reading, Assignments
2	Application of complex analysis in solving various Engineering problems	2 & 3	Reading
3	Solution of Homogenous PDE with constant coefficient	2	Reading

PROPOSED ACTIONS: TOPICS BEYOND SYLLABUS/ASSIGNMENT/INDUSTRY VISIT/GUEST LECTURER/NPTEL ETC

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:

SINO:	TOPIC	PROPOSED ACTIONS	RELEVENCE TO PO
1	Application of analytic functions in Engineering	Reading	3
2	Derivation of Cauchy's integral theorem and Residue theorem	Reading	1
3	Application of Residue theorem in the evaluation of real integrals	Reading	2
4	Steady state condition of one dimensional heat equation	Reading	3

WEB SOURCE REFERENCES:

1	https://www.youtube.com/watch?v=7nPbGhj7DVI
2	https://www.youtube.com/watch?v=U51lQtlzvA0&list=PLgMDNELGJ1CZpu0rJvVh-bUHGFINS7xIk

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑***CHALK & TALK***	☑STUD. ASSIGNMENT	☑WEB RESOURCES	☑LCD/SMART BOARDS
☐***STUD. SEMINARS***	☐ADD-ON COURSES		

ASSESSMENT METHODOLOGIES-DIRECT

☑***ASSIGNMENTS***	☐STUD. SEMINARS	☑TESTS/MODEL EXAMS	☑UNIV. EXAMINATION
☐***STUD. LAB PRACTICES***	☐STUD. VIVA	☐MINI/MAJOR PROJECTS	☐CERTIFICATIONS
☐***ADD-ON COURSES***	☐OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☑ ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☑ STUDENT FEEDBACK ON FACULTY (ONCE)
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

4.2 COURSE PLAN

DAY	MODULE	TOPIC PLANNED
1	I	Partial differential equations, formation of partial differential equations
2		Elimination of arbitrary constants, Elimination of arbitrary functions
3		Solutions of partial differential equations, Equations solvable by direct integration
4		Linear equations of the first order- Lagrange's linear equation
5		Nonlinear equations of the first order - Charpit's method
6		Boundary value problems
7		Method of separation of variables
8	II	One dimensional wave equation- vibrations of a stretched string, derivation
9		Solution of the wave equation using method of separation of variables
10		Fourier series solution of boundary value problems involving wave equation
11		D'Alembert's solution of the wave equation
12		One dimensional heat equation, derivation
13		Solution of the heat equation using method of separation of variables
14		Fourier series solution of boundary value problems involving heat equation
15		Ends kept at 0
16		One or both boundaries insulated
17		Ends are neither at 0 nor insulated
18		Steady state conditions
19	III	Complex function, limit
20		Continuity, derivative
21		Analytic functions,
22		Cauchy-Riemann equations
23		Harmonic functions
24		Finding harmonic conjugate
25		Conformal mappings- mappings of $w = z^2$
26		$w = e^z$
27		$w = 1/z$, , $w = \sin z$
28	IV	Complex integration, Line integrals in the complex plane
29		Basic properties, first evaluation method
30		Second evaluation method
31		Use of representation of a path
32		Contour integrals, Cauchy integral theorem (without proof) on simply connected domain
33		Cauchy's integral theorem on multiply connected domain (without proof). Cauchy Integral formula (without proof)
34		Cauchy Integral formula for derivatives of an analytic function
35		Taylor's series and Maclaurin series
36	V	Laurent's series (without proof)

37		Laurent's series (without proof)
38		Zeros of analytic functions, singularities
39		Poles, removable singularities, essential singularities, residues
40		Cauchy Residue theorem (without proof)
41		Evaluation of definite integral using residue theorem
42		Residue integration of real integrals – integrals of rational functions of $cos\theta$and $sin\theta$
43		Residue integration of real integrals
44		Integrals of improper integrals of the form $\int f(x)dx$ (∞ to −∞) with no poles on the real axis

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4.3 Sample Questions

Module 1

1. Form the differential equation satisfied by $xyz = \phi(x+y+z)$.
2. Form the differential equation satisfied by $z = f(x) + e^y g(x)$.
3. Form the differential equation satisfied by $z = f_1(y+2x) + f_2(y-3x)$.
4. Solve the PDE $\frac{\partial^2 z}{\partial x \partial y} = x^2 y$ by direct integration
5. Solve the PDE $xp + yq = 3z$
6. Solve the PDE $p\sqrt{x} + q\sqrt{y} = z$
7. Solve the PDE $(y^2 + z^2 - x^2)p - 2xyq + 2xz = 0$
8. Solve the PDE $z(x+y)p + z(x-y)q = x^2 + y^2$ (Hint: $(x, -y, z)$ *and* $(y, x, -z)$ are the multipliers)
9. Solve the PDE $q = px + p^2$ by Charpit's method
10. Using Charpit's method solve $p^2 x + q^2 y = z$
11. Using Charpit's method solve $pxy + pq + qy = yz$
12. Using Charpit's method solve $1 + p^2 = qz$
13. Using the method of separation of variables solve $\frac{\partial u}{\partial x} = 4\frac{\partial u}{\partial y}$ $where\ u(0, y) = 8e^{-3y}$
14. Using the method of separation of variables solve $\frac{\partial^2 u}{\partial x^2} = \frac{\partial u}{\partial y} + 2u$ $where\ u = 0\ and\ \frac{\partial u}{\partial x} = 1 + e^{-3y},\ when\ x = 0\ for\ x = 0\ for\ all\ values\ of\ y$

Module 2

1. Derive the one dimensional wave equation.
2. Find the solution of the wave equation corresponding to the initial deflection

$$f(x) = \begin{cases} \frac{2k}{l}x & 0 < x < l/2 \\ \frac{2k}{l}(l-x) & l/2 < x < l \end{cases}$$

   and initial velocity 0.

3. A tightly stretched string of length l has its ends fastened at $x = 0, x = l$. The mid point of the string is then taken to a height h and the string is then released from rest in that position. Find the lateral displacement of a point of the string at time t from the instant of release.

4. Solve $\frac{\partial^2 y}{\partial t^2} = 4\frac{\partial^2 y}{\partial x^2}$ using the method of separation of variables subject to

$$y(0,t) = y(5,t) = 0$$

$$y(x,0) = 0, \frac{\partial y}{\partial t} = \begin{cases} 0 & 0 \le x < 4 \\ 5 - x & 4 \le x \le 5 \end{cases}$$

5. Solve $\frac{\partial^2 y}{\partial t^2} = 8\frac{\partial^2 y}{\partial x^2}$ using the method of separation of variables subject to

$$y(0,t) = y(2\pi,t) = 0$$

$$y(x,0) = \begin{cases} 3x & 0 \le x \le \pi \\ 6\pi - 3x & \pi < x \le 2\pi \end{cases}, \frac{\partial y}{\partial t} = 0$$

6. A tightly stretched string with fixed end points at $x = 0, x = l$ is initially in the position

$$f(x) = \begin{cases} x & 0 \le x \le 1/2 \\ 1 - x & 1/2 \le x \le 1 \end{cases}$$

If it is released from this position with a velocity a perpendicular to the x axis, find the displacement $y(x,t)$ at any point x of the string at any time $t > 0$.

7. The points of trisection of a string are pulled aside through the same distance on opposite sides of the equilibrium position and the string is released from rest. Derive an expression for the displacement of the string at subsequent time and show that the mid point of the string always remains at rest.

8. Solve the wave equation $\frac{\partial^2 y}{\partial t^2} = c^2\frac{\partial^2 y}{\partial x^2}$ under the conditions

$$y(0,t) = y(l,t) = 0$$

$$y(x,0) = f(x) \text{ and } \left(\frac{\partial y}{\partial t}\right)_{t=0} = g(x)$$

9. Solve one dimensional heat equation $\frac{\partial u}{\partial t} = c^2 \frac{\partial^2 u}{\partial x^2}$ subject to the conditions $u(x,t) \neq \infty \; if \; t \to \infty : \; u(0,t) = 0 = u(\pi,t) : \; u(x,0) = \pi x - x^2, 0 \le x \le \pi$.

10. Derive one dimensional heat equation

11. Find the temperature in a laterally insulated bar of length L whose ends are kept at temperature zero if the initial temperature is $f(x) = \begin{cases} x, & 0 < x < \frac{L}{2} \\ L - x, & \frac{L}{2} < x < L \end{cases}$

12. Find the temperature in a bar of length 2m whose ends are kept at zero temperature and lateral surface insulated if the initial temperature is $\left(sin\, \frac{\pi x}{2} + 3\, sin\, \frac{5\pi x}{2} \right)$

Module 3

1. Show that the function
$$f(z) = \begin{cases} (\frac{2xy^2}{x^2+3y^4} & z \neq 0 \\ 0 & z = 0 \end{cases}$$
is discontinuous at $z = 0$.

2. Show that the function $f(z) = \sinh z$ is analytic everywhere. Also find its derivative.

3. Show that the function $f(z) = \sqrt{x+y}$ is not differentiable at $z = 0$.

4. Prove that the function
$$f(z) = \begin{cases} \frac{x^2y^5(x+iy)}{x^4+y^{10}} & z \neq 0 \\ 0 & z = 0 \end{cases}$$
is not differentiable at origin, although Cauchy-Riemann equations are satisfied at the origin.

5. Prove that $u = x^2 + y^2$ is not a harmonic function.

6. Find an analytic function whose imaginary part is $\frac{x-y}{x^2+y^2}$.

7. Find a so that the function $u = x^3 + axy^2$ is harmonic. Find its harmonic conjugate.

8. If u is harmonic prove that $u_x - iu_y$ is analytic.

9. Find all points at which the function $w = cosh\ 2\pi z$ is not conformal

10. Find all linear fractional transformation with fixed points $z = \pm i$

11. Find all linear fractional transformation with fixed points $z = \pm 1$

12. Find the fixed points of the transformation $w = \frac{iz+4}{2z-5i}$

13. Find the fixed points of the transformation $w = \frac{aiz-1}{z+ai}$

14. Find the inverse of the inverse of the transformation $w = \frac{i}{2z-1}$

15. Find the inverse of the inverse of the transformation $w = \frac{z - \frac{i}{2}}{\frac{-iz}{2} - 1}$

Module 4

1. Find the Maclaurin series of $\sin^2(z)$ and its radius of convergence.
2. Find the Taylor series of $f(z) = \cos z$ with center at $z_0 = \pi$, and find its radius of convergence.
3. Find the Taylor series of $f(z) = \dfrac{1}{(z-i)^2}$ with center at $z_0 = -i$, and find its radius of convergence.
4. Evaluate $\int_C e^z dz$, where C is the shortest path from $\dfrac{\pi}{2i}$ to πii.
5. Evaluate $\int_C ze^{z^2} dz$, where C is the path from 1 along the axes to i.
6. Evaluate $\int_C Re(z^2)dz$ clockwise around the boundary of the square with vertices $0, i, 1+i, 1$.
7. Show that $\int_C \frac{1}{z}dz = \pi i$ or $-\pi i$ according as C is the semicircle $|z| = 1$ above or below the real axis from $(1,0)$ to $(-1,0)$.
8. Evaluate $\int_C \frac{cos\pi z}{z^2-1}dz$ where C is the rectangle with vertices $2 \pm i, \ -2 \pm i$
9. Evaluate $\int_C \frac{e^z}{(z+1)^3}dz$ where C is $|z+1| = 1$
10. Evaluate $\int_C \frac{z^2+5z+3}{(z-2)^3}dz$ where C is $|z| = 3$
11. Using Cauchy's integral formula, Evaluate $\int_C \frac{z^2}{(z-1)^2(z+2)}dz$ where C is $|z-2| = 2$
12. Evaluate $\int_C \frac{\cos \pi z^2}{(z-1)(z-2)}dz$ where C is $|z| = 3$
13. Evaluate $\int_C \frac{2z-1}{z(z+1)(z-1)}dz$ where C is $|z| = 2$
14. Evaluate $\int_C \frac{dz}{z^2(z-1)}dz$ where C is $|z| = 2$
15. Evaluate $\int_C \frac{2z-1}{z(z+1)(z-1)}dz$ where C is $|z| = 2$
16. Evaluate $\int_C \frac{ze^z}{(z+1)(z+2)}dz$ where C is $|z-i| = 3$

Module 5

1. Find the Laurent series expnasion of $\frac{1}{z^2(z-i)}$ at the singular point $z = i$.
2. Find the Laurent series expnasion of $z^3\ cosh\frac{1}{z}$ at the singular point $z = 0$.
3. Determine singularities of the following function
   (a) $tan\ \pi z$
   (b) $cot\ z$
   (c) $\frac{1}{1-e^z}$
4. Expand the following function in Laurent's series
   (a) $\frac{1}{z-2},\ for\ |z| > 2$
   (b) $\frac{z^2-1}{(z+2)(z+3)}\ for\ |z| > 3$
5. Find the Laurent series expansion of $\frac{1-cos\ z}{z^3}$, about $z = 0$.
6. Find all singular points and the corresponding residues:
   (a) $\frac{1}{(z^2-1)^2}$
   (b) $\frac{1/3}{z^4-1}$
   (c) $\frac{z^2}{z^4-1}$
7. Evaluate $\oint_{|z|=2} \tan \pi z dz$.
8. Evaluate $\oint_{|z|=4.5} \frac{e^z}{\cos z} dz$.
9. Evaluate $\oint_{|z|=1} \frac{\cosh z}{z^3 - 3iz} dz$.
10. Evaluate $\int_0^{2\pi} \frac{1+4\cos\theta}{17-8\cos\theta} d\theta$.
11. Evaluate $\int_0^{2\pi} \frac{1}{5-4\sin\theta} d\theta$.
12. Evaluate $\int_0^{2\pi} \frac{\sin^2\theta}{5-4\cos\theta} d\theta$.

5. 100006/ME300B MECHANICS OF SOLIDS

5.1 COURSE INFORMATION SHEET

PROGRAMME: **MECHANICAL ENGINEERING**	DEGREE: **B. TECH** UNIVERSITY: **KTU (Autonomous)**
COURSE: **MECHANICS OF SOLIDS**	SEMESTER: **III** CREDITS: **4**
COURSE CODE: 100006/ME300B REGULATION: : 2020	COURSE TYPE: **CORE**
COURSE AREA/DOMAIN: **APPLIED MECHANICS**	CONTACT HOURS: 3+1 (Tutorial) **hours/Week.**
CORRESPONDING LAB COURSE CODE (IF ANY): 100006/ME322T	LAB COURSE NAME: **MATERIALS TESTING LAB**

SYLLABUS:

UNIT	*DETAILS*	*HOURS*
I	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
II	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
III	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, 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	9

	supported beams. Differential equations between load, 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.	
IV	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
V	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. 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.	8
	TOTAL HOURS	**43**

TEXT/REFERENCE BOOKS:

T/R	*BOOK TITLE/AUTHORS/PUBLICATION*
T1	Mechanics of materials in S.I.units, R .C. Hibbeler, Pearson Higher Education 2018
T2	Advanced Mechanics of Solids, L. S. Srinath, TMH MECHANICAL ENGINEERING
T3	Design of Machine Elements, V. B Bhandari
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.

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
100908/MA100A	LINEAR ALGEBRA AND CALCULUS	To understand basic tools in Mathematics which are useful in modelling and analysing physical phenomena involving continuous changes of variables or parameters. To understand methods of solving a general system of linear equations. To understand the concept of Eigen values and diagonalization of a matrix which have many applications in Mechanics of Solids. To understand and apply the differential and integral calculus of functions having one or more variables	1
100908/CE900C	ENGINEERING MECHANICS	To apply principles of mechanics to practical engineering problems To identify appropriate structural system for studying a given problem and isolate it from its environment. To develop simple mathematical model for engineering problems and carry out static analysis.	1/2
100908/MA200A	VECTOR CALCULUS, DIFFERENTIAL EQUATIONS AND TRANSFORMS	To understand the basic ideas of differential equations, both ordinary and partial, which are widely used in the modeling and analysis of a wide range of physical phenomena across all branches of engineering. To understand and apply vector calculus in the solution of engineering problems.	3

COURSE OBJECTIVES:

1	To understand the concept of Stress and Strain in different types of Structures.
2	To understand and solve problems in Bending and Torsion of Circular Sections.
3	To understand and apply energy methods for solving structural mechanics problems.
4	To acquaint with the different Theories of Failures.
5	To understand and compute buckling load in columns

COURSE OUTCOMES:

SNO.	*DESCRIPTION*	*Bloom's Taxonomy Level*
100006/ME300B.1	Determine the stresses and displacements of structures by tensorial and graphical (Mohr's Circle) approaches.	*Apply(Level-3)*
100006/ME300B.2	Analyze the strength of materials using stress-strain relationships for structural and thermal loading.	*Apply(Level-3) Analysis (Level-4)*
100006/ME300B.3	Perform basic design of shafts subjected to torsional loading and analyze beams subjected to bending.	*Apply(Level-3) Analysis (Level-4)*
100006/ME300B.4	Determine the deformation of structures subjected to various loading conditions using strain energy methods.	*Apply(Level-3)*
100006/ME300B.5	Analyse column buckling and appreciate the theories of failures and its relevance in engineering design.	*Apply(Level-3) Analysis (Level-4)*

CO-PO AND CO-PSO MAPPING

	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*
100006/ME300 B.1	3	3	2	-	-	-	-	-	-	-	-	1	1	2	1
100006/ME300 B.2	3	3	2	-	-	-	-	-	-	-	-	1	1	2	1
100006/ME300 B.3	3	3	1	-	-	-	-	-	-	-	-	2	1	2	1
100006/ME300 B.4	3	3	1	-	-	-	-	-	-	-	-	1	1	1	1
100006/ME300 B.5	3	3	1	-	-	-	-	-	-	-	-	1	1	2	1

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	***LOW/ MEDIUM/ HIGH***	***JUSTIFICATION***
100006/ME300B .1-PO1	H	Knowledge to determine **stresses, strain** and displacements of structures by tensorial and graphical approach will enable the students to apply these equations for **solve complex problems** in Structural Mechanics and Design of Machine Elements.
100006/ME300B .1-PO2	H	Clear understanding of determining **stresses, strain** and displacements of structures by tensorial and graphical approach will enable the students to identify, formulate and **analyze complex problems** in the Design of Machine Elements, vehicle structure, aircraft structure, ship structure etc.
100006/ME300B .1-PO3	M	Application of **stresses, strain** and displacements determination of structures by tensorial and graphical approach will enable the students to **design safe** structures.
100006/ME300B .1-PO12	L	Knowledge to determine **stresses, strain** and displacements of structures by tensorial and graphical approach will enable the students for **lifelong learning** of the developments in the field of structural mechanics.
100006/ME300B .2-PO1	H	Knowledge to analyse the strength of materials using stress-strain relationships for structural and thermal loading will enable the students to apply these equations for **solve complex problems** in Structural Mechanics and Design of Machine Elements.
100006/ME300B .2-PO2	H	Clear understanding to analyse the strength of materials using stress-strain relationships for structural and thermal loading will enable the students **to analyze complex problems** in the Design of Machine Elements, vehicle structure, aircraft structure, ship structure etc.
100006/ME300B .2-PO3	M	Ability to analyse the strength of materials using stress-strain relationships for structural and thermal loading will enable the students to **design safe** structures.
100006/ME300B .2-PO12	L	Ability to analyse the strength of materials using stress-strain relationships for structural thermal loading will enable the students **for lifelong learning** of the developments in the field of structural mechanics.
100006/ME300B .3-PO1	H	Knowledge to perform basic design of shafts subjected to torsional loading and analyze beams subjected to bending will enable students to **solve complex Problems** in Structural Mechanics and Design of Machine Elements.
100006/ME300B .3-PO2	H	Clear understanding to perform basic design of shafts subjected to torsional loading and analyze beams subjected to bending will enable the students **to**

		identify, formulate and analyze complex problems in the Design of Machine Elements, vehicle structure, aircraft structure, ship structure etc.
100006/ME300B .3-PO3	L	Application of basic design of shafts subjected to torsional loading and analyze beams subjected to bending will enable the students to **design safe** structures.
100006/ME300B .3-PO12	M	Knowledge to perform basic design of shafts subjected to torsional loading and analyze beams subjected to bending will enable the students for **lifelong learning** of the developments in the field of structural mechanics.
100006/ME300B .4-PO1	H	Knowledge to determine the deformation of structures subjected to various loading conditions using strain energy methods will enable the students to solve complex problems in structural mechanics.
100006/ME300B .4-PO2	H	Clear understanding to determine the deformation of structures subjected to various loading conditions using strain energy methods will enable the students to identify, formulate and analyze complex problems in the structural mechanics.
100006/ME300B .4-PO3	L	Knowledge to determine the deformation of structures subjected to various loading conditions using strain energy methods will enable the students to **design safe** structures.
100006/ME300B .4-PO12	L	Knowledge to determine the deformation of structures subjected to various loading conditions using strain energy methods will enable the students for lifelong learning of the developments in the field of structural mechanics
100006/ME300B .5-PO1	H	Knowledge to estimate the strength of columns and appreciate the theories of failures and its relevance in mechanical design will enable the students to apply these concepts solve complex problems in structural mechanics.
100006/ME300B .5-PO2	H	Clear understanding to estimate the strength of columns and appreciate the theories of failures and its relevance in mechanical design will enable the students to identify, formulate and analyze complex problems in the structural mechanics.
100006/ME300B .5-PO3	L	Clear understanding to estimate the strength of columns and appreciate the theories of failures and its relevance in mechanical design will enable the students to **design safe** structures.
100006/ME300B .5-PO12	L	Knowledge to estimate the strength of columns and appreciate the theories of failures and its relevance in mechanical design will enable the students for lifelong learning of the developments in the field of structural mechanics

JUSTIFICATIONS FOR CO-PSO MAPPING

MAPPING	*LOW/ MEDIUM/ HIGH*	*JUSTIFICATION*
100006/ME300B. 1-PSO1	L	Student's knowledge to determine **stresses, strain** and displacements of structures by tensorial and graphical approach will help students to solve engineering problems using advanced technology
100006/ME300B. 1-PSO2	M	Student's knowledge to determine **stresses, strain** and displacements of structures by tensorial and graphical approach will enhance their capability to analyze and design mechanical components.
100006/ME300B. 1-PSO3	L	Student's knowledge to determine **stresses, strain** and displacements of structures by tensorial and graphical approach will enhance their capability to develop and implement new ideas on product design using CAD tools. .
100006/ME300B. 2-PSO1	L	Clear understanding to analyse the strength of materials using stress-strain relationships for structural and thermal loading will enhance student's capability to solve engineering problems using advanced technology .
100006/ME300B. 2-PSO2	M	Clear understanding to analyse the strength of materials using stress-strain relationships for structural and thermal loading will enhance their capability to analyze and design mechanical components.
100006/ME300B. 2-PSO3	L	Clear understanding to analyse the strength of materials using stress-strain relationships for structural and thermal loading will enhance their capability to develop and implement new ideas on product design using CAD tools.
100006/ME300B. 3-PSO1	L	Knowledge to perform basic design of shafts subjected to torsional loading and analyze beams subjected to bending will help students to solve engineering problems using advanced technology.
100006/ME300B. 3-PSO2	M	Knowledge to perform basic design of shafts subjected to torsional loading and analyze beams subjected to bending will enhance their capability to analyze and design mechanical components.
100006/ME300B. 3-PSO3	L	Knowledge to perform basic design of shafts subjected to torsional loading and analyze beams subjected to bending will enhance their capability to develop and implement new ideas on product design using CAD tools.

