INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

CIVIL ENGINEERING

TUTORIAL QUESTION BANK

Course Title	**ADVANCED SOLID MECHANICS**				
Course Code	BSTB02				
Programme	M.Tech				
Semester	I	STE			
Course Type	Core				
Regulation	**IARE - R18**				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	-	3	-	-
Chief Coordinator	Dr. J S R Prasad, Professor, Civil Engineering				
Course Faculty	Dr. J S R Prasad, Professor, Civil Engineering				

I. COURSE OVERVIEW:

This course introduces the principles of elasticity, components of stresses and strains, differential equations of equilibrium, boundary conditions, compatibility conditions and stress function. This course also covers the two dimensional problems in rectangular coordinates and polar coordinates, Fourier series for two dimensional problems stress distribution symmetrical about an axis, pure bending of curved bars, strain components in polar coordinates, displacements for symmetrical stress distributions, simple symmetric and asymmetric problems, analysis of stress strain in three dimensions, torsion of prismatical bars and plasticity. This course in reached to student by power point presentations, lecture notes, and assignment questions, seminars, previous model question papers, and question bank of long and short answers.

II. COURSE OBJECTIVES:

The course should enable the students to:

I	Solve advanced solid mechanics problems using classical methods
II	Apply commercial software on select, applied solid mechanics problems.

III. COURSE OUTCOMES (COs):

CO 1	Understand the theory of elasticity including strain/displacement and Hooke's law relationships
CO 2	Analyse solid mechanics problems using classical methods and energy methods
CO 3	Solve for stresses and deflections of beams under unsymmetrical loading
CO 4	Obtain stresses and deflections of beams on elastic foundations
CO 5	Apply various failure criteria for general stress states at points

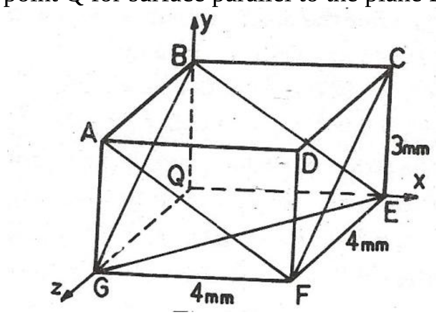
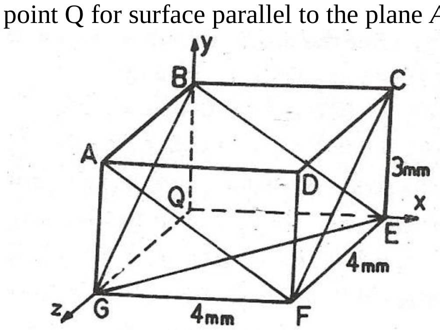
IV. COURSE LEARNING OUTCOMES:

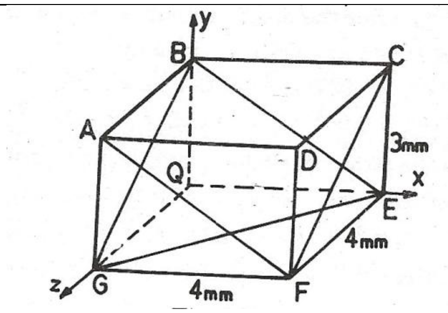
Students, who complete the course, will have demonstrated the ability to do the following:

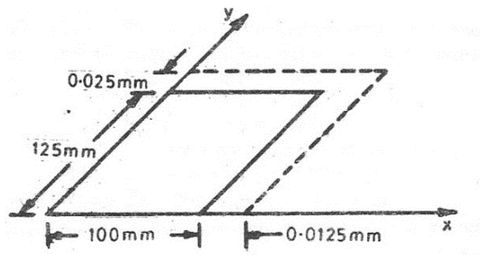
CLO Code	CLO's	At the end of the course, the student will have the ability to:
BSTB02.01	CLO 1	Understand the Displacement, Strain and Stress Fields
BSTB02.02	CLO 2	Understand the Constitutive Relations, Cartesian Tensors
BSTB02.03	CLO 3	Solve the problems on Equations of Elasticity
BSTB02.04	CLO 4	Know the Elementary Concept of Strain
BSTB02.05	CLO 5	Understand the Strain at a Point
BSTB02.06	CLO 6	Know concept of Principal Strains and Principal Axes
BSTB02.07	CLO 7	Understand the concept of Compatibility Conditions
BSTB02.08	CLO 8	Understand the concept of Stress at a Point
BSTB02.09	CLO 9	Develop the Stress Components on an Arbitrary Plane
BSTB02.10	CLO 10	Understand the concepts on differential Equations of Equilibrium
BSTB02.11	CLO 11	Know the Hydrostatic and Deviatoric Components.
BSTB02.12	CLO 12	Understand the Equations of Equilibrium, Strain Displacement and Compatibility Relations
BSTB02.13	CLO 13	Understand the formulation of Stress- Strain relations
BSTB02.14	CLO 14	Concept of Strain Displacement
BSTB02.15	CLO 15	Understand the solutions for boundary value problems
BSTB02.16	CLO 16	Know the co-axiality of the Principal Directions
BSTB02.17	CLO 17	Understand the Plane Stress and Plane Strain Problems
BSTB02.18	CLO 18	Know the Two-Dimensional Problems in Polar Coordinates
BSTB02.19	CLO 19	Understand the Saint Venant's Method, Prandtl's Membrane Analogy
BSTB02.20	CLO 20	Formulation of Torsion of Rectangular Bar and thin plates
BSTB02.21	CLO 21	Understand the concept of Plastic Stress-Strain Relations
BSTB02.22	CLO 22	Solution of Principle of Normality and Plastic Potential, Isotropic Hardening

TUTORIAL QUESTION BANK

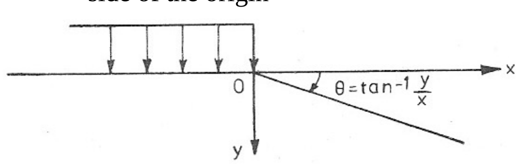
UNIT – I				
INTRODUCTION TO ELASTICITY:				
Part - A (Short Answer Questions)				
1	Give the tensor notations of generalized three dimensional state of stress and strain at a point in an elastic material, with appropriate figures.	Remember	CO 1	BSTB02.01
2	Define Hooke's law and give the three dimensional equations for Hooke's law for an elastic material.	Understand	CO 1	BSTB02.01
3	Give the relationship between the three elastic modulli, namely Young's modulus, rigidity modulus and bulk modulus for an elastic material.	Remember	CO 1	BSTB02.01
4	What are Lame's constants? Give the relationship between stress and strain in terms of Lame's constant and rigidity modulus.	Understand	CO 1	BSTB02.01
5	Define principal planes and principal stresses	Remember	CO 1	BSTB02.02
6	What are stress-invariants? Give the expressions for the three stress-invariants?	Remember	CO 1	BSTB02.02
7	What are strain-invariants? Give the expressions for the three strain-invariants?	Understand	CO 1	BSTB02.02
8	Write the basic equations of equilibrium for a generalized three dimensional stress element?	Remember	CO 1	BSTB02.02
9	Write the strain displacement equations?	Remember	CO 1	BSTB02.02
10	Express the biharmonic equation for plane stress?	Remember	CO 1	BSTB02.02
Part - B (Long Answer Questions)				
1	The state of stress at a point relative to an xyz coordinate system is $\begin{bmatrix} 400 & 100 & -100 \\ 100 & 0 & 200 \\ -100 & 200 & 0 \end{bmatrix}$ N/mm^2. Determine the complete state of stress relative to an $x'y'z'$ co-ordinate system if <table><tr><td></td><td>x</td><td>y</td><td>z</td></tr><tr><td>x'</td><td>30°</td><td>60°</td><td>90°</td></tr><tr><td>y'</td><td>120°</td><td>30°</td><td>90°</td></tr><tr><td>z'</td><td>90°</td><td>90°</td><td>90°</td></tr></table>	Apply	CO 1	BSTB02.01
2	The state of stress at a point relative to an xyz coordinate system is $\begin{bmatrix} 200 & 50 & -100 \\ 50 & 0 & 150 \\ -100 & 150 & 0 \end{bmatrix}$ N/mm^2. Determine the complete state of stress relative to an $x'y'z'$ co-ordinate system if <table><tr><td></td><td>x</td><td>y</td><td>z</td></tr><tr><td>x'</td><td>45°</td><td>30°</td><td>90°</td></tr><tr><td>y'</td><td>60°</td><td>45°</td><td>90°</td></tr><tr><td>z'</td><td>90°</td><td>90°</td><td>90°</td></tr></table>	Apply	CO 1	BSTB02.01