100006/ME300B.4-PSO1	L	Clear understanding to determine the deformation of structures subjected to various loading conditions using strain energy methods will enhance student's capability to solve engineering problems using advanced technology.
100006/ME300B.4-PSO2	L	Clear understanding to determine the deformation of structures subjected to various loading conditions using strain energy methods will enhance the student's capability to analyze and design mechanical components.
100006/ME300B.4-PSO3	L	Clear understanding to determine the deformation of structures subjected to various loading conditions using strain energy methods will enhance their capability to develop and implement new ideas on product design using CAD tools.
100006/ME300B.5-PSO1	L	Knowledge to estimate the strength of columns and appreciate the theories of failures and its relevance in mechanical design will enhance student's capability to solve engineering problems using advanced technology.
100006/ME300B.5-PSO2	M	Knowledge to estimate the strength of columns and appreciate the theories of failures and its relevance in mechanical design will enhance the student's capability to analyze and design mechanical components.
100006/ME300B.5-PSO3	L	Knowledge to estimate the strength of columns and appreciate the theories of failures and its relevance in mechanical design will enhance their capability to develop and implement new ideas on product design using CAD tools

GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSIONAL REQUIREMENTS:

Sl No	***DESCRIPTION***	***RELEVENCE TO PO\PSO***	***PROPOSED ACTIONS***
1	Compatibility Equations	PO1: Applying the principles of Compatibility Equations will enable the students to apply these equations for **solve complex problems** in Structural Mechanics and Design of Machine Element	Class Lecture, https://www.youtube.com/watch?v=OA_QsQZYoSg

PROPOSED ACTIONS: TOPICS BEYOND SYLLABUS/ASSIGNMENT/INDUSTRY VISIT/GUEST LECTURER/NPTEL ETC

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:

SINO:	TOPIC	RELEVENCE TO PO\PSO	PROPOSED ACTIONS
1	Introduction to Mohr's circle for 3D state of Stress	PO1: Applyng the principle of Mohrs circle will enable the students to solve complex problems	Class Lecture, https://ocw.mit.edu/courses/ mechanical-engineering/ 2-080j-structural-mechanics-fall-2013/ recitations/MIT2_080JF13_ Recitation2.pdf https://www.youtube.com/watch?v=9x6lpkap9qs

WEB SOURCE REFERENCES:

1	https://www.youtube.com/watch?v=ICDZ5uLGrI4
2	https://www.youtube.com/watch?v=C-FEVzI8oe8
3	https://www.youtube.com/watch?v=BthnS6LJt8s
4	https://www.youtube.com/watch?v=aivDhiLwu8E
5	https://www.youtube.com/watch?v=xkbQnBAOFEg
6	https://www.youtube.com/watch?v=AvvaCi_Nn94

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑ ***CHALK & TALK***	☑ STUD. ASSIGNMENT	☑ WEB RESOURCES	☑LCD/SMART BOARDS
☐ ***STUD. SEMINARS***	☐ ADD-ON COURSES		

ASSESSMENT METHODOLOGIES-DIRECT

☑ ***ASSIGNMENTS***	☐ STUD. SEMINARS	☑ TESTS/MODEL EXAMS	☑ UNIV. EXAMINATION ☐
☐ ***STUD. LAB PRACTICES***	☐ STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐ CERTIFICATIONS
☐ ***ADD-ON COURSES***	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☑ ***ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)***	☑ STUDENT FEEDBACK ON FACULTY (TWICE)
☐ ***ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS***	☐ OTHERS

5.2 COURSE PLAN

DAY	MODULE	TOPIC PLANNED
1	1	Introduction
2	1	Deformation behaviour of elastic solids in equilibrium, Method of sections
3	1	Simple stress and strain â€“ problems
4	1	Stress vectors on Cartesian coordinate planes, Stress tensor, Equality of cross shears, Cauchys equations
5	1	Problems based on Cauchys equations
6	1	Displacement, gradient of displacement, Cartesian strain matrix, strain displacement relations for small-strain, strain tensor plane strain conditions. Simple problems to find strain matrix given displacement field for 2D and 3D cases
7	1	Concepts of principal planes and principal stress, characteristic equation of stress matrix and evaluation of principal stresses and principal planes as an eigen value problem, meaning of stress invariants, maximum shear stress
8	1	Problems to find principal stresses, max shear stress and principal planes
9	1	Stress transformation equations, stress on an arbitrary plane, principal stresses and planes, maximum shear stress
10	1	Mohrs circle for 2D case
11	1	Mohrs circle problems
12	2	Stress-strain diagram, Stress“Strain curves of Ductile and Brittle Materials, Poissons ratio
13	2	Constitutive equations-generalized Hookes law, equations for linear elastic isotropic solids in in terms of Youngs Modulus and Poissons ratio (3D)
14	2	Hookes law for Plane stress and plane strain conditions. Relations between elastic constants E, G, &
15	2	Calculation of stress, strain and change in length in axially loaded members with single and composite materials
16	2	Problems of Hookes law
17	2	Effects of thermal loading thermal stress and thermal strain. Thermal stress on a prismatic bar held between fixed supports
18	2	Numerical problems for axially loaded members
19	2	Numerical problems for axially loaded members
20	3	Torsional deformation of circular shafts, assumptions for shafts subjected to torsion within elastic deformation range, derivation of torsion formula
21	3	Torsional rigidity, Polar moment of inertia, comparison of solid and hollow shaft. Simple problems to estimate the stress in solid and hollow shafts
22	3	Numerical problems for basic design of circular shafts subjected to externally applied torques
23	3	Shear force and bending moment diagrams for cantilever beams subjected to point load, moment, UDL and linearly varying load
24	3	Shear force and bending moment diagrams for simply supported beams subjected to point load, moment, UDL and linearly varying load
25	3	Shear force and bending moment diagrams for cantilever and simply supported beams subjected to point load, moment, UDL and linearly varying load
26	3	Differential equations between load, shear force and bending moment
27	3	Normal and shear stress in beams: Derivation of flexural formula, section modulus, flexural rigidity
28	3	Numerical problems to evaluate bending stress and economic sections
29	3	Shear stress formula for beams: Derivation.
30	3	Numerical problem to find shear stress distribution for rectangular section

31	4	Deflection of cantilever beams subjected to point load, moment and UDL using Macauleys method
32	4	Deflection of simply supported beams subjected to point load, moment and UDL using Macauleys method
33	4	Deflection of cantilever beams and simply supported beams - problems
34	4	Deflection of cantilever beams and simply supported beams - problems
35	4	Linear elastic loading, elastic strain energy and Complementary strain energy. Elastic strain energy for axial loading.
36	4	Elastic strain energy for transverse shear, bending and torsional loads.
37	4	Expressions for strain energy in terms of load, geometry and material properties of the body for axial and shearing loads“ Simple problems.
38	4	Expressions for strain energy in terms of load, geometry and material properties of the body for bending and torsional loads - Simple problems.
39	4	Castiglianos second theorem to find displacements, reciprocal relation, proof for Castiglianos second theorem..
40	4	Simple problems to find the deflections using Castiglianos theorem
41	5	Stresses in a thin spherical vessel and numerical problems
42	5	Fundamentals of bucking and stability, critical load, Eulerâ€™s formula for long columns, assumptions and limitations
43	5	Effect of end conditions, equivalent length - problems
44	5	Critical stress, slenderness ratio, Rankines formula for short columns
45	5	Problems using Rankines formula
46	5	Introduction to Theories of Failure. Rankines theory for maximum normal stress, Guests theory for maximum shear stress
47	5	Saint-Venants theory for maximum normal strain, Hencky-von Mises theory for maximum distortion energy
48	5	Haighs theory for maximum strain energy
49	5	Circumferential and Longitudinal stress in a thin cylindrical vessel Problems

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5.3 Sample Questions

Module 1

1. The stress tensor at a point is given by the following matrix

$$\begin{bmatrix} 50 & -20 & 40 \\ -20 & 20 & 10 \\ 40 & 10 & 30 \end{bmatrix} \text{kPa}$$

Determine the stresses on a plane whose unit normal has direction cosines $\frac{1}{\sqrt{2}}, \frac{1}{2}\ and\ \frac{1}{2}$.

Ans: T_x = 45.36 MPa; T_y = 0.86 MPa; T_z= 48.28 MPa; Normal Stress, σ = -9.92 kPa; Shear Stress τ = 18.66kPa

2. The stress state a point P is given by:

$$\begin{bmatrix} 1 & 2 & 1 \\ 2 & -2 & -3 \\ 1 & -3 & 4 \end{bmatrix} \text{MPa}$$

Find the normal stress and the shear stress on a plane whose direction cosines are $n_x = \frac{2}{3}$; $n_y = \frac{1}{3}$; $n_z = \frac{2}{3}$.**Ans: T_x = 2 MPa; T_y = -1.33 MPa; T_z= 2.33 MPa; Normal Stress, σ = 2.44 MPa; Shear Stress τ = 2.29 MPa**

3. Determine the normal stress and shear stress on a plane whose direction cosines are $\left(\frac{1}{\sqrt{2}}; \frac{1}{\sqrt{2}}; 0\right)$, if the state of stress at the point is σ_x= 2 MPa; σ_y = 4 MPa; σ_z = 1 MPa; τ_{xy} = 3 MPa; $\tau_{xz} = \tau_{yz}$ = 0.

Ans: T_x = 3.54 MPa; T_y = 4.95 MPa; T_z= 0 MPa; Normal Stress, σ = 6 MPa; Shear Stress τ = 1 MPa

4. Find the normal stress and the shear stress at point Q on a plane whose normal has direction cosines $\left(n_x = \frac{\sqrt{3}}{2}; n_y = \frac{1}{2}; n_z = 0\right)$. Given the stress state at point Q is:

$$\begin{bmatrix} 10 & 5 & 8 \\ 5 & 15 & 7 \\ 8 & 7 & 20 \end{bmatrix} \text{MPa}$$

Ans: T_x = 11.16 MPa; T_y = 11.83 MPa; T_z = 10.43 MPa.; Normal Stress, σ = 15.58 MPa; Shear Stress τ = 11.42 MPa

5. The state of stress at point in cartesian coordinates is given below. Find the normal stress and shear stress on a plane whose normal has direction cosines $\left(n_x = \frac{1}{\sqrt{2}}; n_y = \frac{1}{\sqrt{3}}; n_z = \frac{1}{\sqrt{6}}\right)$.

$$\begin{bmatrix} 20 & 10 & 10 \\ 10 & 20 & 10 \\ 10 & 10 & 20 \end{bmatrix} \text{MPa}$$

Ans: T_x = 24 MPa; T_y = 22.7 MPa; T_z = 21.01 MPa.; Normal Stress, σ = 38.65 MPa; Shear Stress τ = 6.21 MPa

6. The state of stress at a point is given by the Cartesian tensor

$$\begin{bmatrix} 2 & -1 & 1 \\ -1 & 3 & -1 \\ 1 & -1 & 2 \end{bmatrix} \text{kPa}$$

Find the following:

I. The three stress invariants
II. Characteristic Equation
III. Principal Stresses
IV. Any one unit normal of the principal planes

Ans: I_1 = 7; I_2 = 13; I_3 = 7; σ^3-7σ^2+13 σ-7=0;

Principal Stress	**Principal Plane**
σ_1 = 4.41kPa	**n_x = 0.50; n_y = -0.71; n_z = 0.5**
σ_2 = 1.59kPa	**n_x = 0.50; n_y = 0.71; n_z = 0.5**
σ_3 = 1kPa	**n_x = 0.71; n_y = 0; n_z = -0.71**

7. The state of stress at a point is characterised by the components: σ_x=12.31 MPa; σ_y = 8.96 MPa; σ_z = 4.34 MPa; τ_{xy} = 4.20 MPa; τ_{xz} = 0.84 MPa; τ_{yz} = 5.27 MPa. Determine the values of Principal Stresses and the Maximum Shear Stress at the point.
   σ_1 = 16.41 MPa; σ_2 = 8.55MPa; σ_3 = 0.65MPa; Maximum Shear Stress = 7.88 MPa.

8. Find the principal stresses and Principal Directions for the following 3D stress state in Cartesian Coordinates.

$$\begin{bmatrix} 10 & 5 & 8 \\ 5 & 15 & 7 \\ 8 & 7 & 20 \end{bmatrix} \text{MPa}$$

Principal Stress	**Principal Plane**
σ_1 = 29.49MPa	**n_x = 0.44; n_y = 0.51; n_z = 0.74**
σ_2 = 10.11MPa	**n_x = 0.09; n_y = -0.84; n_z = 0.53**
σ_3 = 5.41MPa	**n_x = 0.90; n_y = -0.17; n_z = -0.41**

9. For the following state of stress at a point on an elastic body, determine the maximum normal stress, plane on which it is acting and the value of maximum shear stress at the point.

$$\begin{bmatrix} 0 & 1 & 1 \\ 1 & 0 & 1 \\ 1 & 1 & 0 \end{bmatrix} \text{MPa}$$

   Ans: σ_1 = 2 MPa; n_x= 0.58; n_y= 0.58; n_z = 0.58; Maximum Shear Stress = 1.50 MPa.

10. The state of stress at a point is characterised by σ_x=18kPa; σ_y = -50kPa; σ_z = 32 kPa; τ_{xy} = 0; τ_{xz} = 24 kPa; τ_{yz} = 0. Find the maximum normal stress, plane on which it is acting and the value of maximum shear stress at the point.

    Ans: σ_1 = 50 MPa; n_x = 0.6; n_y= 0; n_z = 0.8; Maximum Shear Stress = 49.98 MPa.

11. Displacement field for a 2D plane strain case is given as, $U = [(x^2 + xy)\hat{\imath} + (y^2 + xy)\hat{\jmath}]\text{x}\,10^{-2}$find the strain components at the point (2,4).
    Ans: Strain Matrix is $\begin{bmatrix} 4 & 6 \\ 6 & 10 \end{bmatrix} \text{x}\ 10^{-2}$

12. A displacement field $U = 2xyi + 3zk$ where i and k are unit vectors along x and z directions is acting at (1,1,0). Find the rectangular components of strain and obtain the state of strain matrix.

    Ans: State of Strain is $\begin{bmatrix} 2 & 2 & 0 \\ 2 & 0 & 0 \\ 0 & 0 & 3 \end{bmatrix}$

13. If the displacement field is given by $U = (x^2 + y)i + (3 + z)j + (x^2 + 2 - y)k$ write down the strain tensor at point (3,2,-1). Corresponding to the above, determine the strain at the point in the direction $n_x = n_y = n_z = \frac{1}{\sqrt{3}}$.

Ans: Strain Tensor is : $\begin{bmatrix} 6 & 0.5 & 3 \\ 0.5 & 0 & 0 \\ 3 & 0 & 0 \end{bmatrix}$ **Strain along the given direction is 4.33**

14. Displacement field is given by $U = [(x^2 + y^2 + 2)i + (3x + 4y^2)j + (2x^3 + 4z)k]10^{-4}$. Find the distance between points P and Q before and after deformation, if original coordinates are P(1,1,3) and Q(0,0,-2).

Ans: P'(1.0004, 1.0007, 3.0014); Q'(0.0002, 0, -2.0008); PQ = 5.1962; P'Q' = 5.1984

15. Displacement field for a body is given by $U = [(x + y^2)i + (3 + z)j + (2x + y^2)k]10^{-4}$, write down the displacement gradient matrix at point (2,3,1).

Ans: Displacement Gradient Matrix is $\begin{bmatrix} 1 & 6 & 0 \\ 0 & 0 & 1 \\ 2 & 6 & 0 \end{bmatrix} x\, 10^{-4}$

16. The displacement field for a body is given by $[(2x^2 + 3y^2 + 2)i + (3x + 4y^3)j + (2x^2 + 4z)k]10^{-4}$, Find the position of a point P after deformation whose original position was (2,1,3). Also find the linear strain components at point P.
Ans: Position of P after deformation is P'(2.0013, 1.001, 3.002); Linear Strain Components at P are 0.0008; 0.0012; 0.0004.

17. Find the Strain components and strain tensor at point (2,1,3), if the displacement field is given by $U = [(x + y^2)i + (3 + z)j + (2x + y^2)k]10^{-4}$.

Ans: Strain Tensor is $\begin{bmatrix} 1 & 1 & 1 \\ 1 & 0 & 1.5 \\ 1 & 1.5 & 0 \end{bmatrix} x\, 10^{-4}$

18. The displacement field at a point is given by $= kyz; v = 2k(y + z); w = 3k(x + z^2)$, Write the strain matrix. What is the strain along the direction $n_x = n_y = n_z = \frac{1}{\sqrt{3}}$.

Ans: Strain Matrix is $\begin{bmatrix} 0 & kz & ky + 3k \\ kz & 2k & 2k \\ ky + 3k & 2k & 6kz \end{bmatrix}$**; Strain along the given direction is** $\frac{7k}{3} + \frac{k}{3}y + \frac{7k}{3}z$

19. The state of strain at a point is given by $\varepsilon_{xx} = 0.001$; $\varepsilon_{yy} = 0.003$; $\varepsilon_{zz} = 0.002$; $\gamma_{xy} = 0.001$; $\gamma_{xz} = 0.002$; $\gamma_{yz} = 0.005$. Determine the strain invariants, principal strains and the corresponding principal planes.
Ans:

Principal Strain	Principal Plane
$\varepsilon_1 = 5.29 \times 10^{-3}$	$n_x = 0.23$; $n_y = 0.74$; $n_z = 0.63$
$\varepsilon_2 = 0.95 \times 10^{-3}$	$n_x = 0.89$; $n_y = -0.43$; $n_z = 0.17$
$\varepsilon_3 = 0.24 \times 10^{-3}$	$n_x = 0.40$; $n_y = 0.52$; $n_z = -0.76$

20. Corresponding to the displacement given by $(x^2 + y)i + (3 + z)j + (x^2 + 2y)k$ on a body, determine the strain tensor at the point (1,0,2).

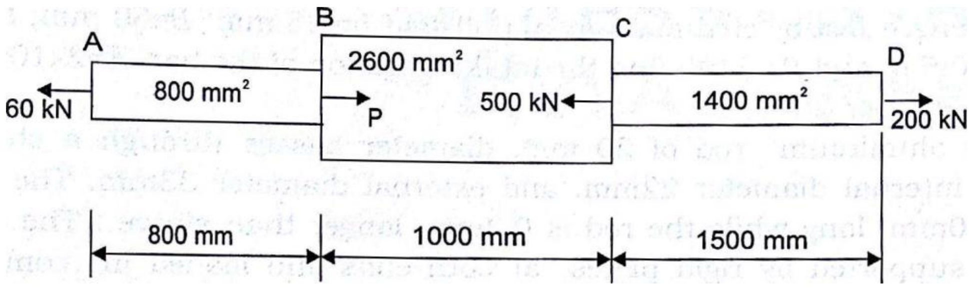
Ans: Strain Tensor is $\begin{bmatrix} 2 & 0.5 & 1 \\ 0.5 & 0 & 1.5 \\ 1 & 1.5 & 0 \end{bmatrix}$

Module 2

1. Two vertical rods one of steel and the other copper are each rigidly fixed at the top and 500 m apart. Diameters and lengths of each rods are 20 mm and 4 m respectively. A cross bar fixed to the rods at the lower ends carries a load of 5000N such that the cross bar remains horizontal even after loading. Find the stress in each rod and the position of the load on the bar. E=2 x $10^5$1\l/mm^2 E_{copper} = 1 X 10^5 N/mm^2.
2. A steel wire of 10 mm. diameter is used for lifting a load of 1 kN at its lowest end, the length of the wire hanging vertically being 200 mm. Taking the unit weight of steel = 78 kN/m^3 and E=2x10^5 N/mm^2., Calculate the total elongation of the wire.
3. Two steel rods and one brass rod each of 30 mm diameter are arranged vertically to take a load of 25 KN. The central brass rod is 2.5 m long and outer steel rods are 3 m in length. Take E_s = 200 KN/mm^2 and E_b = 100 kN/mm^2. Find the stresses in steel and brass.
4. A tapering steel rod of length 500mm has a diameter of 20mm at one end and 40mm at the other end. The rod is held between two unyielding supports at room temperature. What is the maximum stress induced in the rod, if temperature rises by 30°C? E_s =2x10^5N/mm^2, a_s= 12x10^{-6}/°C. Derive the expression used.
5. Two vertical rods one of steel and the other copper are each rigidly fixed at the top and 500 m apart. Diameters and lengths of each rods are 20 mm and 4 m respectively. A cross bar fixed to the rods at the lower ends carries a load of 5000N such that the cross bar remains horizontal even after loading. Find the stress in each rod and the position of the load on the bar. E_s= 2 x 10^5 N/mm2 E_{copper} = 1 x 10^5 N/mm^2.
6. Three short pillars, each 450mm^2 in section, support a weight of 190 kN. The central pillars are of steel and the outer ones are of copper. The pillars are so adjusted that at a temperature of 15°C each carries equal load. The temperature is then raised to 120°C. Estimate the stresses in each pillar. Take E_s= 210 GN / m^2, E_c=105GN / m^2, α_s =12x10^{-6}/ °C, α_c = 17.5 x10^{-6}/°C.
7. A compound bar is made of a central steel plate 60 inm wide and 10 mm thick to which copper plates 40 rnm wide by 5 mm thick are connected rigidly on each side. The length of the bar at normal temperature is one meter. If the

temperature is raised by 80°C, determine the stress in each metal and the stresses in each metal and the change in length.

8. A bar ABCD is subjected to loads as shown in Figure. Determine (i) the force P necessary for equilibrium and (ii) total elongation of the bar.



9. A steel bar ABCD consists of three sections : AB is of 20 mm diameter and 200 mm long, BC is 25 mm square and 400 mm long, and CD is of 12 mm diameter and 200 mm long. The bar is subjected to an axial compressive load which induces a stress of 30 MN/m^2 on the largest cross section. Determine total decrease in length of the bar when the load is applied. For steel E = 210 GPa.
10. A copper rod of 25mm in diameter is surrounded by a steel tube of 35mm external diameter and 30mm internal diameter. The rod and the tube are of same length and their ends are rigidly fixed. If the tube and rod are at 20°C, calculate the stress in each material, when the temperature is raised to 120°C. Take E_s= 200GN/m^2, E_b=100GN/m^2, α_s= 11.6x10^{-6}/°C,α_b=18.7x10^{-6}/°C.
11. A steel bar 50mm in diameter and 2m long is firmly encased in a shell of cast iron 5mm thick. Compute the stress in each material if a composite axial load of 200kN is applied to the assembly. For steel E= 200GPa, and for cast iron E= 100GPa.
12. A steel bar of 500mm length with uniformly varying diameter is held between two unyielding supports at room temperature. The diameters of the bar at the ends are 20mm and 40mm respectively. What is the maximum stress induced in the bar, if temperature rises by 30° C? Take Modulus of elasticity as 2x10^5MPa and coefficient of thermal expansion as 12x10^{-6}/°C.
13. A copper bar 25 mm. diameters is completely enclosed in a steel tube, 25 mm. internal diameters and 40 mm. external diameter. A pin, 10 mm. in diameter is fitted transversely to the axis of the bar near each end, to secure the bar to the tube. Calculate the intensity of shear stress induced in the pin when the

temperature of the whole is raised by 40°K. Take E_c = $1x10^5$ N/mm^2. ; E_s= $2x10^5 N/mm^2$; $\alpha_c = 18x10^{-6}$ per °K; $\alpha_s = 12x10^{-6}$ per °K.

14. A steel wire of 10 mm. diameter is used for lifting a load of 1 kN at its lowest end, the length of the wire hanging vertically being 200 mm. Taking the unit weight of steel = 78 kN/m^3 and $E=2x10^5$ N/mm^2., Calculate the total elongation of the wire.
15. Obtain an expression for the elongation of a bar of constant thickness *t* and of width *b* at one end varying uniformly to width *B* at the other end over a length L subjected to an axial pull *P*. If *b*= 25 mm; B=50 mm; *t* = 5 mm, L=0.5 m and *P*= 5 kN, find the total elongation of the bar. $E=2x10^5$ N/mm^2.
16. An aluminium rod of 20 mm. diameter passes through a steel sleeve of internal diameter 22mm. and external diameter 33mm. The sleeve is 400mm. long while the rod is 0.3mm. longer than sleeve . The assembly is supported by rigid plates at both ends and loaded in compression. Determine the maximum load on the assembly , if allowable stresses in aluminium and steel are 120 and 180 MPa respectively. Also calculate the deformation of the assembly under the maximum load.E = 210 GPa , E = 70 GPa.
17. A 12mm diameter bronze bolt is co- axially passes inside an aluminum tube of inner diameter 14mm and wall thickness 3mm . A nut is turned on the threaded end of the bolt such that it first touches the tube. When the nut is further tightened by half a revolution., determine stresses in the materials and deformation produced. Pitch of the thread is 1.6mm. Length of tube is 300mm. $\boldsymbol{E_b}$ **=** 84 GPa and F_A=70GPa.
18. A brass bar of 25 mm diameter is enclosed in a steel tube of 25 mm internal diameter and 50 mm external diameter. Both of them are 1 m long at room temperature and fastened rigidly to each other at the ends. If the room temperature is 20°C, find to what temperature the assembly should be heated so as to generate a compressive stress of 48.7 MN/m^2 in brass. What is the stress in steel at this temperature? Take *E = 200GN/m²*, $^E b$ 100GN/m², $\alpha_s = 11.6x10^{-6}/^\circ C$, $\alpha_b = 18.7x10^{-6}/^\circ C$.