<table>
<tr><td>3</td><td>The state of stress at a point relative to an xyz coordinate system is
$$\begin{bmatrix} 500 & 150 & -200 \\ 150 & 0 & 200 \\ -200 & 200 & 0 \end{bmatrix} \text{N/mm}^2.$$
Determine the complete state of stress relative to an $x^{'} y^{'} z'$ co-ordinate system if
<table>
<tr><td></td><td>x</td><td>y</td><td>z</td></tr>
<tr><td>x'</td><td>60°</td><td>45°</td><td>90°</td></tr>
<tr><td>y'</td><td>150°</td><td>60°</td><td>90°</td></tr>
<tr><td>z'</td><td>90°</td><td>90°</td><td>90°</td></tr>
</table></td><td>Apply</td><td>CO 1</td><td>BSTB02.01</td></tr>
<tr><td>4</td><td>At point Q in a body the state of stress relative to a xyz co-ordinate system is
$$\begin{bmatrix} 500 & 200 & -200 \\ 200 & 0 & 400 \\ -200 & 400 & 300 \end{bmatrix} \text{MPa}$$
Using the cube shown in Fig., determine the normal and shear stress at point Q for surface parallel to the plane BCGF

</td><td>Apply</td><td>CO 1</td><td>BSTB02.02</td></tr>
<tr><td>5</td><td>At point Q in a body the state of stress relative to a xyz co-ordinate system is
$$\begin{bmatrix} 400 & 250 & -200 \\ 250 & 0 & 300 \\ -200 & 300 & 200 \end{bmatrix} \text{MPa}$$
Using the cube shown in Fig., determine the normal and shear stress at point Q for surface parallel to the plane ABEF.

</td><td>Apply</td><td>CO 1</td><td>BSTB02.02</td></tr>
<tr><td>6</td><td>At point Q in a body the state of stress relative to a xyz co-ordinate system is
$$\begin{bmatrix} 600 & 300 & -250 \\ 300 & 0 & 500 \\ -250 & 500 & 400 \end{bmatrix} \text{MPa}$$
Using the cube shown in Fig., determine the normal and shear stress at point Q for surface parallel to the plane BGE.</td><td>Apply</td><td>CO 1</td><td>BSTB02.02</td></tr>
</table>