Module 3

1. A solid circular shaft and a hollow circular shaft whose inside diameter is *³/4* of the outside diameter are of the same material, equal length and are required to transmit a given torque. Compare the weights of these shafts if the maximum stress developed are equal. (MGU, Nov 2011, MPU)

2. A solid circular shaft transmits 80 kN power at 190 rpm. Calculate the diameter of the shaft if the twist in the shaft is not to exceed 1° in 2 m length of shift and stress is limited to 60 MPa. Take *G* = 100 Gpa. (MGU, Apr 2011).

3. A hollow shaft is of 140mm external diameter and internal diameter ratio 0.6. If the maximum shear stress in the shaft limited to 110MPa and allowable twist 1° per meter length, find the maximum power that can be transmitted to the shaft, if it is to rotate at 100 rpm. Take C=8x10^4MPa.

4. A solid steel shaft of diameter 60mm is to be designed using an allowable shear stress of 40MPa and an allowable angle of twist per unit length 1° per meter. Determine the maximum permissible torque that may be applied to the shaft, assuming a modulus of rigidity of 80GPa. (MGU, Apr 2009, MPU).

5. A hollow low carbon steel shaft is subjected to a torque of 0.25 MNm. If the ratio of internal to external diameter is 1 to 3 and the shear stress due to torque has to be limited to 70 MN/ m^2 determine the required diameters and angle of twist in degrees per meter length of shaft. G = 80 GPa. (MGU, Nov 2009, C).

6. A hollow steel shaft of external diameter equal to twice the internal diameter has to transmit 2250 kW power at 400 rpm. If the angle of twist has not to exceed 1° in a length of 16 times the external diameter and the maximum turning moment is $^1/4$ times the mean, calculate the maximum stress. (MGU, Nov 2008, C).

7. A hollow shaft is of external diameter 70mm and diameter ratio 0.8. It transmits a power of 2HP at 25 rpm. If the maximum torque exceed the average torque by 25% draw the shear stress distribution across the section of the shaft. (MGU, May 2008, MPU).

8. A solid shaft transmits 250 kW at 100 r.p.m., if the shear stress is not to exceed 75 N/mm^2, What should be the diameter of the shaft? If this shaft is to be replaced by a hollow shaft with internal diameter 0.6 times the outer diameter, find the sizes of the hollow shaft and the percentage saving in weight, the maximum shear stress being the same. (MGU, Dec 2007, C).

9. A hollow shaft has to transmit 600kW at 80 r.p.m. The maximum torque exceed the mean by 40%. Design a suitable section if the permissible shear stress is 70N/mm^2 . The diameter ratio is to be 0.8. What will be the angular twist over a length of 2m. if modulus of rigidity is 84000MPa. (MGU, Jul 2007, C).

10. A hollow shaft has an external diameter of 360mm and a bore of 20mm. When transmitting power it is observed that the angle of twist is 0.5 0 in a length of 3.5 m. If G = $8x10^4$ N/mm^2 and T_{max} = 1.4 T_{mean} calculate (i) the power transmitted by the shaft, if speed is 300 rpm. (ii) the maximum shear stress induced in the shaft.
11. A hollow shaft is of 120mm external diameter and diameter ratio 0.6. If the maximum shear stress in the shaft is limited to 100MPa and allowable twist 1° per meter length, find the maximum power that can be transmitted to the shaft, If it is to rotate at 10 r.p.m . Take C=$8x10^4$MPa. (MGU, Nov 2005).
12. Calculate the maximum torque and mean power being transmitted in the case of a hollow shaft of outer diameter 200mm and inner diameter 100mm. The shear stress is not to exceed 60MN/m^2 and the shaft speed is 300 rpm. Assume maximum torque to be 25% more than the mean. (MGU, May 2005, MPU).
13. A hollow steel shaft of 150 mm external diameter and 100mm and bore twist through an angle of 0.8 degree in a length of 2 m. When subjected to an axial torque. What are the values of shearing stresses at the inner and outer surfaces of the shaft? Calculate the power that is transmitted by the shaft at a speed of 250 r.p.m. When the above torque is applied.= 90 GN/m^2. (MGU, Oct 2004, MPU)
14. An overhanging beam ABC length 7cm supported on AB length 5m. The overhanging portion BC of length 2m.A.U.D.L. of 2kN/m is acting over a length of 3m from the left support, Two point loads of 4kN and 6kN acting at a distance of 4m from left support and at the free end C. Draw S.F. and B.M. diagrams. Also find the location of point of contraflexure. (MGU, Apr 2011, MPU)
15. Draw the shear force and bending moment diagrams for a cantilever bem of span 5 m subjected to a uniformly distributed load of 5kN/ m over a length of 2 meter at a distance of 1 meter from the fixed end. (MGU, Apr 2011, C)

3. A beam of ABCDE is simply supported at A and D. It carries the following loading : a distributed load of 30 kN/ m between A and B : a concentrated load of 20 KN at C : a concentrated load of 10 kN at E. Span AB = 1.5 m, BC=CD=DE= lm. Draw the shear force and bending moment diagrams. Find also the magnitude and position of the maximum bending moment. (MGU, May 2010, C).

4. A beam ABCD, 12m long, is freely supported at A and C, 10m apart, with an overhang CD of 2m. It carries a uniformly distributer load of 25 kN/m over the length and a couple of 100 kN m at B, 3m from A. State the position and amount of maximum B.M in BC and sketch the S.F.D and B.M.D.
5. A beam ABCDE, with A on the left is 5.6m long and is simply supported at B and E. The length of various portions are AB= 1.5m, BC= 1.5m, CD-- 1m, DE=2m. There is a uniformly distributed load of 15kN/m between B and a point 2m to the right of 3 and concentrated loads of 30kN act at A and D. Draw the shear force and bending moment diagram showing their maximum values. (MGU, May 2010, MPU).
6. A beam ABCDE, with A on the left, is 7m long and is simply supported at A and D. The lengths of various portions are AB=2m, BC= 2.5m, CD= 1.5m, DE= lm. There is a uniformly distributed load of 15kN/m, between B and a point 3.5m, to the right of B and concentrated loads of 30kN act at BC and E. Draw the shear force and bending moment diagram showing their maximum values. (MGU, Nov 2009, MPU).
7. A simply supported beam AB of span 5m is subjected to a couple of 4kN/m at end A and a uniformly distributed load of 2kN/m for a distance of 1.5m from the end B. Draw the shear force and bending moment diagrams. (MGU, Apr 2009, MPU).
8. A beam ABCDE with A on the left, is 7 m. long and is simply supported at B and E. The lengths of various portions are AB=1.5m,. BC = 1.5m. CD = 1 m, DE=3m. There is a uniformly distributed load of 15 kN/m. between B and a point 2m. to the right of B and concentrated loads of 20 kN act at A and D. Draw the shear force and bending moment diagram showing their maximum values. (MGU, Nov 2009, C).
9. A beam, 6 m. long is simply supported at the ends, and carries a uniformly distributed load of 15 kN/m (including its own weight) and threeconcentrated loads of 10 kN, 20 kN and 30 kN acting respectively at the left quarter point, centre point and right quarter point. Draw the shear force and bending moment diagrams and determine the maximum bending moment. (MGU, May 2008, C).
10. The intensity of loading on a simply supported beam of 5 m. span increases gradually from 1 kN/m. at one end to 2 kN/m. run on the other end. Find the position and amount of maximum bending moment. Also, draw the shear force and bending moment diagram. (MGU, May 2008, C)

1. A simply supported beam PQ of span 6m carries : (i) a point load of 30kN at R (which is at a distance of 1.2m from P) and (ii) a point load of 40kN at S (which is at a distance of 1.5m from Q). Determine the position and magnitude of maximum deflection by Macaulay's method.

2 A simply supported beam of 20 m span carries two point loads of 4 kN and 10 kN at 8 m and12 m from left end. Determine the deflection under each load and maximum deflection.Take EI = 200 x 1012 Nmm^2

3 A steel girder of uniform section, 12m long, is simply supported at its ends. It carries concentrated loads of 140kN and 70kN at two points 3m and 4.5m from the two ends respectively. If for the section bcx=16x10^{-4} m^4 and 21OGN/ m2, find (i) the deflection and slope under the loads and (ii) position and amount of maximum deflection.

4. A 6m long cantilever is loaded with a UDL of 2kN/m over the 4m from the fixed end and a point load of lkN at the free end. If the section is rectangular 80mm (wide) x160mm (deep), and E=10GN/m^2, calculate the slope and deflection (i) at the free end of the cantilever and (ii) at a distance of 0.6m from the free end.

5. A horizontal beam of uniform section and 9m long is simply supported at its ends. Two vertical loads of 52kN and 45kN act 2.5 and 5.5m respectively from the left hand support. Determine (1) the deflection and slope under the loads and (ii) position and magnitude of maximum deflection.

6. A uniform beam is simply supported over a span of 6m. It carries a trapezoid ally distributed load with intensity varying from 30kN/m, at the left- hand support to 90kN/m, at the right-hand support. Find the equation of the deflection curve and hence the deflection at the mid-span point. The second moment of area of the cross section of the beam is 120x $10^6$$mm^2$, and Young's modulus E= 206000N/mm^2.

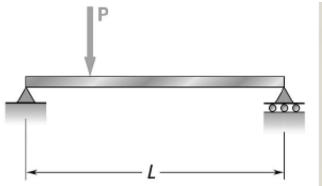
7. A cantilever of length L and having a flexural rigidity EI carries a distributed load that varies in intensity from w per unit length at the built-in end to zero at the free end. Find the slope and deflection of the free end.

8. 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 × 108 mm4 and Es =

210 kN/mm2. Calculate the deflection of the girder at points under the two loads and maximum deflection using Macaulay's method.

9. 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.

10. 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.



11. State and prove Castigliano's second theorem.

Module 5

1. 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/mm2. Compare this load by crippling load given by Euler's formula. Take E = 110 GPa.
2. Explain the maximum normal stress theory, maximum strain energy theory and maximum shear stress theory of failure.
3. A hollow cylindrical column is 6m long with both ends fixed. Determine the minimum diameter of the column, if it has to carry a safe load of 300kN with *FS* of 4. Take the internal diameter as 0.8 times the external diameter and E = 2.1 x 10^5 N/ mm^2. If the column is hinged at both ends, calculate the safe load.(MGU, Nov 2011, MPU)
4. A hollow cast iron column of outside diameter 250 mm and thickness 15 mm is 3 m long and is hinged at one end fixed at the other end. Find the ratio of the Euler's and Rankine's load and (b) for what length, the critical load by Euler's and Rankine's formulae will be equal? Take E = 80 Gpa, f_c= 550 MPa and a = 1/600. (MGU, Apr 2011, C)
5. 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 = 8.0x10^4N/mm^2. For what length the critical load by Euler's and Rankine's formula be equal. Take constant a -1/1600 and f_c=600N/mm^2. (MGU, Nov 2010, MPU)

6. A tubular column has an effective length of 2.5m and is to be. designed to carry a safe load of 300kN. Assuming an approximate ratio of thickness to external diameter of 1/16, determine a practical diameter and thickness using the Rankine's formula with a=330N/mm^2 and a= 1/7500. Use a safe factor of 3. (MGU, May 2010, MPU)
7. A hollow cast iron column of outside diameter 200 mm and thickness 20mm is 4.5 m long and is fixed at both ends. Calculate the safe load by Rankine's formula using a factor of safety of 2.5. Find the ratio of Euler's to Rankine's loads. Take E= 100 GP a and Rankine's constant = 1/1600 for both ends pinned case and f_c= 550 N/mm^2. (MGU, Nov 2010, C)
8. Compare the crippling loads given by the Euler and Rankine formula for a pin jointed cylindrical strut 1.75 m long and 50 mm diameter. For Rankine formula use 4=315 MN/m^2 a = 1/7500 E = 200 GPa. (MGU, May 2010, C)
9. An aluminum tube of length 8 m. used as a column pinned at both ends carrying a 1.2 kN axial load. If the outer diameter of the tube is 50 mm. compute the inner diameter that would provide a factor of safety of 2 against buckling. Use E=70 GPa for aluminum. (MGU, Nov 2009)
10. Determine the Euler's critical load for a hollow cylindrical mild steel column 120mm internal diameter and 25mm wall thickness, 70m long with one end fixed and other end hinged. Compare this load with the critical load as given by the Rankine's formula using yield stress 600MPa, a=1/7500 and E=2x10^{5}MPa. For what length of column of this cross section does Euler's formula cease to apply? (MGU, Apr 2009, MPU)
11. Determine Euler's critical load for a hollow cylindrical cast iron column 150mm internal diameter and 30mm wall thickness, 8m long with both ends hinged. Compare this load with the critical load as given by Rankine's formula using yield stress 500MPa and a= 1/ 1600 and E= lx10^{5}MPa. For what length of column of this cross section does Euler's formula ceases. (MGU, Nov 2008)
12. Find the ratio of crippling loads by Euler's and Rankine's formula for a hollow strut of 40mm external diameter and 30mm internal diameter pinned at both .ends. Take yield stress as 300 MPa, modulus of elasticity as 200GPa and Rankine's constant as 1/7500. (MGU, May 2008, MPU)

13. Find the Euler's crippling load for a hollow cylindrical steel column of 38 mm. external diameter and 2.5 mm. thick. Take length of the column as 2.3 m. and hinged at its both ends. Take E = 205 kN/mm^2. (MGU, May 2008, C)
14. Compare the strengths of a solid steel Colu.mn 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. (MGU,Jul 2007, MPU)
15. Determine the external and internal diameter of a hollow circular cast-iron column, which carries a load of ‘1000KN. Length of column 6m. Internal diameter is half of external diameter. Use Rankine's formula. Take = 550N/ mm^2. and a=1/1600. Take FS=3. Column is fixed at both ends. (MGU,Jul 2007, MPU)
16. A hollow column with fixed ends supports an axial load of 1000kN. If the column is 6m. long and has external diameter 200 mm. Find- the thickness of metal required 1/6400. Working stress= 80 MPa. (MGU, Jan 2007, MPU)
17. Determine the ratio of buckling strength of two columns one hollow and other solid. Both are made of same material and have equal length, cross sectional area and same end conditions. Internal diameter is half of external diameter (MGU, Jul 2007, C)
18. Find the Euler's crushing load for a hollow cylindrical cast iron column of 150 mm. External diameter and 20 mm thickness. It is 6m long and hinged at both ends. Value of E = 7.8x10^4 N/mm^2. Compare the load with the crushing load given by Rankine's formula using a constant of 1/1600 and = 563 N/mm^2. (MGU, May 2006, MPU)
19. Determine Euler's critical load for a hollow cylindrical cast iron column 150mm. External diameter and 100mm. Internal diameter, If it is 6m long and hinged at both the ends. Compare this load with the critical load as given by Rankine's formula using yield stress of 550N/mm^2 and constant 1/1600. For what length of this • column does Euler's formula ceases to apply ? Take E =80kN/mm^2. (MGU, May 2006)
20. Find the Euler's critical load for a hollow cylindrical cast iron column of 200mm external diameter and 256mm thickness. It is 5m long and hinged at both ends. Value of E= 8.0x 10^4 N/mm^2. For what length the critical load by Euler's and Rankine's formula be equal? Take constant of 1/1600 and f_c = 600N/mm^2. (MGU, Nov 2005)

6. 100006/ME300C MECHANICS OF FLUIDS

6.1 COURSE INFORMATION SHEET

PROGRAMME: ME	***DEGREE: BTECH***
***COURSE:* MECHANICS OF FLUIDS**	**SEMESTER:** 3 **CREDITS:** 4
COURSE CODE: 100006/ME300C ***REGULATION:* 2020**	**COURSE TYPE:** CORE
COURSE AREA/DOMAIN: **FLUID MECHANICS**	**CONTACT HOURS:** 3(Lecture)+1(Tutorial) Hours/Week.
CORRESPONDING LAB COURSE CODE (IF ANY): 100006/ME422S	**LAB COURSE NAME:** *Fluid Mechanics and Hydraulic Machines Laboratory*

SYLLABUS:

UNIT	***DETAILS***	***HOURS***
I	*Fluid Statics:* 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.	7-2-0
II	*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.	6-2-0
III	*Dynamics of Fluid flow:* 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.	6-2-0
IV	*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.	9-3-0
V	*Boundary Layer Theory and Dimensional Analysis:* Boundary Layer: Growth of boundary layer over a flat plate and definition of boundary layer thickness, displacement thickness, momentum thickness and energy thickness, laminar	8-2-0

	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.	
TOTAL HOURS		**47**

TEXT/REFERENCE BOOKS:

T/R	***BOOK TITLE/AUTHORS/PUBLICATION***
T1	John M. Cimbala and Yunus A. Cengel, Fluid Mechanics: Fundamentals and Applications 4th edition, SIE, 2019.
T2	Robert W. Fox, Alan T. McDonald, Philip J. Pritchard and John W. Mitchell, Fluid Mechanics, Wiley India, 2018.
R1	White F.M, Fluid Mechanics, McGraw Hill Education India Private Limited, 8th edition, 2017.
R2	Rathakrishnan, E., Fluid Mechanics: An Introduction, Prentice Hall India, 3rd edition, 2012.
R3	Bansal, R. K., A Textbook of Fluid Mechanics and Hydraulic Machines, Laxmi Publications, 2005.
R4	Modi P. N. and S. M. Seth, Hydraulics & Fluid Mechanics, S.B.H. Publishers, New Delhi, 2002.
R5	Streeter V. L., E. B. Wylie and K. W. Bedford, Fluid Mechanics, Tata McGraw Hill, Delhi, 2010.
R6	Joseph Katz, Introductory Fluid Mechanics, Cambridge University Press, 2010.

COURSE PRE-REQUISITES: NIL

COURSE OBJECTIVES:

1	To study the mechanics of fluids.
2	To establish fundamental knowledge of basic fluid mechanics and address specific topics relevant to simple applications involving fluids.
3	To familiarize students with the relevance of fluid dynamics to many engineering systems.

COURSE OUTCOMES:

SNO	*DESCRIPTION*	*Bloom's Taxonomy Level*
100006/ME300C.1	**Define** properties of fluids and **solve** problems on hydrostatics.	*Apply* (Level 3)
100006/ME300C.2	**Explain** aspects of fluid kinematics, dynamics and **classify** fluid flows.	*Understand* (Level 2)
100006/ME300C.3	**Interpret** Euler and Navier-Stokes equations and **solve** problems using Bernoulli's equation.	*Analyze* (Level 4)
100006/ME300C.4	**Evaluate** energy loses in pipes and sketch energy gradient lines.	*Evaluate* (Level 5)
100006/ME300C.5	**Explain** the concept of boundary layer and its application to estimate drag.	*Understand* (Level 2)
100006/ME300C.6	**Apply** dimensional analysis for model studies.	*Create* (Level 6)

CO-PO AND CO-PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
100006/ME300C.1	3	2	-	-	-	-	-	-	-	-	-	-	2	2	-
100006/ME300C.2	3	2	1	-	-	-	-	-	-	-	-	-	-	-	-
100006/ME300C.3	3	2	1	-	-	-	-	-	-	-	-	-	3	3	-
100006/ME300C.4	3	2	1	-	-	-	-	-	-	-	-	-	3	3	-
100006/ME300C.5	3	2	1	-	-	-	-	-	-	-	-	-	2	2	-
100006/ME300C.6	3	2	1	-	-	-	-	-	-	-	-	-	2	3	-

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	*LOW/MEDIUM/ HIGH*	*JUSTIFICATION*
100006/ME300C.1-PO1	H	Students will be able to appreciate and to a considerable extent *solve complex engineering problems* related to fluid statics, based on acquired **knowledge**.
100006/ME300C.1-PO2	M	**Problem analysis** based on *first principles of mathematics and research based relevant data* is essential to *analyze* the pressure variations in static fluids.
100006/ME300C.2-	H	Students will be able to *solve complex engineering*

PO1		*problems* related to fluid kinematics and dynamics, based on acquired **knowledge**.
100006/ME300C.2-PO2	M	**Problem analysis** based on *first principles of mathematics and research based relevant data* is essential to *analyze* the classification of fluid flow and different flow characteristics.
100006/ME300C.2-PO3	L	**Design/development of solutions** *for complex kinematic flow problems* finds applications in dam construction for production of electricity, and in the oil production sector which has relevance in societal and environmental considerations.
100006/ME300C.3-PO1	H	Deeper **knowledge** gained into the development of momentum and energy equations will help to *solve complex engineering problems* related to flow through bend pipes, fluid machinery etc.
100006/ME300C.3-PO2	M	To **conduct investigations of complex problems** on *experimental analysis* of lifting surfaces/aerodynamic bodies in wind tunnels and to generate *relevant experimental data*, the fundamental background on momentum and energy equations is essential.
100006/ME300C.3-PO3	L	**Design/development of solutions** *for complex fluid dynamics problems* utilizing computational techniques that has strong relevance in applications related to public health and safety, and civil considerations.
100006/ME300C.4-PO1	H	Students will be able to *solve complex engineering problems* related to fluid flow in pipes, based on acquired **knowledge**.
100006/ME300C.4-PO2	M	While **conducting investigations of complex problems** to *validate/conclude* on *analysis* whether a complex pipe system with given bends and contractions will sustain the fluid pressure and overcome frictional losses, the student has to *use research-based knowledge* (Moody's chart, loss coefficient charts: exhaustive data is available) and *interpret relevant data* at his/her disposal.
100006/ME300C.4-PO3	L	**Design/development of solutions** *for complex pipe flow problems* that has relevance in fluid transport systems dominantly utilized for welfare of civilians.
100006/ME300C.5-PO1	H	Students will be able to *solve complex engineering problems* related to boundary layer flow, based on acquired **knowledge.**
100006/ME300C.5-PO2	M	**Problem analysis** based on *first principles of mathematics and research based relevant data* is essential to *analyze* problems related to boundary layer theory.
100006/ME300C.5-PO3	L	**Design/development of solutions** *for complex boundary layer flow problems* that has relevance in aerospace industry dominantly aimed at public safety and environmental considerations.
100006/ME300C.6-PO1	H	Student will gain a broad overview of *basic/fundamental knowledge in (engineering)* dimensional analysis, wind tunnel application, and **knowledge** will be applied towards

		use of the principle of dimensional similarity in the *solution to a complex problem.*
100006/ME300C.6-PO2	M	**Problem analysis** based on *first principles of mathematics* (Rayleigh method, pi theorem etc.) is essential to *analyze, evaluate, debate and recommend* appropriate non-dimensional terms for a fluid flow experiment.
100006/ME300C.6-PO3	L	In the **design/development of solutions** *for complex external flow problems in wind tunnel/water tunnel etc. and to design fluid dynamic systems* that ensures civilian *safety* on ground, the knowledge of devising a test model based on dimensional analysis before building a prototype is a must.

JUSTIFICATIONS FOR CO-PSO MAPPING

MAPPING	*LOW/MEDIUM/ HIGH*	*JUSTIFICATION*
100006/ME300C .1-PSO1	M	Students will acquire basic knowledge on fluid properties, fluid statics and pressure measurement, and will be able to *apply this knowledge in the domain of thermal and fluid sciences to solve engineering problems*.
100006/ME300C .1-PSO2	M	*Design, analysis and implementation of mechanical systems* (pressure measuring devices, structures related to principles of buoyancy and floatation) will be based on the s*uccessful application of the principles learned as a part of the curriculum.*
100006/ME300C .3-PSO1	H	Students will acquire basic knowledge on Euler's and Bernoulli's equations and will be able to *apply this knowledge in the domain of thermal and fluid sciences to solve engineering problems*.
100006/ME300C .3-PSO2	H	*Design, analysis and implementation of mechanical systems* (metering systems, calculation of approach factor, and location of pressure ports with respect to metering device) will be based on the s*uccessful application of the principles learned as a part of the curriculum.*
100006/ME300C .4-PSO1	H	With the knowledge in the domain of pipe flow *engineering* (frictional/transmission losses, Power developed), *thermal and fluid sciences* (fluid mechanics), the students will be successful in *solving* fundamental *engineering problems utilizing advanced technology* in an industry like oil transportation, drinking water pipelining etc.
100006/ME300C .4-PSO2	H	*Principles of design, analysis and implementation of mechanical systems/* manufacturing *processes* for pipe lines are based on the fluid mechanics and pressure, power/performance conditions *which have been learned as a part of the curriculum*.
100006/ME300C .5-PSO1	M	Application of *knowledge gained in the domain of boundary layer theory to solve engineering problems pertaining to fluid flow over aircraft wingspan* using *advanced computational techniques*.