				
7	If $\sigma_x = 4$ MPa, $\sigma_y = 2$ MPa, $\sigma_z = -2$ MPa, $\tau_{xy} = 3$ MPa, $\tau_{yz} = 8$ MPa, $\tau_{zx} = -2$ MPa, then compute the stress vectors on planes with unit normal $\left(\frac{2}{3}, \frac{1}{3}, \frac{2}{3}\right)$ and $\left(\frac{1}{\sqrt{14}}, \frac{2}{\sqrt{14}}, \frac{3}{\sqrt{14}}\right)$. Compute the normal and shearing stresses on these planes.	Apply	CO 1	BSTB02.02
8	Determine the magnitude and the direction of the principal stresses and the maximum shearing stress when, $\sigma_x = 1500$ MPa, $\sigma_y = -1000$ MPa, $\sigma_z = 1000$ MPa, $\tau_{xy} = -300$ MPa, $\tau_{yz} = 0$ MPa, $\tau_{xz} = 100$ MPa.	Apply	CO 1	BSTB02.02
9	For a given displacement field $\bar{u} = (x^2y + 5z^2)\hat{\imath} + (xy^2z + y^2)\hat{\jmath} + x^2y^2z^2\hat{k}$, determine the strain tensor, rotation tensor and the angle of rotation at the point (2, -1,2).	Apply	CO 1	BSTB02.02
10	Show that $\varepsilon_x = c_1(x^2 + y^2)$, $\varepsilon_y = c_1(y^2 + z^2)$, $\gamma_{xy} = c_2xyz$, $\varepsilon_z = \gamma_{xz} = \gamma_{yz} = 0$. where c_1 and c_2 are constants, is not a possible state of strain.	Apply	CO 1	BSTB02.02
11	The state of strain at a point is given by $\varepsilon_x = 0.001, \varepsilon_y = -0.003, \varepsilon_z = 0.002,$ $\gamma_{xy} = 0.001, \gamma_{yz} = 0.0005, \gamma_{yz} = -0.002$ Determine the strain invariants and the prinicipal strains.	Apply	CO 1	BSTB02.02
12	The state of stress at a point is given by $\sigma_x = 200, \sigma_y = -100, \sigma_z = 50,$ $\tau_{xy} = 40, \tau_{yz} = 50, \tau_{zx} = 60$ MPa. If $E = 2.05 \times 10^5$ N/mm^2 and $G = 0.8 \times 10^5$ N/mm^2, then find the strain components.	Apply	CO 1	BSTB02.02
13	The state of strain at a point is defined by the given strain tensor below. For a fibre with direction $(0, -1/\sqrt{5}, -2/\sqrt{5})$, calculate (a) the normal strain for the fibre (b) the magnitude of the strain vector. $[\varepsilon_{ij}] = \begin{bmatrix} 200 & 183 & -25 \\ 183 & 100 & -125 \\ -25 & -125 & 150 \end{bmatrix} \times 10^{-5}$	Apply	CO 1	BSTB02.02
14	At a point, the stress components are: $\sigma_x = 600, \sigma_y = 300, \quad \sigma_z = 900$ $\tau_{xy} = 500, \quad \tau_{yz} = 400, \quad \tau_{zx} = -200$ kPa. Show that the principal directions of stress and derivative stress coincide.	Apply	CO 1	BSTB02.02
15	The state of stress at a point is given by $\sigma_x = 100, \sigma_y = 200, \quad \sigma_z = -100$	Apply	CO 1	BSTB02.02

	$\tau_{xy} = -200, \quad \tau_{yz} = 100, \quad \tau_{zx} = -300$ kPa. Determine the stress invariants.			
Part - C (Problem Solving and Critical Thinking Questions)				
1	The given displacement components are: $u_x = cx(y+z)^2, u_y = cy(x+z)^2, u_z = cz(x+y)^2$, where c is a constant. Find (a) the components of linear strain. (b) the components of rotation.	Analyze & Evaluate	CO 1	BSTB02.01
2	A plate whose thickness is 3 mm is stretched as shown in Fig. Find the principal strains and the maximum shearing strain in the plate.  	Analyze & Evaluate	CO 1	BSTB02.02
3	The stress field on a body is given by $\sigma_x = 20x^2 + y^2, \quad \sigma_y = 30x^3 + 200, \quad \sigma_z = 30(y^2 + z^2)$ $\tau_{xy} = zx, \quad \tau_{xz} = y^2 z, \quad \tau_{yz} = x^3 y.$ What are the components of the body force required to ensure equilibrium?	Analyze & Evaluate	CO 1	BSTB02.02
4	The state of stress at a point is given by $[\tau_{ij}] = 10^2 \begin{bmatrix} 10 & 5 & -10 \\ 5 & 20 & -15 \\ -10 & -15 & -10 \end{bmatrix}$ MPa. Find the magnitude and direction of the stress vector acting on a plane whose normal has direction cosines (1/2, 1/2, $1/\sqrt{2}$). What are the normal and tangential stresses acting on this plane?	Analyze & Evaluate	CO 1	BSTB02.02
5	The state of strain at a point within a material is given by: $\begin{bmatrix} 200 & 100 & 0 \\ 100 & 300 & 400 \\ 0 & 400 & 0 \end{bmatrix} \times 10^{-6}$ For E = 200 GPa and G = 80 GPa, ascertain the components of stress tensor.	Analyze & Evaluate	CO 1	BSTB02.02
6	The state of stress at a point is given by $\sigma_x = 100, \sigma_y = 200, \quad \sigma_z = -100$ $\tau_{xy} = -200, \quad \tau_{yz} = 100, \quad \tau_{zx} = -300$ kPa. Determine the principal stresses and the direction cosines of the principal planes.	Analyze & Evaluate	CO 1	BSTB02.02
7	The displacement field in a body is specified as: $u_x = (x^2 + 3) \times 10^{-3}$ $u_y = 3y^2 z \times 10^{-3}$ $u_z = (x + 3z) \times 10^{-3}$ Determine the strain components at a point whose co-ordinates are (1, 2, 3)	Analyze & Evaluate	CO 1	BSTB02.02
8	The state of stress at a point is given by: $\begin{bmatrix} 20 & -6 & 10 \\ -6 & 10 & 8 \\ 10 & 8 & 7 \end{bmatrix}$ MPa. Determine the principal stresses and principal directions.	Analyze & Evaluate	CO 1	BSTB02.02