100006/ME300C .5-PSO2	M	In the *design and analysis of experimental systems for aircrafts* (for design of lifting surfaces, wings, rotor blades) the *processes* (experimental methods, wind & water tunnels) will be based on the *successful application of the principles learned* on boundary layer theory.
100006/ME300C .6-PSO1	M	Students gain only a peripheral knowledge in the domain of dimensional analysis for experiments (aerospace *engineering*), wind tunnels (*thermal and fluid sciences*). Though elaborate for an undergraduate course, to be successful in *solving high level aircraft/ ship manufacturing engineering problems*, further specific courses is required.
100006/ME300C .6-PSO2	H	*Principles of design, analysis and implementation of experimental mechanical systems* based on dimensional similarity (scaling ratio, relevant non-dimensional numbers, etc) *have been learned as part of curriculum.*

GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSIONAL REQUIREMENTS:

SNO	***DESCRIPTION***	***RELEVENCE TO PO\PSO***	***PROPOSED ACTIONS***
1	Introduction to numerical programming techniques absent in curriculum. Students have to be exposed to simple computational fluid mechanics in order to appreciate some topics in the syllabus, like potential flow theory in Module II: Fluid kinematics.	PO4, PSO1	Programming based information as NPTEL video reference.

PROPOSED ACTIONS:

WEB SOURCE REFERENCES:

1	https://www.youtube.com/watch?v=F_7OhKUYV5c
2	http://freevideolectures.com/Course/89/Fluid-Mechanics
3	https://www.youtube.com/watch?v=brN9citH0RA
4	https://www.youtube.com/watch?v=lfXDJKKPGfY
5	https://www.youtube.com/watch?v=fa0zHI6nLUo&list=PLbMVogVj5nJTZJHsH6uLCO00I-ffGyBEm
6	NPTEL video on "Introduction to basic numerical methods": https://www.youtube.com/watch?v=Zi6YqYDFZQw

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑CHALK & TALK	☑STUD. ASSIGNMENT	☑WEB RESOURCES	☑LCD/SMART BOARDS
☐STUD. SEMINARS	☐ADD-ON COURSES		

ASSESSMENT METHODOLOGIES-DIRECT

☑ASSIGNMENTS	☐STUD. SEMINARS	☑TESTS/MODEL EXAMS	☑UNIV. EXAMINATION
☐STUD. LAB PRACTICES	☐STUD. VIVA	☐MINI/MAJOR PROJECTS	☐CERTIFICATIONS
☐ADD-ON COURSES	☐OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☑ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☑STUDENT FEEDBACK ON FACULTY (ONCE)
☐ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐OTHERS

6.2 COURSE PLAN

HOUR	*MODULE*	*TOPIC PLANNED*
1	I	*Introduction and basic concepts*-Fluids and continuum, Physical properties of fluids, density, specific weight, vapour pressure, Newton's law of viscosity.
2	I	Ideal and real fluids, Newtonian and non-Newtonian fluids. Fluid Statics-Pressure-density-height relationship.
3	I	Manometers
4	I	Manometers
5	I	Pressure on plane and curved surfaces, center of pressure, buoyancy.
6	I	Stability of immersed and floating bodies.
7	I	Fluid masses subjected to uniform accelerations.
8	I	Measurement of pressure.
9	I	Measurement of pressure.
10	II	*Kinematics of fluid flow:*Eulerian and Lagrangian approaches, classification of fluid flow, 1-D, 2-D and 3-D flow.
11	II	steady, unsteady, uniform, non-uniform, laminar, turbulent, rotational, irrotational flows.
12	II	stream lines, path lines, streak lines, stream tubes,
13	II	velocity and acceleration in fluid
14	II	circulation and vorticity
15	II	stream function and potential function
16	II	Laplace equation
17	II	equipotential lines flow nets, uses and limitations,
18	III	Control volume analysis of mass, momentum and energy, Equations of fluid

		dynamics: Differential equations of mass, energy and momentum (Euler's equation)
19	III	Navier-Stokes equations (without proof) in Cartesian co-ordinates
20	III	Equations of fluid dynamics: Differential equations of mass, energy and momentum (Euler's equation)
21	III	*Dynamics of Fluid flow:* Fluid Dynamics: Energies in flowing fluid, head, pressure, dynamic, static and total head,
22	III	Energies in flowing fluid, head, pressure, dynamic, static and total head.
23	III	Bernoulli's equation and its applications: Venturi and Orifice meters
24	III	Notches and Weirs (description only for notches and weirs).
25	III	Hydraulic coefficients, Velocity measurements: Pitot tube and Pitot-static tube.
26	IV	*Pipe Flow: Viscous flow:* Reynolds experiment to classify laminar and turbulent flows, significance of Reynolds number, critical Reynolds number
27	IV	shear stress and velocity distribution in a pipe
28	IV	law of fluid friction, head loss due to friction
29	IV	Hagen Poiseuille equation.
30	IV	Turbulent flow: Darcy- Weisbach equation, Chezy's equation, Moody's chart
31	IV	Darcy-Weisbach equation, Chezy's equation, Moody's chart
32	IV	Darcy-Weisbach equation, Chezy's equation, Moody's chart
33	IV	Major and minor energy losses, hydraulic gradient and total energy line
34	IV	flow through long pipes, pipes in series, pipes in parallel, equivalent pipe, siphon.
35	IV	transmission of power through pipes,
36	IV	efficiency of transmission
37	IV	Water hammer, Cavitation
38	V	*Concept of Boundary Layer:* Growth of boundary layer over a flat plate and definition of boundary layer thickness,
39	V	displacement thickness, momentum thickness and energy thickness
40	V	laminar and turbulent boundary layers, laminar sub layer, velocity profile, Von-Karman momentum integral equations for the boundary layers, calculation of drag.
41	V	separation of boundary and methods of control.
42	V	separation of boundary and methods of control.
43	V	*Dimensional Analysis and Hydraulic similitude:* Dimensional analysis, Buckingham's theorem
44	V	Important dimensional numbers and their significance
45	V	Geometric, Kinematic and dynamic similarity.
46	V	Model studies. Froude, Reynold, Weber, Cauchy and Mach laws.
47	V	Applications and limitations of model testing, simple problems only.

6.3 SAMPLE QUESTIONS

MODULE: 1 Derive an expression for the terminal velocity V [m/s] for a block of weight W [N] sliding over a wedged platform at inclination θ [degrees] with horizontal. The platform is lubricated with oil of viscosity μ [Pa-s].

1. The pressure at the center of a pipe flow (fluid is water) measures 52.1 [kPa] with an inclined manometer. What would be the level rise of Hg column in the inclined limb, if the angle of inclination is θ =30^o, tube-to-tank area ratio is 0.01 and the initial level of Hg in the tank is 0.2 [m] below the center line of the pipe.
2. Fluid pressure at the bottom surface of the following vessels filled with water, with free surface measuring h [m] above bottom, are the same: (a) cylindrical vessel with diameter D [m] and (b) a stepped cylindrical vessel with initial depth h/2 [m] having diameter D/2 [m] and the later depth having diameter D [m]. However, they weigh differently on a scale over which the bottom surface is placed. Explain this 'Hydrostatic paradox' with hydrostatic pressure laws and supporting calculations.

MODULE: 2

1. Consider 2D flow
$$\vec{V} = x^2\mathbf{i} - (2xy + 1)\mathbf{j}$$
a) Check if the flow is possible
b) Check if flow is rotational
2. Explain flow net and its applications.
3. Consider 2D flow
$$u = 2x^3; v = -6x^2y$$
a) Check if the flow is rotational
b) If rotational, find the circulation about the circle
$$x^2 + y^2 - 2ay = 0$$

MODULE: 3

1. Discuss the applications and limitations of Bernoulli's equation.
2. A 30 cm x 15cm venturimeter is provided in a vertical pipeline carrying oil of specific gravity 0.9, the flow being upwards. The difference in elevation of throat section and entrance of the venture is 30 cm. The differential U-tube mercury manometer shows a deflection of 25 cm. Calculate the discharge of oil.
Take $C_d = 0.98$ for the meter and $S_{Hg} = 13.6$

MODULE: 4

1. List the major and minor energy losses for fluid flow through pipes. What is the primary cause for major losses? Write down the expressions for the major losses.
2. Write down the expression for Darcy-Weisbach equation. Clearly define the symbols that appear in the equation. From the equation, mention how can one reduce energy loss due to friction in pipes?
3. Find the head loss due to friction in a pipe of diameter 500 mm and length 100 m, through which water is flowing at a velocity of 10 m/s using: (i) Darcy formula, (ii) Chezy's formula for which $C = 60$. Take viscosity for water = 0.01 poise and coefficient of friction $f = 0.01$.

MODULE: 5

1. Find displacement and momentum thickness for a boundary layer flow whose profile is given by

$$\frac{u}{U_\infty} = 2\left(\frac{y}{\delta}\right) - \left(\frac{y}{\delta}\right)^2$$

2. Explain with neat sketches explain:
   a) boundary layer theory, and
   b) compare the velocity profiles for laminar and turbulent boundary layer flows.
3. a) State Buckingham's - π theorem. Explain dimensional homogeneity with the help of an example.
   b) Define and explain Froude number, Reynolds number, Weber's number and Mach number
4. 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.

Prepared by	**Approved by**
Dr. Rahul Sathyanath	**Dr. Manoj G. Tharian**
(Faculty in charge)	**(HOD)**

7. 100006/ME300D - METALLURGY AND MATERIAL SCIENCECOURSE

7.1 COURSE INFORMATION SHEET

PROGRAMME:	DEGREE: B.TECH
COURSE: **METALLURGY AND MATERIAL SCIENCE**	SEMESTER: **III** CREDITS: **4**
COURSE CODE: 100006/ME300D REGULATION: **UG**	COURSE TYPE: **CORE**
COURSE AREA/DOMAIN: **MECHANICAL**	CONTACT HOURS: **3 (Lecture) hours/Week & 1 Tutorial hour**
CORRESPONDING LAB COURSE CODE (IF ANY): **NA**	LAB COURSE NAME: **NA**

SYLLABUS:

UNIT	DETAILS	HOURS
I	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
II	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
III	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
IV	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
V	Fatigue: - creep -DBTT - super plasticity - need, properties and applications of composites, super alloy, intermetallics, maraging steel, Titanium - Ceramics:- structures, applications.	10
TOTAL HOURS		**45**

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
T	Raghavan V, Material Science and Engineering, Prentice Hall,2004
T	Jose S and Mathew E V, Metallurgy and Materials Science, Pentagon, 2020
R	Anderson J.C. *et.al*., Material Science for Engineers,Chapman and Hall,1990
R	Clark and Varney, Physical metallurgy for Engineers, Van Nostrand,1964
R	Reed Hill E. Robert, Physical metallurgy principles, 4th Edn. Cengage Learning,2009
R	Avner H Sidney, Introduction to Physical Metallurgy, Tata McGraw Hill,2009
R	Callister William. D., Material Science and Engineering, John Wiley,2014
R	Dieter George E, Mechanical Metallurgy,Tata McGraw Hill,1976
R	Higgins R.A. - Engineering Metallurgy part - I – ELBS,1998
R	Myers Marc and Krishna Kumar Chawla, Mechanical behavior of materials, Cambridge University press,2008
R	Van Vlack -Elements of Material Science - Addison Wesley,1989

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
100902/PH900B	Engineering Physics	Fundamental Knowledge	1
100908/CH900B	Engineering Chemistry	Fundamental Knowledge	1

COURSE OBJECTIVES:

1	Understand the basic chemical bonds, crystal structures (BCC, FCC, and HCP), and their relationship with the properties.
2	Analyze the microstructure of metallic materials using phase diagrams and modify the microstructure and properties using different heat treatments.
3	How to quantify mechanical integrity and failure in materials
4	Apply the basic principles of ferrous and non-ferrous metallurgy for selecting materials for specific applications.
5	Define and differentiate engineering materials on the basis of structure and properties for engineering applications.

COURSE OUTCOMES:

SI NO:	DESCRIPTION	Blooms' Taxonomy Level
CMET205.1	Understand the basic chemical bonds, crystal structures (BCC, FCC, and HCP), and their relationship with the properties.	Understand (level 2)
CMET205.2	Analyze the microstructure of metallic materials using phase diagrams and modify the microstructure and properties using different heat treatments.	Analyse (level 4)
CMET205.3	How to quantify mechanical integrity and failure in materials.	Understand (level 2)
CMET205.4	Apply the basic principles of ferrous and non-ferrous metallurgy for selecting materials for specific applications.	Apply (level 3)
CMET205.5	Define and differentiate engineering materials on the basis of structure and properties for engineering applications.	Knowledge & Understand (level 1 & 2)

CO-PO AND CO-PSO MAPPING

	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
CMET205.1	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CMET205.2	-	3	-	-	-	-	-	-	-	-	-	-	-	3	-
CMET205.3	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
CMET205.4	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-
CMET205.5	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-

JUSTIFATIONS FOR CO-PO MAPPING

MAPPING	LOW/MEDIUM/HIGH	JUSTIFICATION
CMET205.1-PO1	H	As they could apply their knowledge of engineering fundamentals to the solution of complex engineering problems.
CMET205.2-PO2	H	As they could analyse phase diagrams and microstructure to arrive at substantiated conclusions.
CMET205.3-PO4	M	They will be able to synthesize the information and arrive at conclusions regarding the failure of materials.
CMET205.4-PO5	H	As they could apply the basic principles of metallurgy to select materials for different applications with an understanding of the limitations.
CMET205.5-PO12	M	As the properties of engineering materials required for various applications keeps on changing, it is mandatory to get updated with the recent developments in this field.

JUSTIFATIONS FOR CO-PSO MAPPING

MAPPING	LOW/MEDIUM/HIGH	JUSTIFICATION
CMET205.2-PSO2	H	Students will be able to select materials depending upon the application for designing components.

GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSION REQUIREMENTS:

SI NO	DESCRIPTION	PROPOSED ACTIONS	RELEVANCE WITH POs	RELEVANCE WITH PSOs
1	Nano-materials and Nanotechnology	Seminars and Notes	6,7	

PROPOSED ACTIONS: Topics beyond syllabus/assignment/industry visit/guest lecturer/video lectures etc.

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN:

SI NO	DESCRIPTION	PROPOSED ACTIONS	RELEVANCE WITH Pos	RELEVANCE WITH PSOs
1	Composite Manufacturing	Seminars and Notes	6,7	

WEB SOURCE REFERENCES:

1	http://nptel.ac.in/courses/113106032/1
2	http://www.myopencourses.com/subject/principles-of-physical-metallurgy-2
3	http://ocw.mit.edu/courses/materials-science-and-engineering/3-091sc-introduction-to solid-state-chemistry-fall-2010/syllabus/
4	http://www.msm.cam.ac.uk/teaching/partIA.php
5	http://www.sv.vt.edu/classes/MSE2094_NoteBook/96ClassProj/examples/kimcon.html
6	http://www.sv.vt.edu/classes/MSE2094_NoteBook/96ClassProj/experimental/ternary2.html
7	http://www.emering.fi/old/download/EP1617_Chapter2.pdf
8	http://www.me.umn.edu/courses/old_me_course_pages/me3221-sum/Overviews/FailureTheories/failuretheories.html

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑ CHALK & TALK	☑ STUD. ASSIGNMENT	☑ WEB RESOURCES	☑ GOOGLE MEET
☑ LCD/SMART BOARDS	☑ STUD. SEMINARS	☐ ADD-ON COURSES	☑ GOOGLE CLASSROOM

ASSESSMENT METHODOLOGIES-DIRECT

☑ ASSIGNMENTS	☑ STUD. SEMINARS	☑ TESTS/MODEL EXAMS	☑ UNIV. EXAMINATION
☐ STUD. LAB PRACTICES	☐ STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐ CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☑ ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☑ STUDENT FEEDBACK ON FACULTY (TWICE)
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

7.2 COURSE PLAN

DAY	MODULE	TOPIC PLANNED
1	1	Introduction to the subject
2	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 force, density, directional and non-directional
3	1	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 on water, application- specific heat, applications
4	1	Crystallography:- Crystal, space lattice, unit cell- SC, BCC, FCC, atomic packing factor and HCP structures - short and long range order
5	1	effects of crystalline and amorphous structure on mechanical properties.
6	1	Coordination number and radius ratio; theoretical density; simple problems - Polymorphism and allotropy.
7	1	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.
8	1	Schmid's law, equation, critical resolved shear stress, correlation of slip system with plastic deformation in metals and applications.
9	1	Mechanism of crystallization: Homogeneous and heterogeneous nuclei formation, under cooling, dendritic growth, grain boundary irregularity
10	1	Effects of grain size, grain size distribution, grain shape, grain orientation on dislocation/strength and creep resistance - Hall - Petch theory, simple problems.
11	2	Classification of crystal imperfections: - types of point and dislocations.
12	2	Effect of point defects on mechanical properties - forest of dislocation, role of surface defects on crack initiation - Burgers vector.
13	2	Dislocation source, significance of Frank-Read source in metals deformation
14	2	Correlation of dislocation density with strength and nano concept, applications
15	2	Significance high and low angle grain boundaries on dislocation , driving force for grain growth and applications during heat treatment

16	2	Polishing and etching to determine the microstructure and grain size-
17	2	Fundamentals and crystal structure determination by X - ray diffraction, simple problems , SEM and TEM.
18	2	Diffusion in solids, fick's laws, mechanisms, applications of diffusion in mechanical engineering, simple problems.
19	3	Phase diagrams: - Limitations of pure metals and need of alloying - classification of alloys, solid solutions
20	3	Hume Rothery`s rule - equilibrium diagram of common types of binary systems: five types.
21	3	Coring - lever rule and Gibb`s phase rule - Reactions: - monotectic, eutectic, eutectoid, peritectic, peritectoid.
22	3	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.
23	3	Heat treatment: - Definition and necessity , TTT for a eutectoid iron, carbon alloy
24	3	CCT diagram, applications - annealing, normalizing, hardening, spheroidizing.
25	3	Tempering: - austermpering, martempering and ausforming - Comparative study on ductility and strength with structure of pearlite, bainite, spherodite, martensite, tempered martensite and ausforming.
26	3	Hardenability, Jominy end quench test, applications- Surface hardening methods:- no change in surface composition methods
27	3	Flame, induction, laser and electron beam hardening processes- change in surface composition methods :carburizing and Nitriding; applications.
28	4	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.
29	4	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 resistance, mechanical properties
30	4	Nickel steels, Chromium steels etc., change of steel properties by adding alloying elements: - Molybdenum, Nickel, Chromium, Vanadium, Tungsten, Cobalt, Silicon,
31	4	Copper and Lead - High speed steels
32	4	Cast irons: Classifications; grey, white, malleable and spheroidal graphite cast iron etc, composition, microstructure, properties and applications
33	4	Principal Non ferrous Alloys: - Aluminum, Copper, Magnesium, Nickel, study of composition, properties, applications,

34	4	Fatigue: - Stress cycles , Primary and secondary stress raisers - Characteristics of fatigue failure, fatigue tests, S-N curve.
35	4	Factors affecting fatigue strength: stress concentration, size effect, surface roughness, change in surface properties, surface residual stress
36	4	Ways to improve fatigue life- effect of temperature on fatigue, thermal fatigue and its applications in metal cutting.
37	5	Fracture: Brittle and ductile fracture ,Griffith theory of brittle fracture , Stress concentration, stress raiser â€“ Effect of plastic deformation on crack propagation
38	5	transgranular, intergranular fracture - Effect of impact loading on ductile material and its application in forging, applications - Mechanism of fatigue failure.
39	5	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.
40	5	Creep: - Creep curves, creep tests - Structural change:- deformation by slip, sub-grain formation, grain boundary sliding
41	5	Mechanism of creep deformation - threshold for creep, prevention against creep - Super plasticity: need and applications
42	5	Composites: - Need of development of composites; fiber phase
43	5	matrix phase; need and characteristics of PMC, MMC, and CMC.
44	5	Modern engineering materials: - only fundamentals, need, properties and applications of, intermetallics, maraging steel, super alloys,
45	5	Titanium- Ceramics:-coordination number and radius ratios
46	5	AX, AmXp, AmBmXp type structures, applications.

Prepared by **Approved by**

Mr. Vineeth Krishna P & Mr. Manu Joseph **Dr. Manoj G Tharian**

Assistant Professor, DME **HOD, D**

7.3 Sample Questions

Module 1

Part A

1. Explain how melting temperature is related to type of bond.

2. What do you mean by amorphous structure?

3. What are the features of metallic bonding?

4. Compare different types of primary bonding with examples.

5. Explain various mechanisms by which plastic deformation takes place in materials.

6. Differentiate between slip and twinning.

7. What is the relation of the packing of the crystals with coordination number?

8. Define (a) Co-ordination number (b) amorphous structure

9. What is atomic packing factor? Calculate it for the simple cubic

10. Explain the important features of miller indices.

11. Briefly explain the packing of atoms in solids.

12. Justify how atomic arrangements results in various material structures

13. Define (a) Atomic packing factor (b) Co-ordination number

14. Explain Bonding forces and energies.

15. Explain Atomic packing factor.

16. Explain the mechanism of slip.

17. Certain directions and planes carry importance in a unit cell. List out the procedures to find those with the help of some examples.

18. What do you mean by Miller indices? Give examples.

19. Explain crystallographic directions and planes.

Part B

1. What are Miller indices? Explain the features. Draw the following planes in a cubic cell.

(a) (101), (b) (112), (c) (102).

2. (a)Explain the features of Metallic bonding. (b) Determine the atomic packing factor for a

simple cubic cell.

3. Determine atomic packing factor for FCC and BCC structures.

4. (a)Explain the feature of miller indices. b) Lead is a FCC structured material with an atomic radius of 1.746 A°. Find the spacing between (200) and (220) planes.

5. (a)What are the important features of miller indices? (b) Draw the (1 12) and (111) planes in a simple cubic cell.

6. Explain how miller indices are used to designate directions within a crystal lattice.

7. Explain crystallographic directions. Sketch the following planes and directions (123), (00-1), (101), (-1-11), (121), (111).

8. For a FCC structure, estimate the atomic packing factor Is there any other structural unit having higher packing factor? (b) Explain homogenous and heterogeneous nuclei formation.

9. What do you mean by miller indices and what are its important features? Explain the procedure for determining miller indices.

10. What are co-ordination number and atomic packing factor? Determine these for the simple cubic, B.C.C. and F.C.C. crystals.

11. Explain about growth of dendrites during cooling of castings.

12. What is meant by equi-axed grain?

13. Give the Hall-Petch equation.

14. What is a dendrite?

15. Discuss the effect of grain size on mechanical properties of metals.

16. Explain homogeneous and heterogeneous nuclei formulation.

17. Explain the mechanism of grain growth in the crystallization process.

18. What is the effect of grain size on mechanical properties?

19. A minimum value of shear stress is required to initiate slip in a crystal. Prove it

20. Distinguish between homogeneous and heterogeneous nuclei formation

21. Explain the mechanism of slip.

22. Explain the mechanism of crystallization in detail.

23. Explain the effect of grain size on mechanical and optical properties of a crystalline solid.

(b) Distinguish between the homogeneous and heterogeneous nuclei formation.

24. Explain the terms (i) Nuclei formation (ii) Dendritic growth (iii) Grain boundary

Module 2

Part A

1. Compare Edge and Screw dislocation

2. List any three applications of diffusion.

3. What is self diffusion?

4. What is interstitialcy?

5. Which are the factors that govern grain growth?

6. What is Burgers vector? Give sketches of Burger's vector in screw or edge dislocation

7. Differentiate between edge and screw dislocation.

8. Explain Fick's second law of diffusion.

9. Explain the Frank-read source for dislocation generation.

10. Explain Fick's first law of diffusion.

11. Explain Burgers vector.

12. What is dislocation climb? How it is related to creep?

13. Explain (a) Frank-Read source of dislocation and (b) Burgers circuit of dislocation.

Part B

1. Explain and compare Edge and Screw dislocations.

2. Explain the need of polishing and etching of metallic surfaces prior to inspection. What are different procedures/ chemicals involved?

3. Explain a) Burger's vector, b) Fick's law of diffusion, c) Frank Read source

4. With the help of suitable sketches explain point imperfections found in solid crystal.

5. Explain edge and screw dislocation with the help of Burger's Circuit. Mention the role of a dislocation in the deformation of metals.

6. What is dislocation in solids and what are the different types of dislocation? Explain the theory and important role of dislocation.