9	The stress field in a continuous body is given by: $$[\tau_{ij}] = \begin{bmatrix} 1 & 0 & 2y \\ 0 & 1 & 4x \\ 2y & 4x & 1 \end{bmatrix} \text{kPa.}$$ Find the stress vector at point P $(1, 2, 3)$,acting on a plane $x + y + z = 6$.	Analyze & Evaluate	CO 1	BSTB02.02
10	The given displacement components are: $u_x = cx(y+z)^2, u_y = cy(x+z)^2, u_z = cz(x+y)^2$, where c is a constant. Find the principal strains at a point whose co-ordinates are (1,1,1).	Analyze & Evaluate	CO 1	BSTB02.02
UNIT – II				
STRAIN AND STRESS FIELD:				
Part - A (Short Answer Questions)				
1	Express the stress function in the form of a doubly infinite power series.	Remember	CO 2	BSTB02.03
2	Express the stress compatibility equation for plane stress case.	Remember	CO 2	BSTB02.03
3	Express the stress compatibility equation for plane strain case.	Remember	CO 2	BSTB02.03
4	Give the equations relating to bending of a beam by uniform load.	Understand	CO 2	BSTB02.04
5	What are conjugate harmonic functions and analytic functions? Give the property of the analytic functions.	Remember	CO 2	BSTB02.04
6	Give the Cauchy-Riemann equations for a stress field. What is the significance of the Cauchy-Riemann equations?	Remember	CO 2	BSTB02.05
7	Express the displacement and stress configurations in terms of complex potentials.	Remember	CO 2	BSTB02.06
8	How does the stress function satisfies the biharmonic equation?	Remember	CO 2	BSTB02.06
9	Express the stresses acting in a Tapering beam	Understand	CO 2	BSTB02.06
10	Express the stresses acting in an infinite wedge.	Remember	CO 2	BSTB02.07
11	Express the stress components in terms of an Airy stress function	Remember	CO 2	BSTB02.07
12	Express the equilibrium equations in polar co-ordinates.	Remember	CO 2	BSTB02.07
Part - B (Long Answer Questions)				
1	A cantilever beam of rectangular cross-section 40 mm wide and 60 mm thick is 800 mm in length. It carries a load of 500 N at the free end. Determine the stresses in the cantilever at mid-length.	Apply	CO 2	BSTB02.03
2	A rectangular beam 80 mm wide and 100 mm thick is of 600 mm in length. It carries a uniformly distributed load of intensity 10 N/mm throughout its length. Plot the variation of stresses in the beam at mid-span.	Apply	CO 2	BSTB02.03
3	A cantilever of length *l* in x-dimension and depth 2C along the y-dimension is loaded with a load P at the free end. The support conditions at $x = l$ are given as: At $x = l, y = 0$: $u_x = u_y = 0$ At $x = l, y = \pm C$: $u_x = 0$ Show that the deflection is now $$(u_y)_{x=y=0} = \frac{Pl^3}{3El}\left[1 + \frac{1}{2}(4+5v)\frac{C^2}{l^2}\right]$$	Apply	CO 2	BSTB02.04
4	Show that $(A\,e^{\alpha y} + B\,e^{-\alpha y} + Cy\,e^{\alpha y} + Dy\,e^{-\alpha y})\sin\alpha x$is a stress function in two dimensional stress field.	Apply	CO 2	BSTB02.04
5	Derive series expressions for the stresses in a semi-infinite plate, $y > 0$, with normal pressure on the straight edge $(y = 0)$ having the distribution	Apply	CO 2	BSTB02.04