7. Differentiate between (i) Slip and twinning (ii) Edge and Screw dislocation (iii) Crystalline and amorphous solids.

8. Explain (i) Dendritic growth; (ii) Amorphous structure ; and (iii) Burger's vector.

9. Explain (i) Dislocation climb and cross slip; (ii) Frank~Read source; (iii) Fick's laws of diffusion.

10. Discuss the various imperfections found in solid materials. Explain with neat sketches.

11. Explain with suitable sketches crystal imperfections.

12. Write a note on (i) Fick's law, (ii) Tilt boundaries and stacking fault.

Module 3

Part A

1. What are (a) Eutectic reaction (b) Eutectoid reaction

2. Classify solid solutions and give two examples of each.

3. What is martempering?

4. What is work hardening?

5. State Gibb's phase rule.

6. What do you mean by spheroidizing?

7. What is pearlite?

8. What in bainite?

9. What do you mean by dispersion hardening?

10. Explain how phase diagrams are categorized.

11. How a hardness test is conducted?

12. What is hardenability

13. What is laser hardening?

14. What is meant by coring?

15. What do you mean by hardenability of steel?

16. What is Bauschinger effect?

17. Write down Hume-Rothery's rules for formation of substitutional solid solution.

18. Explain the features of following microstructures (i) Bainite (ii) Spherodite.

19. Explain the process of full annealing and subcritical annealing.

20. Explain the following processes (i) carburizing (ii) induction hardening

21. What is the difference between cold working and hot working of metals?

22. Explain phase rule.

23. Briefly explain the normalizing process of metals.

24. Explain a eutectoid system.

25. What factors affect the choice of cooling rates for steels?

26. Discuss the similarities and differences between substitutional and interstitial solid solution.

27. With a sketch explain austempering and martempering.

28. Compare hot working and cold working of metals.

29. Describe strain hardening of metals.

30. What are metallurgical advantages of hot working over cold working ?

31. Differentiate between recovery and recrystallization process

32. State Gibb's phase rule. What is its significance?

33. What do you mean by spheroidizing? Why is it done?

34. What is a TTT diagram?

35. List the various diffusion methods of surface treatment.

36. Distinguish between Cold working and Hot working.

37. What are solid solutions? Explain with examples.

38. Explain strain hardening.

39. What is hardening? Explain.

40. What is spheroidizing? Explain.

41. What is Annealing? Explain.

42. Explain Eutectic Reaction.

43. What are hardenability curves? Explain the procedure of plotting the hardenability curves for steel.

44. Explain (i) Austempering and (ii) Martempering.

45. Explain different types of tempering processes.

46. Explain the Jominy end quench test.

Part B

1. Draw the iron carbide diagram and explain the microstructures. Mark important temperatures and compositions.

2. Explain the following heat treatment processes in detail and mention specific applications: (i) Annealing; (ii) Normalizing; (iii) Martempering

3. Draw and explain the iron carbide diagram.

4. Explain the following heat treatment procedures: a) Flame hardening b) Carburizing, c) Tempering.

5. What is lever rule? Explain the equilibrium diagram of a solid solution in which two metals are completely soluble in the liquid and solid states.

6. (a) Describe the special features of martensite transformation compared to other transformations in steel (b) Explain the features of a peritectic system.

7. (a)Describe the process of martempering and austempering. (b) What is metal cladding?

8. Explain the following processes (i) carburizing (ii) nitriding (iii) flame hardening

9. What is lever rule? With a neat sketch explain the equilibrium diagram for binary systems showing complete inter solubility in the liquid and solid states.

10. Draw a neat sketch of the Fe-Fe3C equilibrium diagram. Label all significant features and explain the three important reactions.

11. Explain (i) Spherodizing ; (ii) Austempering; (iii) Martempering ; (iv) Normalizing : (v) Annealing.

12. With sketches explain the flame hardening and induction hardening methods of surface

treatment.

13. What is phase rule? With a neat sketch explain the equilibrium diagram of two metals of mutual liquid solubility and partial solid solubility.

14. Compare hot working and cold working of metals. (ii) Explain the (1) Unary phase diagram and (2) Cooling curves for pure metals and alloys.

15. Explain (i) carburizing ; (ii) nitriding ; (iii) cyaniding ; (iv) work hardening.

16. Explain briefly the theory of tempering. Why steel is tempered and how is it done? Discuss the effects of tempering on the mechanical properties of steel.

17. With a neat sketch explain the Iron-carbon equilibrium diagram showing all the salient features on it. Explain the three invariant reactions involved.

18. What is eutectic system? With a neat sketch explain the equilibrium diagram of two metals completely soluble in liquid state but completely insoluble in the solid state.

19. Enumerate the various heat treatment processes and explain any two of them.

20. Explain (i) Carburizing ; (ii) flame hardening ; (iii) induction hardening

21. With a neat sketch explain the equilibrium diagram of two metals completely soluble in the liquid and solid states.

22. Compare cold and hot working processes of metals. (ii) Explain : (a) Austenite; (b) Ledeburite; (c) Pearlite; (d) Bainite

23. What is a surface hardening process? Explain any three surface hardening processes.

24. (i) Discuss the various mechanisms for strengthening metals and alloys.
(ii) What is critical cooling rate?

25. State the phase rule. Explain any two multiphase equilibrium diagrams.

26. Explain the following: (i) Hot working, (ii) Iron-carbon diagram (iii) Polymorphism

27. Explain (i) Spheroidizing (ii) Normalizing (iii) Austempering and (iv) Martempering.

28. Explain (i) Inter metallic compounds; (ii) Equilibrium diagram reactions; (iii) Phase transformation.

29. Explain with neat sketches, the various strengthening mechanisms in metals.

30. Explain with neat sketches, the microstructure changes during different heat treatment processes.

31. Draw an iron carbon diagram and explain its features

32. Explain with suitable sketches (i) Austenite, (ii) Pearlite (iii) Martensite.

Module 4

Part A

1. Explain how recrystallization occurs.
2. State the various reasons for alloying.
3. Differentiate between recovery and recrystallization in a metal.
4. What are the properties acquired by adding Vanadium to steel?
5. Explain how carbides in steel strengthen the base material?
6. What do you accomplish by adding alloying elements in steel ?
7. Write a note on the classification of cast irons.
8. What are the applications of high speed steels?
9. What are Chromium steels.
10. What is Beryllium Bronze?
11. What is Y alloy?
12. What are the effects of alloying chromium with steel?
13. What is duralumin?
14. Discuss the effect of alloying of (i) Tungsten; (ii) Chromium to steel.
15. What are high speed steels? Explain different grades.
16. What are the constituents of cast iron and how do they vary in gray, white and malleable cast irons?
17. What is duralumin? and what are its properties?
18. Differentiate cast iron, wrought and steel.
19. Explain why the cutting alloys are superior to high speed steels.
20. State the effects of important alloying elements in steel.

21. Write short notes on: (i) High speed steel ; (ii) Babbit metal.

22. What is the difference between cast iron, wrought iron and steel?

23. Explain the composition, properties and uses of important copper alloys.

24. What is high speed steel and what are its uses?

25. Compare cast iron and steel in terms of composition and properties.

26. What are the commercial alloys of aluminum and what are their uses.

27. Differentiate between Malleable and Spheroidal graphite cast iron.

28. Discuss the effects of alloying elements on dislocation movement.

29. Explain the formation of carbides.

30. Discuss the displacement of eutectoid point.

31. Write a note on Aluminum and copper alloys.

32. Explain the difference between carbon steel and alloy steel.

Part B

1. Explain in detail, different types of cast iron.

2. What are HSS? Explain the effect of alloying elements to HSS with respect to properties.

3. Explain the effects of various alloying elements on the properties of steel.

4. Explain different types of cast iron. List the applications.

5. Explain (a) Stainless steel (b) high speed steel (C) displacement of eutectoid

6. (a) Compare cold working and hot working of metals (b) What are inter metallic compounds?

7. Draw the S-N curve for ferrous and non-ferrous meta1s.

8. Explain the process of recovery, recrystallization and grain growth in a strain hardened metal.

9. Describe the composition, properties and uses of (i) spheroidal cast iron (ii) Brass and bronze (iii) Gun metal.

10. Explain how the properties of steel depend upon its alloying elements. List out the various alloy steels giving their uses.

11. Describe the composition, properties, and uses of (i) Duralumin (ii) Babbit metal (iii) Bronze (iv) Gun metal.

12. Give the composition, microstructure, properties and applications of (i) Grey cast iron ;(ii) Malleable cast iron ; (iii) Spheroidal graphite cast iron.

13. Explain composition, microstructure, properties and applications of low, medium, and high carbon steel. What is high speed steel?

14. Write notes on (i) Brasses and Bronzes ; (ii) spheroidal graphite cast iron ; (iii) Free cutting steel (iv) Nickel steel.

15. Explain the classification of cast iron giving their composition, microstructure, properties and uses.

16. Explain the effects of various alloying elements on properties of steel.

17. Describe the composition, properties and uses of (i) Silicon steel (ii) HSS (iii) Mild Steel (iv) Brass.

18. Discuss the various effects of alloying elements on the mechanical properties. Also discuss, the formation and stability of carbides.

19. (a) Explain the composition, microstructure and properties of the principal non-ferrous alloys. (b) What are Chromium steels.

20. Explain the composition, microstructure, properties and applications of cast irons.

21. Briefly discuss : (i) Nickel steels. (ii) Chromium steels. (iii) Polymorphic transformation temperature.

22. Discuss the properties and applications of magnesium and its alloys.

23. Discuss the properties and applications of nickel and its alloys.

24. Discuss the properties and uses of copper alloys

25. Discuss the properties and applications of aluminum alloys.

26. How is grey cast-iron different from S.G.iron. Explain from the point of view of microstructure and application.

27. (i)Classify steel based on their composition name and practical application. (ii) Why steel

and cast iron are alloyed? Name different alloying elements added and the specific property they impart.

28. What is an S-N curve?

29. What is endurance limit?

30. Explain how a good design can resist fatigue failure?

31. What is the effect of stress concentration on fatigue?

32. How will you prevent fatigue failure?

33. What is stress concentration and how it affects fatigue failure.

34. Write a note on thermal fatigue.

35. Explain the effect of surface texture on fatigue failure.

36. Define fatigue strength and endurance limit.

37. Draw and explain S-N curves for ferrous and non-ferrous metals. Explain various ways to improve fatigue resistance.

38. Explain the mechanism of fatigue failure and different types of fatigue loading. What actions are to be taken to prevent fatigue failure?

39. Explain the mechanism of Fatigue.

Module 5

Part A

1. List various types of fracture in metals.

2. What are the factors leading to crack propagation?

3. What is super plasticity?

4. Define fracture toughness.

5. What is trans granular fracture?

6. What is grain boundary sliding?

7. Compare between Ductile and Brittle fracture.

8. What are the features of ductile and brittle fractures?

9. What is a cleavage fracture?

10. Explain the influence of slip on fracture.

11. Write notes on ductile and brittle fracture.

12. Describe Griffith's theory of fracture.

13. Explain ductile-brittle transition temperature.

14. Briefly explain the effect of plastic deformation on crack propagation.

15. Explain "super plasticity" with example.

16. Briefly discuss the effect of stress concentration on fatigue

17. Write a note on cohesive strength of metals

18. What is the role of surface defect on crack propagation?

19. Explain Brittle fracture.

20. Explain the factors leading to crack propagation.

21. Explain super plasticity.

22. Explain Griffith theory of fracture.

23. Explain the influence of slip on fracture.

24. Write a note on Ductlle to Brittle transition.

25. What is meant by stress raiser?

Part B

1. Explain Griffith's theory of fracture. Classifv different types of fractures.Explain methods for protection from fracture.

2. Explain different types of fractures. Explain various theories of fracture.

3. How are the fractures classified? Describe the features of each type of fracture.

4. Discuss (i) Cleavage (ii) effect of stress concentration of fatigue. (iii) Structural changes during creep.

5. (a) Explain Griffith's crack theory. (b) Distinguish between a ductile and brittle fracture.

6. (a) Explain the factors leading to the propagation of crack. (b) Explain stress cycle and fatigue failure.

7. (i) Explain ductile and brittle fracture (ii) Discuss the effect of stress concentration of

fatigue failure.

8. (a) Explain the different factors leading to crack propagation. (b) Explain the mechanism of Creep.

9. (a) Explain Griffith theory of fracture. (b) What is stress concentration and how it affects fatigue failure.

10. Explain: (i) Bonding forces and energies. (ii) Crack initiation. (iii) Stress cycles.

11. (i) Distinguish between Brittle fracture and Ductile fracture. (ii) What are creep curves? Discuss the importance.

12. Explain the effects of stress concentration, size effect and surface texture on fatigue.

13. Explain both creep and fatigue failure of materials and state how to prevent them?

14. How fractures are classified? State and explain different types of fracture giving appearance of the fracture surface in each case.

Part A

1. Write notes on creep resistant materials.

2. Draw a typical creep curve and mark different zones.

3. How slip is related to creep?

4. What is a creep curve?

5. Write a note on Mechanism of creep.

6. Write short notes about metal matrix composites.

7. What are the properties of metal matrix composites?

8. How are composite materials classified?

9. What is a composite? Give examples.

10. What are metal matrix composites? List the advantages.

11. What is meant by maraging steel?

12. Write a note on materials for medical applications.

13. What are smart materials? Explain.

14. List out the features of superalloys.

Part B

1. Draw and explain a creep curve. Explain the features of a creep resistant design.

2. With a neat sketch explain the method of conducting a typical creep test. Draw the typical creep curve for a metal and explain the different regions on it.

3. (a) Sketch creep curve and explain different stages of creep. (b) Write notes on creep resistant materials.

4. Draw the creep curve and explain the various stages of creep.

5. Explain the mechanism of creep deformation.

6. Describe the preparation of metal matrix composites.

7. List type of composites. Explain any two type of composites.

8. What are the different types of composites? Give one application for each type. Give an account of nano materials.

9. What is a ceramic? Give four examples of ceramics used as engineering materials.

10. What are the constituents of a composite material? Give examples of composite material.

11. What are composites? Explain any two different types with their specific applications in engineering.

12. Explain the features of laminated composites.

13. Explain about the various crystal structures observed in ceramics.

14. List out the applications of any three types of ceramic materials

8. 100908/CO900E DESIGN AND ENGINEERING

8.1 COURSE INFORMATION SHEET

PROGRAMME: Mechanical Engineering	DEGREE: B.Tech.
COURSE: **DESIGN AND ENGINEERING**	SEMESTER: S3 CREDITS: 2
COURSE CODE: 100908/CO900E REGULATION: 2019	COURSE TYPE: Core
COURSE AREA/DOMAIN: HUMANITIES	CONTACT HOURS: 2 (Lecture) + 0 (Tutorial) + 0 (Practical) Hours / Week
CORRESPONDING LAB COURSE CODE (IF ANY): NIL	LAB COURSE NAME: NA

SYLLABUS:

Module	DETAILS	HOURS
I	<u>Design Process</u>:- 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.	05
II	<u>Design Thinking Approach</u>:-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.	05
III	<u>Design Communication</u> (Languages of Engineering Design):- Communicating Designs Graphically, Communicating Designs Orally and in Writing. Mathematical Modeling In Design, Prototyping and Proofing the Design.	05
IV	<u>Design Engineering Concepts</u>:-Project-based Learning and Problem-based Learning in Design. Modular Design and Life Cycle Design Approaches. Application of Bio-mimicry, Aesthetics and Ergonomics in Design. Value Engineering, Concurrent Engineering, and Reverse Engineering in Design.	05
V	<u>Expediency, Economics and Environment in Design Engineering</u>:- Design for Production, Use, and Sustainability. Engineering Economics in Design. Design Rights. Ethics in Design	05
	TOTAL HOURS	25

TEXT/REFERENCE BOOKS:

S. No.	T/R	AUTHORS/BOOK TITLE/PUBLICATION
1.	T	Yousef Haik, Sangarappillai Sivaloganathan, Tamer M. Shahin, Engineering Design Process, Cengage Learning, 2003, Third Edition. ISBN-10: 9781305253285

2.	T	Voland. G., Engineering by Design, Pearson India 2014, Second Edition, ISBN: 9332535051
3.	R	Balmer, William Keat, George Wise, Exploring Engineering, Fourth Edition: An Introduction to Engineering and Design, Academic Press 2015, 4th Edition, ISBN: 9780128012420.
4.	R	Clive L. Dym, Engineering Design: A Project based Introduction, John Wiley & Sons, New York 2009, Fourth Edition, ISBN: 978-1-118-32458-5
5.	R	Nigel Cross, Design Thinking: Understanding How Designers Think and Work, Berg Publishers 2011, First Edition, ISBN: 978-1847886361.
6.	R	Pahl. G., Beitz W., Feldhusen J., rote K. H., Engineering Design: A Systematic Approach, Springer 2007, Third Edition, ISBN: 978-1-84628-319-2.
7.	R	Jayasree PK, Balan K, Joy Varghese, Gouri P, Design and Engineering, Second Edition, CBS Publishers & Distributors Pvt Ltd., 2018.

COURSE PRE-REQUISITES:

Nil. The course will be generic to all engineering disciplines and will not require specialized preparation or prerequisites in any of the individual engineering disciplines.

COURSE OBJECTIVES:

1	To introduce the undergraduate engineering students the fundamental principles of design engineering.
2	To make them understand the steps involved in the design process.
3	To familiarize them with the basic tools used and approaches in design.

COURSE OUTCOMES:

Ref. No.	DESCRIPTION	Blooms Taxonomy Level
100908CO 900E.1	Explain the different concepts and principles involved in design engineering.	Remember, Understand (Level 1 & 2)
100908CO 900E.2	Apply design thinking while learning and practicing engineering.	Apply (Level 3)
100908CO 900E.3	Develop innovative, reliable, sustainable and economically viable designs incorporating knowledge in engineering.	Apply (Level 3)

CO-PO AND CO-PSO MAPPING

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
100908CO900E.1	2	1					1			1			2		2

100908CO900E.2		2				1		1				2	2		2
100908CO900E.3			2			1	1		2	2		1			2

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/MEDIUM/HIGH	JUSTIFICATION
100908CO900E.1 -PO1	M	Students will be able to apply the concepts and principles of design engineering.
100908CO900E.1 -PO2	L	Students will be able to analyze and design complex engineering problems.
100908CO900E.1 -PO7	L	Students will be able to understand the impact of engineering designs in societal and environmental contexts.
100908CO900E.1 -PO10	L	Students will be able to communicate the designs effectively to engineering community and society at large.
100908CO900E.1 -PSO1	M	Students will be able to identify, analyze and design complex engineering problems in the area of computer science.
100908CO900E.1 -PSO3	M	Students will be able to design and develop innovative products to meet the societal needs and thereby emerge as eminent researcher and entrepreneur.
100908CO900E.2 -PO2	M	Students will be able to analyze and design complex engineering problems by applying design thinking approach.
100908CO900E.2 -PO6	L	Students will be able to apply design thinking approach considering the societal, health, safety, legal, and cultural issues.
100908CO900E.2 -PO8	L	Students will be able to apply design thinking approach while adhering to ethics and professional responsibility.
100908CO900E.2 -PO12	M	Students will be able to recognize the need for & engage in independent and life-long learning in the context of technological change.
100908CO900E.2 -PSO1	M	Students will be able to identify, analyze and design complex engineering problems in the area of computer science by applying design thinking approach.
100908CO900E.2 -PSO3	M	Students will be able to design and develop innovative products in the computer science area to meet the societal needs and thereby emerge as eminent researcher and entrepreneur.
100908CO900E.3 -PO3	M	Students will be able to design and develop 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.
100908CO900E.3 -PO6	L	Students will be able to develop designs considering the societal, health, safety, legal, and cultural issues.
100908CO900E.3 -PO7	L	Students will be able to develop designs, understanding the impact of engineering designs in societal and environmental

		contexts.
100908CO900E.3 -PO9	M	Students will function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings while developing innovative designs.
100908CO900E.3 -PO10	M	Students will be able to communicate the designs they develop effectively to engineering community and society at large.
100908CO900E.3 -PO12	L	Students will be able to recognize the need for & engage in independent and life-long learning in the context of technological change while involving design and development.
100908CO900E.3 -PSO3	M	Students will be able to design and develop innovative products in the computer science area to meet the societal needs and thereby emerge as eminent researcher and entrepreneur.

INDUSTRY RELEVANCE:

Innovation and entrepreneurship has become a focus area in all universities and industry for more than a decade. We have seen many start-up companies and student entrepreneurs coming up with innovative products, disruptive technologies & businesses. Design and Engineering is a new course introduced by KTU in the B.Tech. programme (which was not there in MGU B.Tech. curriculum) with the intention of fostering innovation and entrepreneurship among engineering students. As students do this course, they may come up with innovative ideas & concepts, design and develop those concepts as marketable products and may become entrepreneurs by the time they complete B.Tech.

Also, as engineers/designers in software/IT industry where majority of our students are going work, they would help the businesses to grow by designing and developing innovative products and services.

GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSION REQUIREMENTS: None identified at this time.

S. NO	DESCRIPTION	PROPOSED ACTIONS	PO MAPPING

PROPOSED ACTIONS: NA

TOPICS BEYOND SYLLABUS/ADVANCED TOPICS/DESIGN: None thought about at this time.

S. NO	TOPIC	PO MAPPING
1		
2		

WEB SOURCE REFERENCES:

1	
2	

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☐ CHALK & TALK	☐ **STUD. ASSIGNMENT** √	☐ **WEB RESOURCES** √
☐ LCD/SMART BOARDS	☐ STUD. SEMINARS	☐ DISCUSSIONS/ DEBATES
☐ **ONLINE CLASSES** √	☐ **ONLINE QUIZ & POLLS** √	

ASSESSMENT METHODOLOGIES-DIRECT:

☐ **ASSIGNMENTS** √	☐ STUD. SEMINARS	☐ **TESTS/MODEL EXAMS** √	☐ **UNIV. EXAMINATION** √
☐ STUD. LAB PRACTICES	☐ STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐ CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT:

☐ **ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)** √	☐ **STUDENT FEEDBACK ON FACULTY (ONCE)** √
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

8.2 COURSE PLAN

DAY	***MODULE***	***TOPIC PLANNED***
1	1	Introduction to Design and Engineering Design
2	1	Design Process –Detailing Customer Requirements
3	1	Design Process –Detailing Customer Requirements(Contd..),Setting Design Objectives
4	1	Design Process –Identifying Constraints, Establishing Functions, Establishing Specifications
5	1	Design Process –Generating Design Alternatives & Choosing a Design
6	2	Introduction to Design Thinking
7	2	Design Thinking in a Team Environment, Design Thinking Frameworks, Design Thinking Process Stages -Empathize
8	2	Design Thinking Process Stages -Empathize(Contd..),Analyze, Define
9	2	Design Thinking Process Stages -Ideate
10	2	Design Thinking Process Stages -Ideate(Contd..),Prototype &Test

11	3	Communicating Designs Graphically
12	3	Communicating Designs Orally and in Writing
13	3	Mathematical Modelling in Design
14	3	Prototyping and Proofing the Design
15	3	Case Studies: Communicating Designs Graphically
16	4	Project based Learning and Problem based Learning in Design
17	4	Modular Design and Life Cycle Design Approaches
18	4	Application of Biomimicry, Aesthetics and Ergonomics in Design
19	4	Value Engineering, Concurrent Engineering, and Reverse Engineering in Design
20	4	Case Studies: Biomimicry based Designs
21	5	Design for Production, Use and Sustainability
22	5	Engineering Economics in Design
23	5	Design Rights
24	5	Ethics in Design
25	5	Case Studies: Design for Production, Use and Sustainability
26	1	Revision-Module 1
27	2	Revision-Module 2
28	3	Revision-Module 3
29	4	Revision-Module 4
30	5	Revision-Module 5

Prepared by **Approved by**

Mr. Vishnu Sankar
(Faculty)

Dr. Manoj G. Tharian
(HOD)

8.3. QUESTION BANK

1. Think of any two design changes for a selfie stick that can add value to it.
2. Hexagonal cross sectional pencils are more commonly used than circular and square cross sectional ones, why?
3. Three different designs of chairs are given below.

   A: plastic moulded chair; B: wooden chair; C: multifunctional office chair

   Give the advantages and limitations of these three designs in the following way:

4. With sketches compare the design changes while designing a

   a. short (5cm long) screw driver

   b. Long (15cm long) screw driver

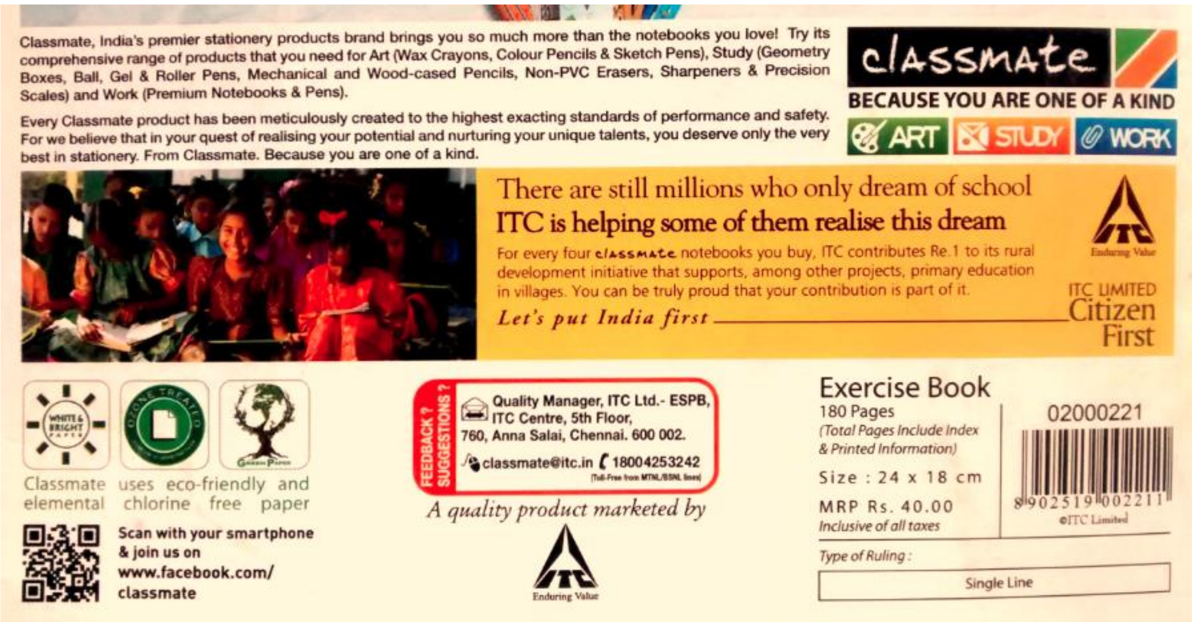
5. Design a mineral water bottle which can be produced economically with the major design consideration as logistics
6. The figure shows a door self-locking system. Why this is designed so. Suggest an another economical method to perform the same function.

Door self locking system

7. People in a village find it difficult to walk a distance of two km and carry nearly twenty litters of waterjust by holding the drums in their hands and on head. Give a Design modification to the drums so

as to make this task easier. Give your design options and make a rough sketch of the design you have chosen giving reasons for your choice, within 15 lines.

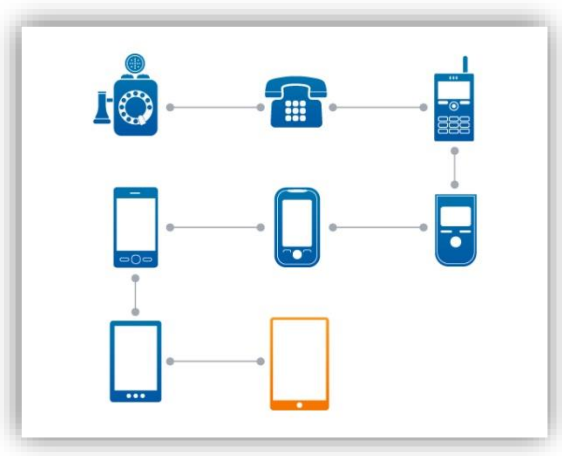
8. Prepare an Objective tree for drinking water facility at College
9. Discuss various aspects of Design such as Objective, design spaces (options), Functions, Means, Constraints and forms of a Walking stick for blinds.
10. Identify and discuss any systems, elements in the nature from which we could draw inspiration to solve Design or Engineering problems. (Bio mimicry)
11. What are various Need gap identification methods
12. What are the regulatory constraints of an automobile
13. Explain Science Engineering Technology with example.
14. Assume that you are in charge for conducting University Semester Examination at State wide for student strength of 50000. Design an effective process which enables the Exam result to be published in shortest time.
15. Design an Automatic Machine for making Masala dosa. Use neat sketches
16. Discuss the concept of "Complex is Simple" with an example and neat sketch.
17. Assume you are introducing a new Bicycle to the market. Discuss various standardized components that will be considered for the Design and Engineering of this product.
18. Below shown is the cover page of a Note Book. What are the various communications made by the manufacturer to the Customers about the product?



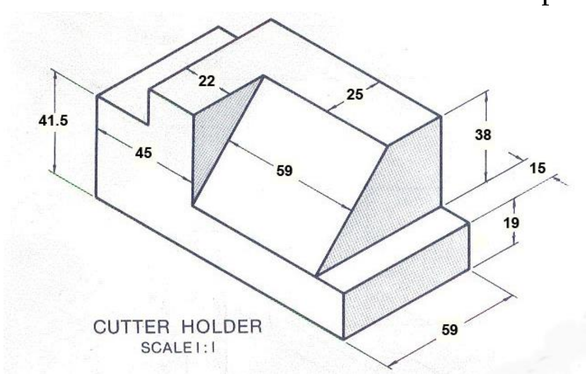
19. Below picture shows a spanner set and a Wrench. List out the advantages and disadvantages of both Artifacts.

20. Perform SWOT analysis of Samsung mobile phones.
21. Most of the Pencils have hexagonal cross section instead of round one. Give reasons for this design.

22. Evolution of phones is as shown in figure. What could be the possible future design for it by 2025



23. Isometric view of a Cutter holder is shown below. Sketch Front Top and Side views.



24. Compare the Design of a).Disposable pen, b). Refillable pen, c). Reparable pen
25. Differentiate the features of a). ceiling fan, b).table fan and a pedestal fan

26. Construct the frame of a chair with same dimension for seat height, width and back support with a steel rod of length 4.5 m. Give proper tolerance.
27. A box consists of oranges of different size. Design a system for sorting the oranges into 3 sets based on their size without any block. Justify your design.
28. Construction of a house requires the following works.

    A – Foundation work – takes 4 months

    B – Wood work – takes 4 months

    C – Brick work – takes 6 months

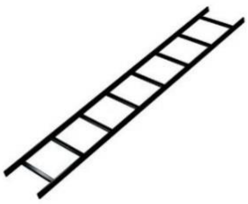
    D – Frame fixing/Electrical /Plumbing – takes 2 months

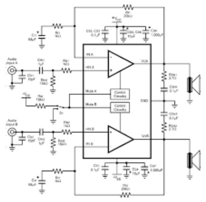
    E – Finishing works – takes 3 months

    Prepare a plan using a suitable chart

    1. Can you identify the design function of the following figure?
    2. What all are the design constraints considered during the designing stage of the product?
    3. Can you suggest some value added features to the product?

29. Can you explain the role of science, engineering and technology behind an iron box?
30. Classify the following products in to functional and strength design, justify your answer also?




HOOK

SOUND AMPLIFIER

31. Sketch a new form for spectacles which is more comfortable to customers?
32. Design and sketch a water bottle that can be open with one hand?
33. Sketch a short screw driver (5cm) and long screw driver (15cm). Compare the merit and demerit of both the designs. (Given length is excluding the handle)?
34. Sketch the QFD of laptop and compare it with any 2 competitive laptops available in market?
35. Arun is travelling through a highway and when he reached a junction, Traffic signal becomes red and he has to wait. Arun thought a design alternative replacing the traffic signal and there is no need of waiting. What may be his design? (assume it’s a 4 way junction. you can’t use subways and over bridges)
36. Provide a solution for a more user friendly entrance into the school bus?
37. A steel tube of about 4.5 m is available for making the frame for a chair. This tube is allowed to be bend in any direction at 8 places only. Cutting of the tube and joining the parts is not permitted. However, any extra length may be cut. Once the frame is ready, the seat which is a square plate of 45 cm is to be screwed and another rectangular piece of 45 cm length and 15 cm width is to be screwed as back rest. Sketch the proposed design of the chair.

38. “Flipping over is a main defect of ordinary umbrellas”. Design an umbrella which can overcome this defect and thereby increase its value

39. Sketch a four sided dice and explain how to predict value of roll.

40. Three different designs of bikes are given below. (5)

Give the advantages and limitations of these three designs in the following way:

Bikes: A B C
Design Advantages:
Design Limitations:

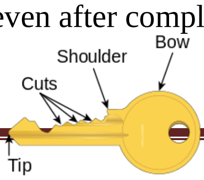


41. Commonly used axe is different from the three designs given below. Why is this so?

(5)



42. Why the bow of a key protrudes even after completely entering the key into the hole? Also Why cuts are provided in keys? (5)



9. 100908/CO300F SUSTAINABLE ENGINEERING

9.1 COURSE INFORMATION SHEET

PROGRAMME: **COMPUTER SCIENCE AND ENGINEERING**	DEGREE: **B.TECH**
COURSE: SUSTAINABLE ENGINEERING	**SEMESTER: 3 CREDITS:** NIL
COURSE CODE: 100908CO300F **REGULATION:** 2019	**COURSE TYPE:** CORE
COURSE AREA/DOMAIN: ENGINEERING (All Branches)	**CONTACT HOURS:** 2(LECTURE) HOUR/WEEK
CORRESPONDING LAB COURSE CODE (IF ANY): NIL	**LAB COURSE NAME:** NIL

SYLLABUS:

MODULE	CONTENTS	HOURS
I	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
II	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
III	Environmental management standards: ISO 14001:2015 frame work and benefits, Scope and goal of Life Cycle Analysis (LCA), Circular economy, Bio-mimicking, Environment Impact Assessment (EIA), Industrial ecology and industrial symbiosis.	6

IV	Resources and its utilization: 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
v	Sustainability practices: Basic concept of sustainable habitat, Methods for increasing energy efficiency in buildings, Green Engineering, Sustainable Urbanization, Sustainable cities, Sustainable transport.	4

TEXT/REFERENCE BOOKS:

T/R	***BOOK TITLE/AUTHOR/PUBLICATION***
T1	Allen, D. T. and Shonnard, D. R., Sustainability Engineering: Concepts, Design and Case Studies, Prentice Hall.
T2	Bradley. A.S; Adebayo,A.O., Maria, P. Engineering applications in sustainable design and development, Cengage learning.
T3	Environment Impact Assessment Guidelines, Notification of Government of India, 2006.
T4	Mackenthun, K.M., Basic Concepts in Environmental Management, Lewis Publication, London, 1998.
T5	ECBC Code 2007, Bureau of Energy Efficiency, New Delhi Bureau of Energy Efficiency Publications-Rating System, TERI Publications - GRIHA Rating
T6	Ni bin Chang, Systems Analysis for Sustainable Engineering: Theory and Applications, McGraw-Hill Professional.
T7	Twidell, J. W. and Weir, A. D., Renewable Energy Resources, English Language Book Society (ELBS).
T8	Purohit, S. S., Green Technology - An approach for sustainable environment, Agrobios publication

COURSE PRE-REQUISITES:

NIL

COURSE OBJECTIVES:

CO1	Understand the relevance and the 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

COURSE OUTCOMES:

Sl. NO	DESCRIPTION	Blooms' Taxonomy Level
100908C 0300F.1	Understand the relevance and the concept of sustainabilityand the global initiatives in this direction	Knowledge(Level 1)
100908C 0300F.2	Explain the different types of environmental pollution Problems & sustainable solutions	Understand (Level 2)
100908C 0300F.3	Discuss the environmental regulations and standards	Understand (Level 2)
100908C 0300F.4	Outline the concepts related to conventional and non-conventional energy	Understand (Level 2)
100908C 0300F.5	Demonstrate the broad perspective of sustainable practices by utilizing engineering knowledge and principles	Apply (Level 3)

CO-PO AND CO-PSO MAPPING

	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
CO300F.1	1	1				2	3								
CO300F.2	2	2				2	3	1						1	
CO300F.3		2	3			2	3	2							
CO300F.4	1	1	3			2	3	1							
CO300F.5	1					2	3	2							2

C O 3 0 0 F	1	1.66	3			2	3	1.5						0 . 2	0.4

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/ MEDIUM / HIGH	JUSTIFICATION
100908CO300F.1 — PO.1	L	Fundamental awareness about the concept and importance of sustainability is essential for the existence in future world
100908CO300F.1 — PO 6	M	Social sustainability is a major part of sustainabledevelopment
100908CO300F.1 —PO.7	H	Environmental sustainability is a major part sustainable development
100908CO300F.2 —PO.1	M	Definition of pollution and its impacts
100908CO300F.2 —PO.2	M	Environmental pollution problems could be identified
100908CO300F.2 — PO 6	M	New designs should be developed such that the pollution is less.
100908CO300F.2 — PO.7	H	The environment will be sustainable if all types of pollutions are restricted within the carrying limit of the nature
100908CO300F.2 — PO.8	L	An engineer should not compromise his ethical values inenvironmental issues.
100908CO300F.3— PO.2	M	The impacts on environment due to a product or processcould be identified
100908CO300F.3 — PO.3	H	8est products or processes could be designed so that theimpact is minimum.
100908CO300F.3 — PO.6	M	Social responsibility of an Engineer in designing theproduct

100908CO300F.3 — PO.7	H	The environment will be sustainable if the products orprocesses make minimum impact.
100908CO300F.3 — PO.8	M	Professional ethics and responsibilities for best sustainable practices.
100908CO300F.4 — PO.1	L	Definition of green buildings and sustainable habitat
100908CO300F.4 — PO.2	L	Identifying green materials for sustainable buildings
100908CO300F.4 — PO.3	H	Buildings designed green
100908CO300F.4 — PO.6	M	Green building materials are nontoxic and less pollutingand long lasting
100908CO300F.4 — PO.7	H	Green building materials are sustainable & produce lessenvironmental impact
100908CO300F.4 — PO.8	L	Green buildings & ethics
100908CO300F.5 — PO.1	L	Concept of renewability of energy sources
100908CO300F.5 — PO.6	M	Energy resources and social concerns
100908CO300F.5 — PO.7	H	Sustainability of energy sources
100908CO300F.5 — PO.8	M	Ethics in energy consumption

JUSTIFATIONS FOR CO-PSO MAPPING

MAPPING	LOW/MEDIUM/HIGH	JUSTIFICATION
100908CO300F .2 —PSO.2	L	New mechanical systems could be designed so thatthe waste generation is minimum
100908CO300F .5 —PSO.3	M	Green engineering and better sustainable product design

GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSION REQUIREMENTS:

Sl. No	DESCRIPTION	PROPOSED ACTIONS	RELEVANCE WITH POs	RELEVANCE WITH PSOs
1	NIL	NIL	-	

WEB SOURCE REFERENCES:

1	www.nptel.ac.in
2	file:///E:/Sustainab1eEnggNew/PublishBook/SolidWaste/Keynote%20Address%20for%203rd%20Regiona1%203R%20Forum.pdf
3	https://synapse.bio/blog/10-biomimicry-examp1es
4	http://lokaa.in/blog/top-10-green-buildings-india/
5	http://www.gdrc.org/sustdev/concepts/16-1-eco.html
6	http://web.mit.edu/dorourke/www/PDF/IE.pdf

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑ CHALK & TALK	☑ STUD. ASSIGNMENT	☑ WEB RESOURCES	☑ LCD/SMART BOARDS
☐ STUD. SEMINARS	☐ ADD-ON COURSES		

ASSESSMENT METHODOLOGIES-DIRECT

☑ ASSIGNMENTS	☐ STUD. SEMINARS	☑ TESTS/MODEL EXAMS	☑ UNIV. EXAMINATION
☐ STUD. LAB PRACTICES	☐ STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐ CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☑ ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	☑ STUDENT FEEDBACK ON FACULTY (ONCE)
☐ ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

9.2 Course Plan

Sl. No.	Module	Topic
1	1	Introduction to Sustainable Engineering
2	1	Evolution and need of the concept 3 Pillar concept of Sustainability Nexus between Technology and Sustainable Development
3	1	Millennium Development Goals Sustainable Development Goals
4	1	Clean development mechanism
5	2	Air Pollution Major Air pollutants and their effects Types of air pollution
6	2	Water pollution Types Major pollutants and their effects
7	2	3R concept and Zero Waste concept in Solid Waste Management Green House Effect, Global Warming and Climate Change
8	2	Ozone Layer depletion Legislations to prevent pollution Air act, Water Act, CPCB, SPCB
9	3	ISO 14001:2015 Life Cycle Analysis
10	3	Circular economy Bio mimicking
11	3	EIA, Industrial Ecology, Industrial Symbiosis
12	4	Conventional Energy Sources
13	4	Renewable and nin renewable energy sources Fossil fuels, Solar and Wind power
14	4	Fuel Cells, Small Hydropower plants, Energy from Ocean, Geothermal Energy.
15	5	Sustainable practices: Basic idea about sustainable habitat Green building and Green building materials
16	5	Green Building Certification Method to improve energy efficiency of

		buildings
17	5	Green Engineering Sustainable Urbanization Sustainable Cities

Prepared by

Mr. John Paul C D

Mr. Tony Chacko

Approved by

Dr. Manoj G Tharian.

9. 3 Sample Questions

Model Questions

Module 1

1. Explain the three pillar model of sustainability.

2. List four strategies for achieving Sustainable development.

3. Illustrate the nexus between agricultural technology and sustainability.

4. What is the relevance of Kyoto Protocol?

5. Give an example of a technology which has contributed positively to sustainable development.

Module 2

1. Suggest any two sustainable methods for waste water treatment.

2. Explain the phenomenon of Ozone layer depletion.

3. Explain the significance of carbon footprint. Suggest two methods for reducing the carbon footprint in your house.

4. Suggest any one method of sustainable waste water treatment.

5. Write a short note on any local environmental issue (can be based on your own study)

Module 3

1. EMS frame work follows a Plan-Do-Check-Act (PDCA) cycle. Explain.

2. What do you mean by Bio-mimicking? Support your answer with one example.

3. List out various procedures of EIA in India

4. List any four sustainable building materials.

5. Explain three methods for increasing energy efficiency of buildings.

Module 4

1. Explain a solar water heating system with the help of a diagram.

2. Explain the working of a Photovoltaic cell with a neat diagram

3. What are the steps involved in bio-fuel production?

4. Explain any one method to extract Geothermal energy.

5. Illustrate the push factors and pull factors which leads to the migration of people from rural areas to urban areas.

Module 5

1. List out various procedures of EIA in India

2. List any four sustainable building materials.

3. Explain three methods for increasing energy efficiency of buildings.

4. Suggest five strategies for achieving sustainable transport and explain.

5. List out any 5 principles of green engineering.

10. 1000006/ME322S COMPUTER AIDED MACHINE DRAWING

10.1 COURSE INFORMATION SHEET

PROGRAMME: ME	**DEGREE:** BTECH
COURSE: Computer Aided Machine Drawing	**SEMESTER:** 3 **CREDITS:**2
COURSE CODE: ***1000006/ ME322S*** **REGULATION:** 2022	**COURSE TYPE:** CORE
COURSE AREA/DOMAIN: Mechanical Systems, Design and Analysis	**CONTACT HOURS:** 3 hours /week
CORRESPONDING LAB COURSE CODE (IF ANY): NA	**LAB COURSE NAME:** NA

SYLLABUS:

UNIT	DETAILS	HOURS
PART –A (Manual drawing) **(Minimum 6 drawings compulsory)**	**Temporary Joint:** Principles of drawing, free hand sketching, Importance of machine Drawing. BIS code of practice for Engineering Drawing, lines, types of lines, dimensioning, scales of drawing, sectional views, **Riveted joints.**	3
	Fasteners: Sketching of conventional representation of welded joints, Bolts and Nuts **or** Keys and Foundation Bolts.	3
	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.	3
	Detailed drawing of Cotter joints, Knuckle joint and Pipe joints	3
	Assembly drawings(2D): Stuffing box and Screw jack	3
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.	3
	Drawing of Shaft couplings and Oldham's coupling	3
	Assembly drawings(2D) with Bill of materials: Lathe Tailstock and Universal joint	3
	Assembly drawings(2D)with Bill of materials: Connecting rod and Plummer block	3
	Assembly drawings(2D)with Bill of materials: Rams Bottom Safety Valve **OR** steam stop valve	3
TOTAL HOURS		**30**

TEXT/REFERENCE BOOKS:

T/R	BOOK TITLE/AUTHORS/PUBLICATION
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.
R1	Ajeet Singh, Machine Drawing Includes AutoCAD, Tata McGraw-hill.
R2	P S Gill, Machine Drawing, Kataria& Sons.

COURSE PRE-REQUISITES:

C.CODE	COURSE NAME	DESCRIPTION	SEM
	ENGINEERING GRAPHICS	Should possess basic knowledge in Engineering drawing: Fundamental Engineering Drawing Standards, Dimensioning and preparation of neat drawings and to understand symbols used in engineering drawings.	1

COURSE OBJECTIVES:

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

COURSE OUTCOMES:

Sl. NO	DESCRIPTION	Bloom's Taxonomy Level
1000006/ ME322S.1	**Apply** the knowledge of engineering drawings and standards to prepare standard dimensioned drawings of machine parts and other engineering components.	Apply (Level 3)
1000006/ ME322S.2	**Prepare** standard assembly drawings of machine components and valves using part drawings and bill of materials.	Apply (Level 3)
1000006/ ME322S.3	**Apply** limits and tolerances to components and choose appropriate fits for given assemblies.	Apply (Level 3)
1000006/ ME322S.4	**Interpret** the symbols of welded, machining and surface roughness on the component drawings.	Understand (Level 2)
1000006/ ME322S.5	**Prepare** part and assembly drawings and Bill of Materials of machine components and valves using CAD software.	Create (Level 6)

CO-PO AND CO-PSO MAPPING

	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
1000006/ ME322S.1	3	-	-	-	-	-	-	-	-	3	-	-	-	2	-
1000006/ ME322S.2	3	-	2	-	-	-	-	-	-	3	-	-	-	2	-
1000006/ ME322S.3	3	2	-	-	-	-	-	-	-	-	-	-	-	2	-
1000006/ ME322S.4	3	-	-	-	-	-	-	-	-	-	-	-	-	2	-
1000006/ ME322S.5	3	-	-	-	3	-	-	-	-	3	-	1	-	2	3
1000006/ ME322S (Avg. Value)	**3**	**2**	**2**		**3**					**3**		**1**		**2**	**3**

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/MEDIUM/ HIGH	JUSTIFICATION
1000006/ ME322S.1- **PO1**	H	Students develop their fundamental knowledge in various standards, specifications, dimensioning methods, symbols followed while preparing Engineering drawings
1000006/ ME322S.1- **PO10**	H	Drawings are the communication tool of an engineer. Students develop their skill to understand information from drawings.
1000006/ ME322S.2- **PO1**	H	Fundamental knowledge in various standards, specifications, dimensioning methods, symbols used is necessary to create manual drawings of components.
1000006/ ME322S.2- **PO3**	M	Skill to draft manual drawings of machine components is essential to design system components.
1000006/ ME322S.2- **PO10**	H	Drawings are the communication tool of an engineer. Students develop their skill to understand information from manual drawings.
1000006/ ME322S.3- **PO1**	H	Selection and assembly of mechanical components requires fundamental knowledge in machine components
1000006/ ME322S.3- **PO2**	M	Skill to assembly components and to create assembled views is necessary for the analysis of mechanical systems before part manufacturing.
1000006/	H	Students would be able to apply their knowledge in weld

***ME322S*.4-PO1**		symbols to solve engineering problems related to different welded components.
***1000006/ ME322S*.5-PO1**	H	Modelling of machine components using CAD software require fundamental knowledge in Engineering drawings.
***1000006/ ME322S*.5-PO5**	H	AUTOCAD is a modern drafting and modelling tool which helps engineers to draft complex machine components and its assembly.
***1000006/ ME322S*.5-PO10**	L	Drawings are the communication tool of an engineer. With the help of modern CAD tools drawings can be created and can be easily communicate with others.

JUSTIFICATIONS FOR CO-PSO MAPPING

MAPPING	LOW/MEDIUM/ HIGH	JUSTIFICATION
***1000006/ ME322S*.1-PSO2**	M	Knowledge in Engineering drawing standards and principles is required for designing engineering components.
***1000006/ ME322S*.2-PSO2**	M	While designing mechanisms or systems one should be familiar with the machine components, joints, couplings etc. to choose appropriate one for designing and to develop new ideas in product design.
***1000006/ ME322S*.3-PSO2**	M	For assembly of machine components and to sketch assembled views of mechanical systems one should have knowledge to apply design principles
***1000006/ ME322S*.4-PSO2**	M	Fits and tolerance of machine components is an important area to understand while designing mechanical systems
***1000006/ ME322S*.5-PSO2**	M	Students are using modern tools of their choice to design machine components by applying design principles.
***1000006/ ME322S*.5-PSO3**	H	Students are using modern tools of their choice to design machine components.

ADD-ON PROGRAMMES:

SNO	DESCRIPTION	RELEVENCE TO PO\PSO

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

√CHALK & TALK	☐STUD. ASSIGNMENT	√ WEB RESOURCES	☐LCD/SMART BOARDS
☐STUD. SEMINARS	☐ADD-ON COURSES		

ASSESSMENT METHODOLOGIES-DIRECT

☐ASSIGNMENTS	☐STUD. SEMINARS	√TESTS/MODEL EXAMS	√UNIV. EXAMINATION
√STUD. LAB PRACTICES	√ STUD. VIVA	☐MINI/MAJOR PROJECTS	☐CERTIFICATIONS
☐ADD-ON COURSES	☐OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

√ ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	√STUDENT FEEDBACK ON FACULTY (TWICE)
☐ASSESSMENT OF MINI/MAJOR PROJECTS BY EXT. EXPERTS	☐OTHERS

10.2 COURSE PLAN

SESSION	MODULE	TOPIC PLANNED
1	**PART –A** **(Manual drawing)** (Minimum 6 drawings compulsory)	**Temporary Joint:** Principles of drawing, free hand sketching, Importance of machine Drawing. BIS code of practice for Engineering Drawing, lines, types of lines, dimensioning, scales of drawing, sectional views, **Riveted joints.**
2		**Fasteners:** Sketching of conventional representation of welded joints, Bolts and Nuts **or** Keys and Foundation Bolts.
3		**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.
4		Detailed drawing of Cotter joints, Knuckle joint and Pipe joints
5		**Assembly drawings(2D):** Stuffing box and Screw jack
6	**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.
7		Drawing of Shaft couplings and Oldham's coupling
8		**Assembly drawings(2D) with Bill of materials:** Lathe Tailstock and Universal joint
9		**Assembly drawings(2D)with Bill of materials:** Connecting rod and Plummer block
10		**Assembly drawings(2D)with Bill of materials:** Rams Bottom Safety Valve **OR** steam stop valve

10.3 SAMPLE QUESTIONS

Part A

1. Sketch two views of a single riveted single strap butt joint. Take dimensions of the plate as 10mm. Mark the proportions in the drawing.

2. Show by means of neat sketches, any three methods employed for preventing nuts from getting loose on account of vibrations

3. Compute the limit dimensions of the shaft and the hole for a clearance fit based on shaft basis system if: Basic size= φ30 mm, Minimum clearance = 0.007 mm, Tolerance on hole = 0.021 mm, Tolerance on shaft= 0.021 mm, Check the calculated dimensions. Represent the limit dimensions schematically.

4. For the fabrication of a boiler two sheets of thickness 12mm are to be joined permanently. Select the best method of joining and draw the sectioned elevation and plan of the joint

5. Draw the dimensioned cross sectional view of the butt weld welded under the following conditions for joining two plates of thickness 4mm , a) Butt welded between raised edges melted completely, b) Butt welded with raised edge, height of raised edge is 15mm and depth of penetration is 5mm

6. Draw a Hook end foundation bolt for diameter 30mm and indicate all standard proportions on the drawing.

7. Draw a sectional view of a foundation arrangement using a bolt designated by: Foundation bolt. A 20 x 400 N IS: 5626-1970

8. Sketch a Knuckle joint for connecting rods of 30mm diameter. Indicate approximate proportions.

9. Draw the top half sectional elevation of a Short nipple joint for connecting two pipes of diameter 25mm. The outside diameter is 35mm and length of short nipple is 65mm. Also indicate the important dimensions on the drawing.

10. Draw the top half sectional elevation and an end view of cotter joint. Diameter of the shaft is 50 mm.

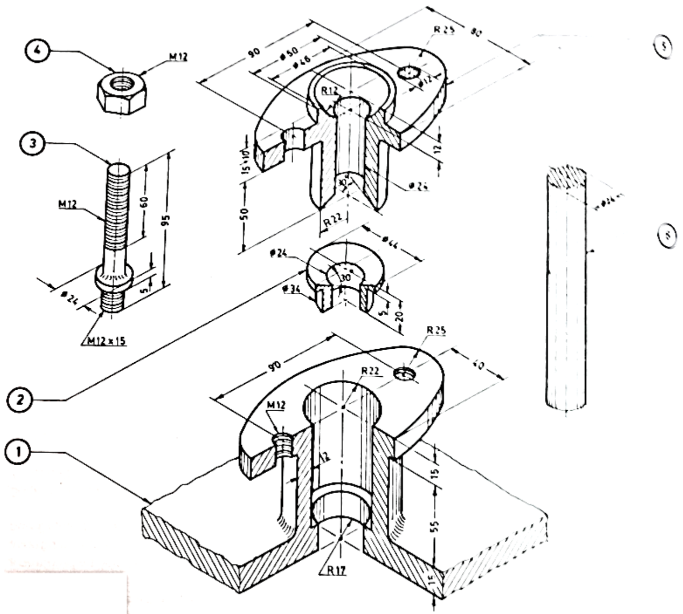
11. Draw the right half sectional elevation and plan view of assembled stuffing box. Refer figure A.1

12. Details of a screw jack is shown in the figure. Draw Elevation and right half in section of the assembled screw jack. Refer figure A.2s

13. Make a neat sketch of a hydraulic pipe joint for connecting two pipes of 75 mm diameter.

Outside diameter of pipe	=	120
Diameter of the spigot end	=	100
Projection of the spigot end	=	8
Distance between bolt centres	=	200
Size of the bolts	=	*M* 30
Number of bolts	=	2
Thickness of the flange	=	60
Width of the oval shaped flange	=	150
Length of the oval shaped flange	=	280

Indicate all important dimensions in the drawing.

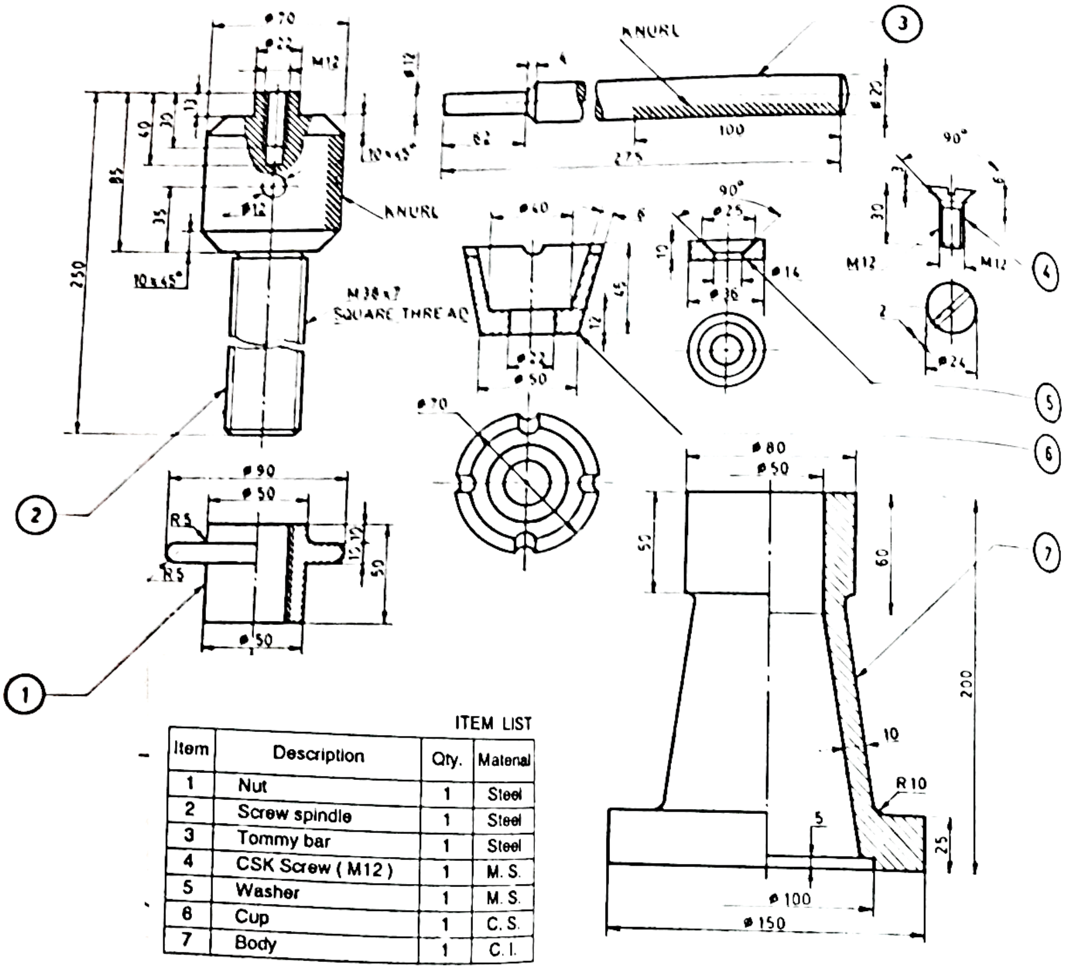


ITEM LIST

Item	Description	Qty.	Material
1	Body	1	C.I.
2	Gland bush	1	Brass
3	Stud	2	M.S.
4	Nut	2	M.S.
5	Gland	1	C.I.
6	Piston rod	1	Steel

STUFFING BOX

Figure A.1. Stuffing Box



Item	Description	Qty.	Material
1	Nut	1	Steel
2	Screw spindle	1	Steel
3	Tommy bar	1	Steel
4	CSK Screw (M12)	1	M. S.
5	Washer	1	M. S.
6	Cup	1	C. S.
7	Body	1	C. I.

Figure A.2 Screw Jack

Part B

1. Using CAD software, draw the half sectional elevation, top view and end views of the assembled Oldham's coupling as per the details given in the figure B.1.

2. Draw top half section and left side view of assembled Lathe tail stock as per the details given in the figure using any suitable CAD software. Also prepare bill of materials and tolerance data sheet. Refer figure B.2.

3. Draw top half section and right side view of assembled Universal Joint as per the details given in the figure using any suitable CAD software. Also prepare bill of materials and tolerance data sheet. Refer figure B.3.

4. Using CAD software, raw top half section views of the Connecting rod as per the details given in the figure. Also prepare bill of materials and tolerance data sheet. Refer figure B.4.

5. Draw left half section and top view of the Plummer block as per the details given in the figure using any suitable CAD software. Also prepare bill of materials and tolerance data sheet. Refer figure B.5.

6. Draw any two assembled views of the Rams Bottom Safety Valve as per the details given in the figure using any suitable CAD software. Also prepare bill of materials and tolerance data sheet. Refer figure B.6.

7. Draw left half section and top view of the steam stop valve ss per the details given in the figure using any suitable CAD software. Also prepare bill of materials and tolerance data sheet. Refer figure B.7.

All dimensions are in mm

4	TAPER KEY	Fe-410 W	2
3	SHAFT	Fe-410 W	2
2	CENTRE DISC	STEEL	1
1	FLANGE	STEEL	2
PART NO	DESCRIPTION	MATERIAL	NO OFF

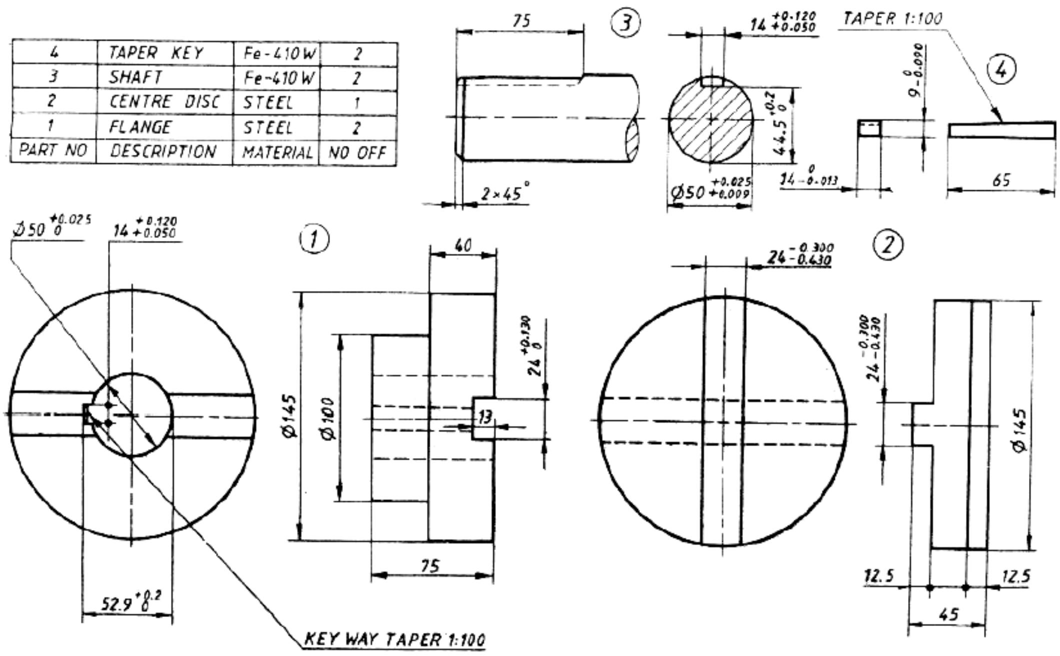
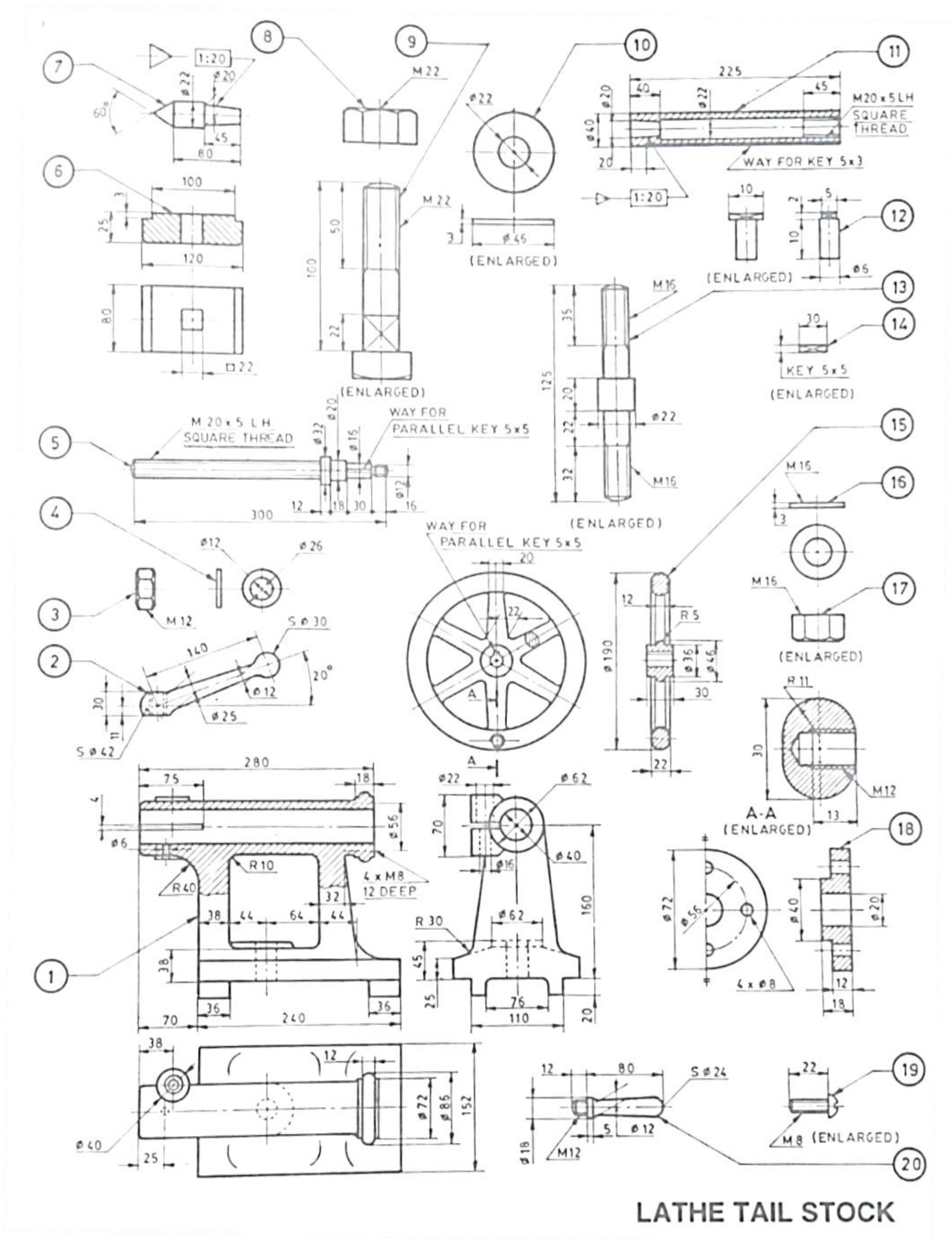


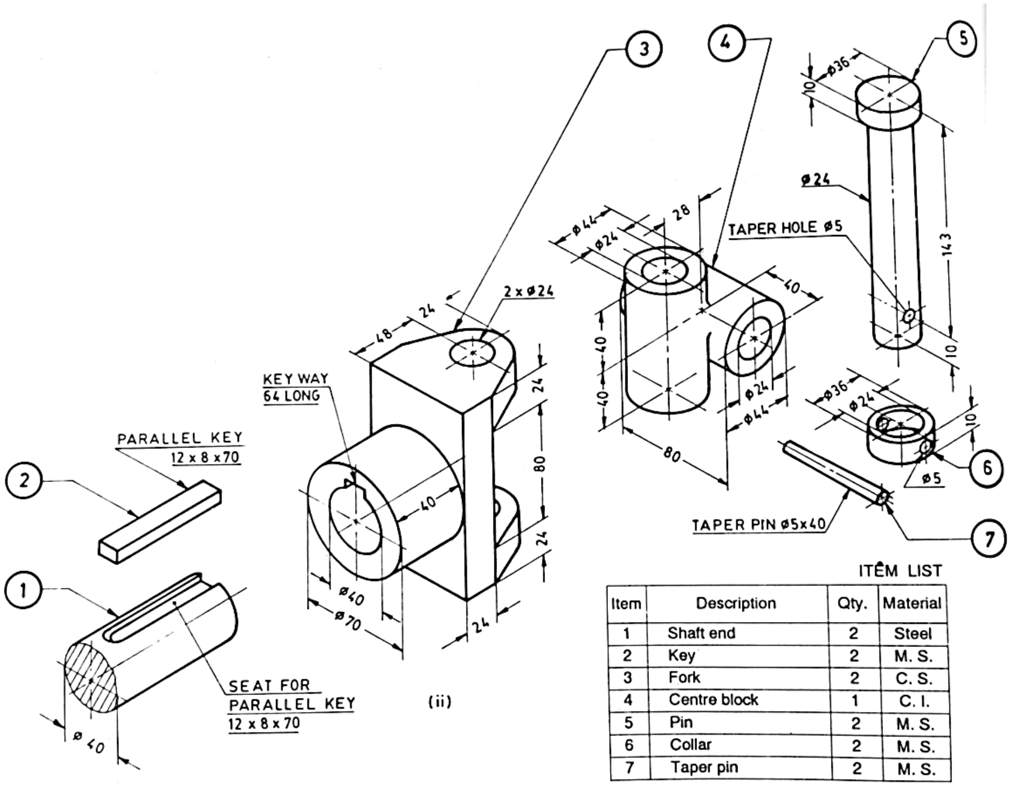
Figure B.1. Oldham's coupling



ITEM LIST

Item	Description	Qty.	Material	Item	Description	Qty.	Material
1	Body	1	C. I.	11	Barrel	1	C. I.
2	Handle (Lock)	1	C. I.	12	Key (Barrel)	1	M. S.
3	Nut (M 12)	1	M. S.	13	Stud	1	M. S.
4	Washer (M 12)	1	M. S.	14	Key (Wheel)	1	M. S.
5	Screw spindle	1	M. S.	15	Hand Wheel	1	C. I.
6	Clamping plate	1	Steel	16	Washer (M16)	1	M. S.
7	Dead centre	1	Steel	17	Nut (M 16)	1	M. S.
8	Nut (M22)	1	M. S.	18	Flange	1	C. I.
9	Sq. bolt (M22)	1	M. S.	19	Screw (M8)	4	M. S.
10	Washer (M22)	1	M. S.	20	Handle (Wheel)	1	M. S.

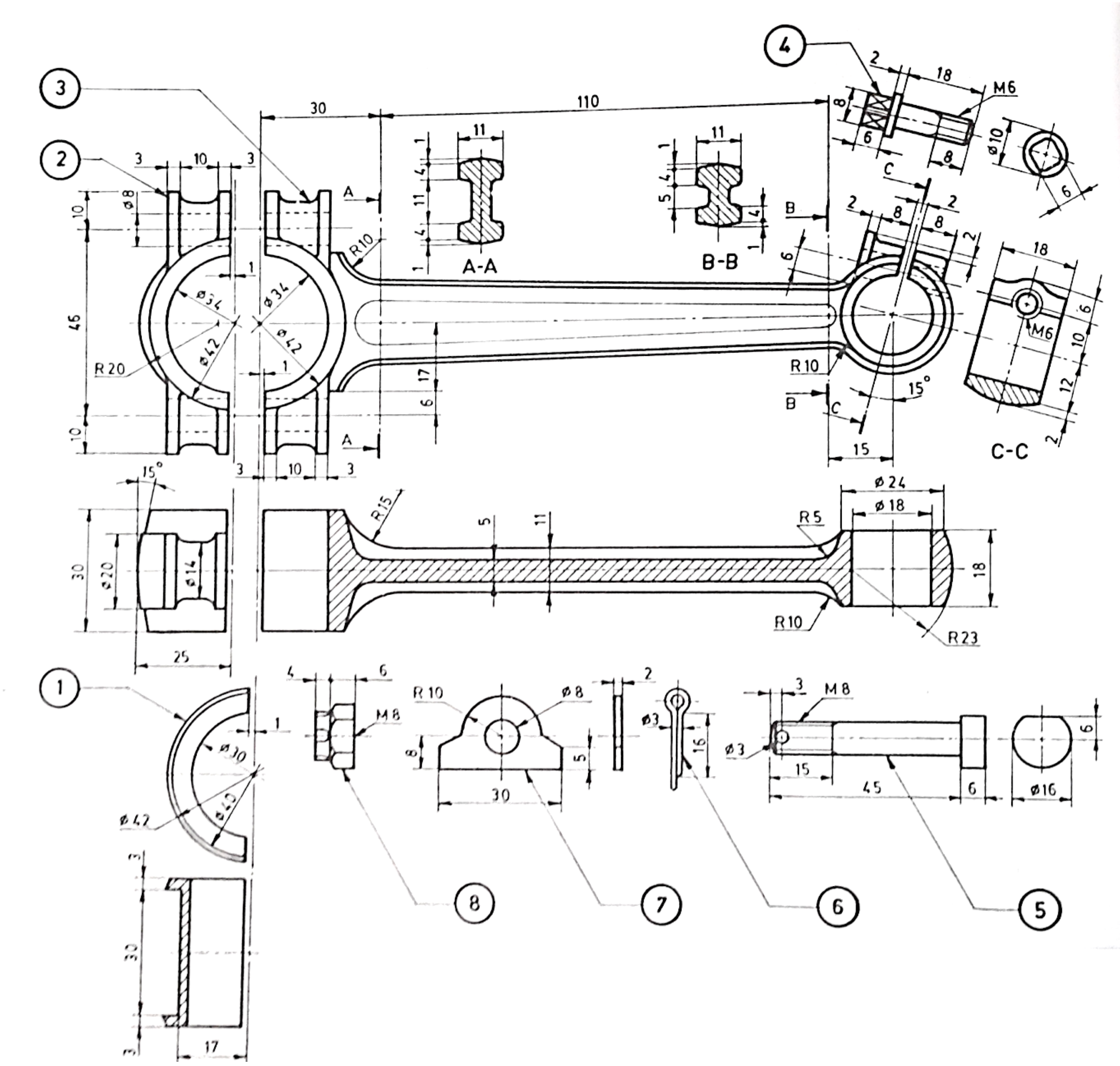
Figure B.2. Lathe tail stock



ITEM LIST

Item	Description	Qty.	Material
1	Shaft end	2	Steel
2	Key	2	M. S.
3	Fork	2	C. S.
4	Centre block	1	C. I.
5	Pin	2	M. S.
6	Collar	2	M. S.
7	Taper pin	2	M. S.

Figure B.3. Universal Joint

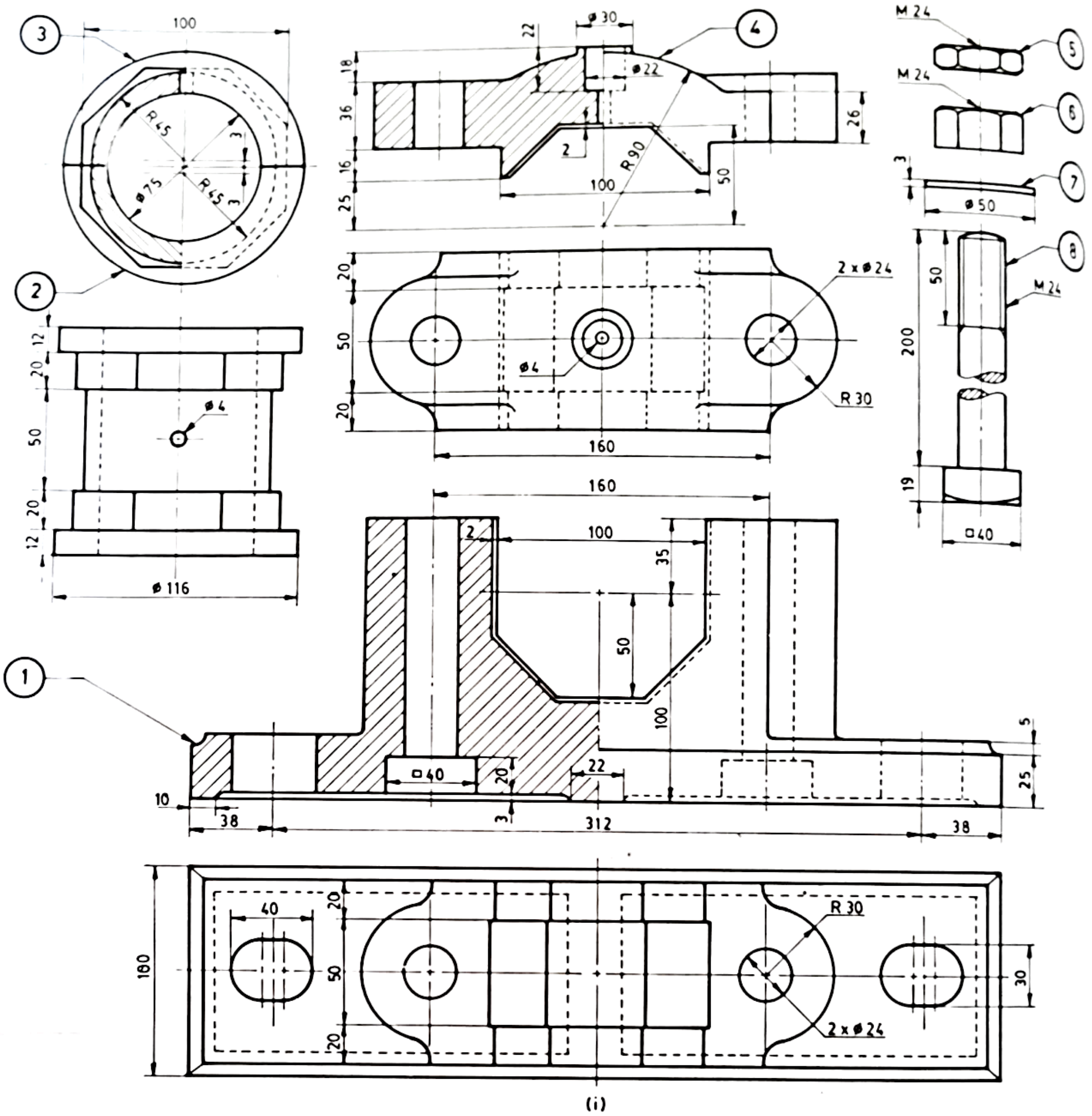


ITEM LIST

Item	Description	Qty.	Material
1	Big end bush (Half)	2	Bronze
2	Cap	1	Duralumin
3	Body	1	Duralumin
4	Set screw	1	Steel
5	Bolt	2	Steel
6	Split pin	2	M.S.
7	Shim	2	Bronze
8	Castle nut	2	Steel

I.C. ENGINE CONNECTING ROD

Figure B.4. Connecting rod



ITEM LIST

Item	Description	Qty.	Material
1	Block	1	C. I.
2	Brass (Bottom)	1	Brass
3	Brass (Top)	1	Brass
4	Cover	1	C. I.
5	Locknut	2	M. S.
6	Nut	2	M. S.
7	Washer	2	M. S.
8	Bolt	2	M. S.

PLUMMER BLOCK

Figure B.5. Plummer block

Item	Description	Qty	Material	Item	Description	Qty	Material
1	Body	1	C.I.	8	Split Pin	3	M.S.
2	Valve Seat	2	G.M.	9	Pin for link	2	M.S.
3	Spring	1	Steel	10	Pin for Pivot	1	M.S.
4	Valve	2	G.M.	11	Shackle	1	M.S.
5	Lever	1	M.S.	12	Washer	1	M.S.
6	Pivot	1	M.S.	13	Nut	1	M.S.
7	Link	2	M.S.	14	Lock Nut	1	M.S.

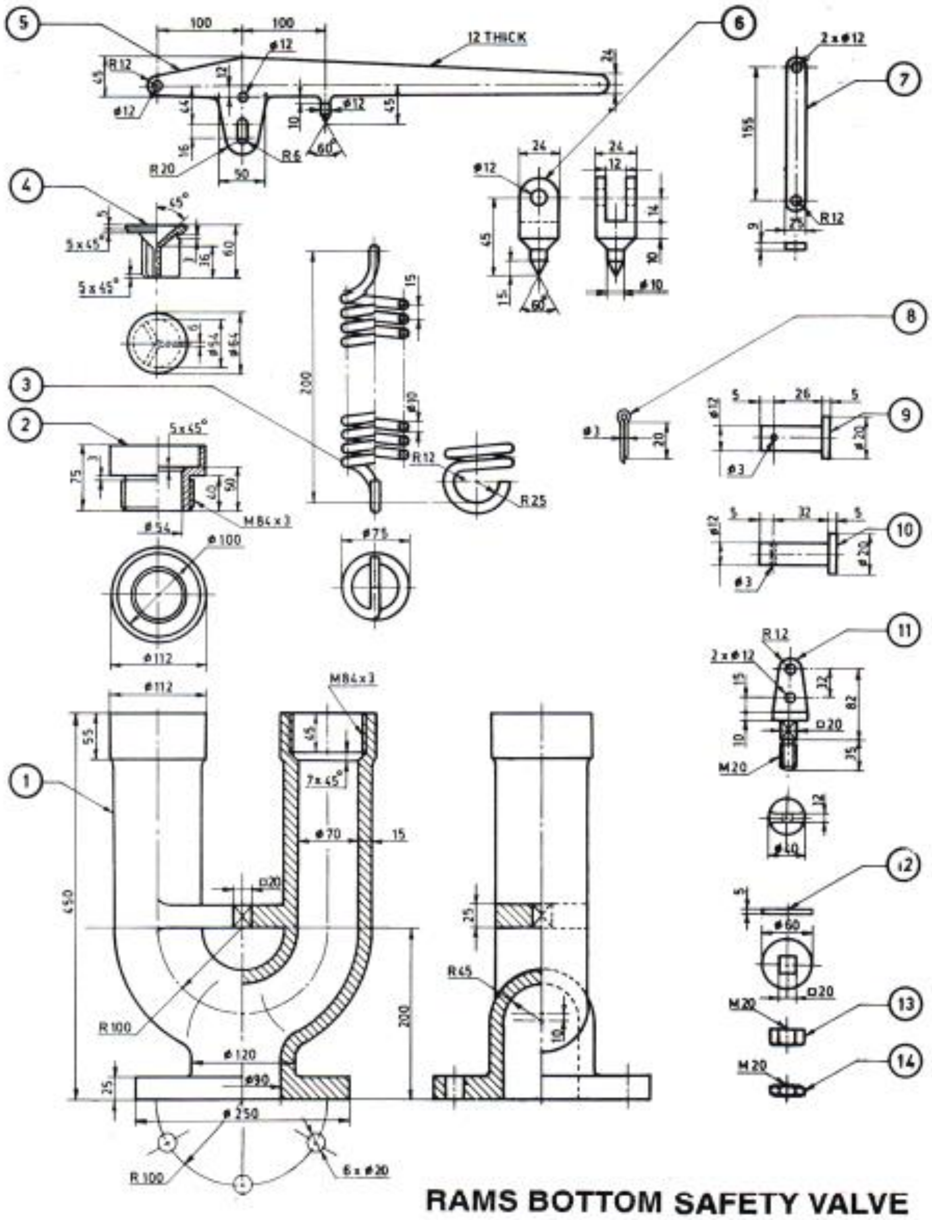


Figure B.6. Rams Bottom Safety Valve

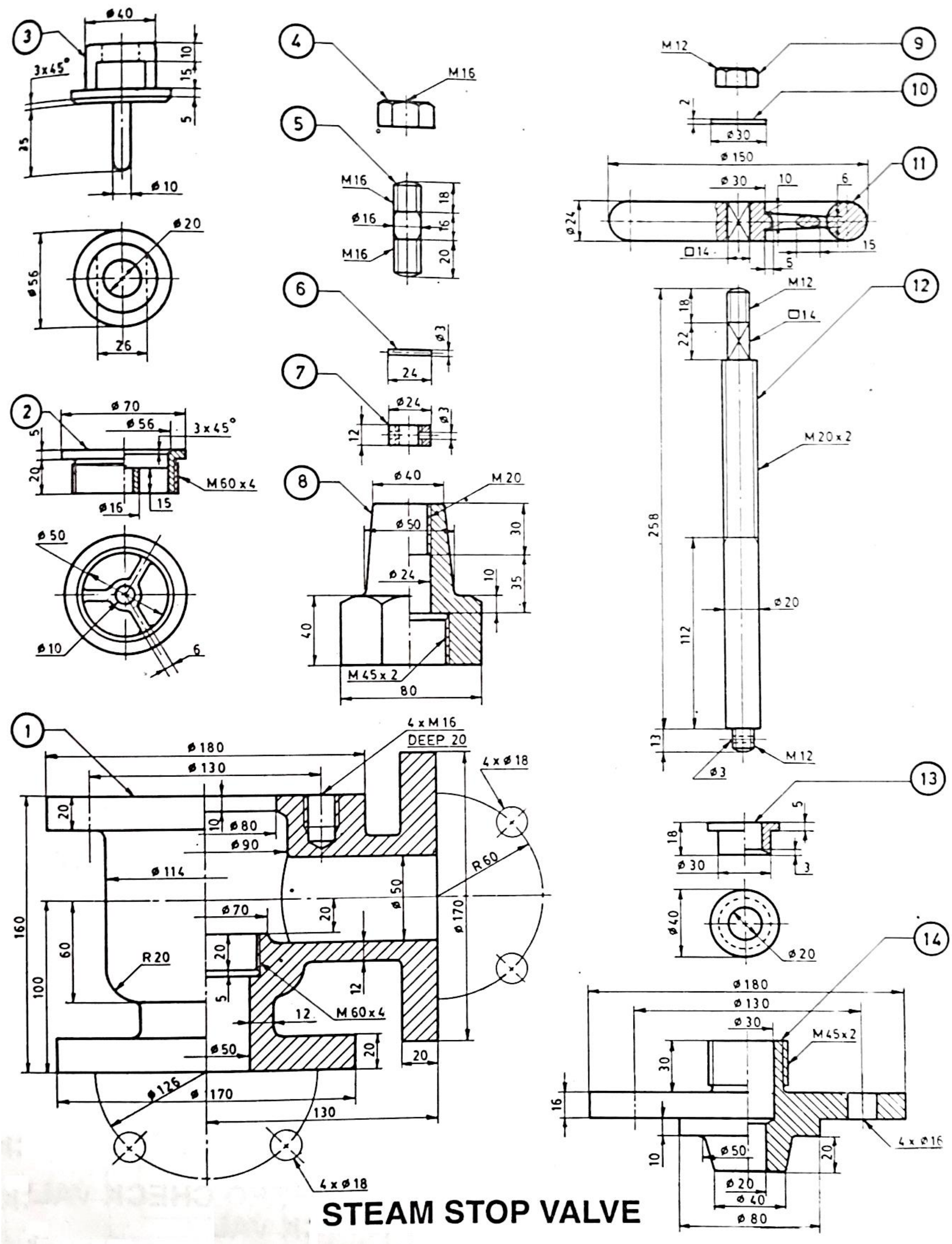


Figure B.7. Steam stop valve

Prepared by **Approved by**

Mr. Jithin P. N

Mr. Manu Joseph, **Dr.Manoj G. Tharian**

Dr. Joseph babu K, **HoD,ME**

Mr. Tony C.

(Faculty)

11. 100006/ME322T: MATERIAL TESTING LAB

11.1 COURSE INFORMATIONSHEET

PROGRAMME: ME	DEGREE: BTECH
COURSE: MATERIAL TESTING LAB	SEMESTER: S3 CREDITS:2
COURSE CODE: 100006/ME322T REGULATION: B Tech 2019 regulation KTU	COURSE TYPE: LAB (CORE)
COURSE AREA/DOMAIN: APPLIED MECHANICS	CONTACT HOURS: 6 hours per week

SYLLABUS:

CYCLE	DETAILS	HOURS
I	1. Tension test on mild steel rod 2. Bending Test on wooden beams 3. Shear Test on mild steel rods 4. Torsion test on mild steel rod 5. Izod Impact test	15
II	1. Charpy Impact Test 2. Brinell hardness test 3. Rockwell Hardness tests 4. Vicker's Hardness test 5. Test on springs (Open and closed coiled) 6. Reciprocal theorem	18
TOTAL HOURS		33

TEXT/REFERENCE BOOKS:

T/R	*BOOK TITLE/AUTHOR/PUBLICATION*
T1	Timoshenko S.P., Strength of Materials Part I, D. Van Nostrand Company, INC. New York
T2	Bansal R.K., Strength of Materials, Lakshmi Publications, New Delhi
R1	Mott, Robert L., Applied Strength of Materials, Fifth Edition, Prentice Hall of India

R2	Popov, E.P., Engineering Mechanics of Solids, Prentice Hall of India, New Delhi
R3	Ramamrutham S., Strength of Materials, Sixteenth Edition, DhanpatRai Publishing Company
R4	Bhavikatti S.S., Strength of Materials and Structural Engineering, Vikas Publishing House Pvt. Ltd.
R5	Nash W. A., Strength of Materials, Schaum's Outlines, 5th Edition, TMH
R6	Geri, James M., Mechanics of Materials, Cengage Learning
R7	Shames I.H., Pitarresi, James. M., Introduction to Solid Mechanics, Prentice Hall of India

COURSE PRE-REQUISITES: NIL

C.CODE	COURSE NAME	DESCRIPTION	SEM
ME 201	Mechanics of Solids	Mechanical properties of materials	3

COURSE OBJECTIVES

1	To make the students understand various strength parameters of materials subjected to load such as Tension, Compression, Flexure, Shear, Torsion, Impact & Hardness
2	To acquire knowledge on mechanical properties of materials such as various Elastic Moduli

COURSE OUTCOMES:

Sl.NO	DESCRIPTION	Blooms' Taxomomy Level
CMEL203.1	To determine the Modulus of Elasticity of steel and wood using UTM	Knowledge Level 5
CMEL 203.2	To determine the Modulus of rigidity of steel using torsion test and spring test	Knowledge Level 5
C MEL203.3	To analyses the toughness of a specimen using Impact testing machine	Analysis Level 4

CMEL203.4	To test the hardness of a material by Rockwell, Brinell and Vicker Hardness test.	Analysis Level 4
CMEL203.5	To determine the ultimate shear stress of steel using UTM	Evaluate Level 5

CO-PO AND CO-PSO MAPPING

	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
CMEL203.1	3	-	-	3	-	-	-	-	-	-	-	-	-	-	-
CMEL203.2	3	-	-	3	-	-	-	-	-	-	-	-	-	-	-
CMEL203.3	**3**	-	-	2	-	-	-	-	-	-	-	-	-	-	-
CMEL203.4	**3**	-	-	2	-	-	-	-	-	-	-	-	-	-	-
CMEL203.5	3	-	-	3	-	-	-	-	-	-	-	-	-	-	-

1- Low correlation (Low), 2- Medium correlation(Medium), 3-High correlation(High)

JUSTIFICATIONS FOR CO-PO MAPPING

MAPPING	LOW/MEDIUM/ HIGH	JUSTIFICATION
CMEL203.1- PO1	3	The knowledge about material properties like modulus of elasticity and how to determine them is of paramount importance for a Mechanical engineer
CMEL203.1- PO4	3	Conducting experiments to determine material properties provides an insight into the concepts behind the experiment and how they were designed
CMEL203.2- PO1	3	The knowledge about material properties like modulus of rigidity and how to determine them is of paramount importance for a Mechanical engineer
CMEL203.2- PO4	3	Conducting experiments to determine material properties provides an insight into the concepts behind the experiment and how they were designed
CMEL203.3- PO1	3	Conducting experiments to determine material properties

CMEL203.3- PO4	2	Conducting experiments to determine material properties provides an insight into the concepts behind the experiment and how they were designed
CMEL203.4- PO1	3	Conducting experiments to determine material properties
CMEL203.4- PO4	2	Conducting experiments to determine material properties provides an insight into the concepts behind the experiment and how they were designed
CMEL203.5- PO1	3	The knowledge about material properties like shear strength and how to determine them is of paramount importance for a Mechanical engineer
CMEL203.5- PO4	3	Conducting experiments to determine material properties provides an insight into the concepts behind the experiment and how they were designed

GAPS IN THE SYLLABUS - TO MEET INDUSTRY/PROFESSION REQUIREMENTS:

SI NO	DESCRIPTION	PROPOSED ACTIONS	RELEVANCE WITH POs	RELEVANCE WITH PSOs
1	Tests on durability in stainless steel	Experiment as per ASTM Standard	PO1 and PO4	Tension durability in stainless steel

WEB SOURCE REFERENCES:

1	http://nptel.ac.in/courses/Webcourse-contents/IIT-ROORKEE/strength%20of%20materials/lects%20&%20picts/image/lect12/lecture12.htm
2	http://nptel.ac.in/courses/112107146/lects%20&%20picts/image/lect11/lecture11.htm
3	https://www.youtube.com/watch?v=qbv2rOEMyiA
4	https://www.youtube.com/watch?v=ICDZ5uLGrI4
5	https://www.youtube.com/watch?v=MlwwdyItf9A
6	https://www.youtube.com/watch?v=EXL1wgCb0jw

DELIVERY/INSTRUCTIONAL METHODOLOGIES:

☑**CHALK & TALK**	☐ STUD.ASSIGNMENT	☑**WEB RESOURCES**
LCD/SMART BOARDS	☐ STUD.SEMINARS	☐ ADD-ONCOURSES

ASSESSMENT METHODOLOGIES-DIRECT

☐ ASSIGNMENTS	☐ STUD. SEMINARS	☑TESTS/MODEL EXAMS	☑UNIV. EXAMINATION
☑STUD. LAB PRACTICES	☑STUD. VIVA	☐ MINI/MAJOR PROJECTS	☐ CERTIFICATIONS
☐ ADD-ON COURSES	☐ OTHERS		

ASSESSMENT METHODOLOGIES-INDIRECT

☑ASSESSMENT OF COURSE OUTCOMES (BY FEEDBACK, ONCE)	**☑STUDENT FEEDBACK ON FACULTY (TWICE)**
☐ ASSESSMENT OFMINI/MAJOR PROJECTS BY EXT. EXPERTS	☐ OTHERS

11.2 Course Plan

Day	CYCLE	DETAILS	HOURS
1	I	1. Tension test on mildsteel rod	3
2		2. Bending Test on woodenbeams	3
3		3. Shear Test on mild steelrods	3
4		4. Torsion test on mild steelrod	3
5		5. Izod Impacttest	3
6	II	1. Charpy ImpactTest	3
7		2. Brinell hardness test	3
8		3. Rockwell Hardnesstests	3
9		4. Vicker's Hardness test	3
10		5. Test on springs (Open and closedcoiled)	3
11		6. Reciprocal theorem	3
	TOTAL HOURS		**33**

Prepared by

Tony C, and Jithin P.N.
(Faculty,DME)

Approved by

Dr. Manoj G Tharian
(HOD, DME)

11.3. QUESTION BANK

OPEN QUESTIONS

Tension Test

1. Define Hooke's Law.
2. What is stress?
3. What is strain?
4. What is deformation?
5. How is deformation calculated?
6. What is a Rigid Body?
7. What is a deformable solid?
8. Differentiate simple and compound stress.
9. What is stiffness?
10. Types of stresses.
11. Types of strains.
12. What is volumetric strain?
13. Differentiate Tensile Strain and Tensile stress.
14. Differentiate Compressive Strain and Compressive stress.
15. Differentiate Shear Strain and Shear stress.
16. What is factor of safety?
17. What is Ultimate strength?
18. What is working stress?
19. What is Yield Strength?
20. Define Stiffness of a helical spring.
21. Sketch the 'nominal' stress-strain curve and compare it with the actual stress-strain curve?
22. What is meant by 'strain hardening'?
23. Discuss the types of fracture in tension with suitable examples?

24. Why does sliding of ductile material during a tension test generally occur at an inclination of 45° to the axis of the bar?
25. Determine the values of the principal stresses and the maximum shear stress at any point in the test specimen, subjected to an axial tension of 500kg.
26. Draw the schematic diagram of the experimental set-up.
27. What is Strain energy?
28. What is Resilience?
29. define proof of resilience.
30. Define modulus of resilience.

Sping Test

1. Differentiate between closed and open coil helical spring
2. Define

   a) Pitch b) Stiffness of spring c) Helix angle of a spring d) Modulus of Rigidity

3. What are the major stresses produced in helical springs?

Impact Test (Charpy&Izod)

1) What is the engineering significance of the impact test?
2) What is the significance of providing a notch for the testspecimen?
3) Compare the position of the notch in relation to striking mass for Charpy and Izod tests.

Torsion Test

1. Explain torque.
2. What is Torsional force?
3. What is torsional rigidity?
4. Explain Radius of gyration.
5. What is Moment of inertia.
6. Explain Polar moment of inertia.
7. Why do we use a cylindrical specimen to conduct the torsion test?
8. Explain Torsion Equation.

Hardness Tests

1. Discuss the merits and demerits of the Rockwell Hardness Test.
2. Discuss the typical applications of Rockwell Hardness scale.
3. Discuss the importance of hardnesstest.
4. What are the advantages of Vickers's Hardness test over Brinnel Hardness test and Rockwell Hardness test?

Bending Test on Wooden Beam

1. Explain Bending Equation.
2. Draw Shear force diagram for a cantilever beam with udl and point load.
3. Draw Shear force diagram for a SSB with udl and point load.

4. What are SSB, Fixed Beams, Hinged Beams?
5. Explain the equilibrium condition for a body.
6. Types of beams.
7. What is Shear Centre?
8. Explain elastic constants.
9. What is Poisson's ratio?
10. Differentiate Longitudinal and Lateral Strain.
11. Relation between Bulk Modulus and Young's modulus.

Verification of Clark Maxwell's Reciprocal Theorem

1. Explain *Clark Maxwell's Reciprocal Theorem*
2. Derive the deflection equation used in *Clark Maxwell's Reciprocal Theorem*

Double Shear Test

1. Distinguish between single shear and double shear.
2. Give sketches showing single shear and double shear.

ADVANCE QUESTIONS

1. Why do we have to make the assumption that plane sections are plane?
2. What is non isotropic material?
3. What are nonlinear elastic materials?
4. Why is the variation of shear strain with radius linear?
5. What is combined bending and Torsion of a shaft?