	$\sum_{m=1}^{\infty} b_m \sin \frac{m\pi x}{l}$			
6	Show that if V is a plane harmonic function, *i.e.* it satisfies the Laplace equation $\nabla^2 V = 0$, then the functions $xV, yV,\ (x^2+y^2)V$ satisfy the bilharmonic equation and so can be used as stress functions.	Apply	CO 2	BSTB02.05
7	Determine the stress fields that arise from the following stress functions: i. $\phi = Cy^2$ ii. $\phi = Ax^2 + Bxy + Cy^2$	Apply	CO 2	BSTB02.06
8	Determine the stress fields that arise from the following stress function: $\phi = Ax^3 + Bx^2y + Cxy^2 + Dy^3$	Apply	CO 2	BSTB02.06
9	A cantilever of length *l* in x-dimension and depth 2C along the y-dimension is loaded with a load P at the free end. The stress field for this cantilever considering bending and transverse shear effects are: $\sigma_x = -\frac{Pxy}{I}, \sigma_y = 0, \quad \tau_{xy} = -\frac{P}{2I}(C^2 - y^2).$ Verify that this stress field satisfies the equilibrium equations.	Apply	CO 2	BSTB02.07
10	Find the stress and displacement fields corresponding to the complex potentials $\varphi(z) = \alpha + iAz,\ \psi(z) = \beta$ where α and β are complex constants and A is real. Interpret this displacement field.	Apply	CO 2	BSTB02.07
	Part - C (Problem Solving and Critical Thinking Questions)			
1	Show that the complex potentials $\varphi(z) = \alpha z, \quad \psi(z) = \beta$ Correspond to a uniform stress field. Find α and β so that $\sigma_x = X, \quad \tau_{xy} = S, \quad \sigma_y = Y$	Analyze & Evaluate	CO 2	BSTB02.03
2	Determine the stress and displacement fields in an infinite medium due to equal and opposite point forces acting at different points along their common line of action.	Analyze & Evaluate	CO 2	BSTB02.03
3	Consider the effect of a point force $X + iY$ acting at an internal point Z_0 of the half plane S^+ when the boundary $y = 0$ is unstressed. Determine the normal displacement on $y = 0$.	Analyze & Evaluate	CO 2	BSTB02.04
4	Using Fourier integral method, determine the solution of biharmonic equation in Cartesian co-ordinates.	Analyze & Evaluate	CO 2	BSTB02.04
5	A semi-infinite elastic medium is subjected to a normal pressure of intensity p distributed over a circular area of radius αat $x = 0$. Determine the stress distribution by using Fourier integral method.	Analyze & Evaluate	CO 2	BSTB02.04
6	Show that the stress function $\phi = C\left[(x^2+y^2)\tan^{-1}\frac{y}{x} - xy\right]$ provides the solution to the problem of the semi-infinite elastic medium acted upon by a uniform pressure q on one side of the origin 	Analyze & Evaluate	CO 2	BSTB02.04
7	Investigate the plane stress problem represented by the Airy's stress function	Analyze & Evaluate	CO 2	BSTB02.06

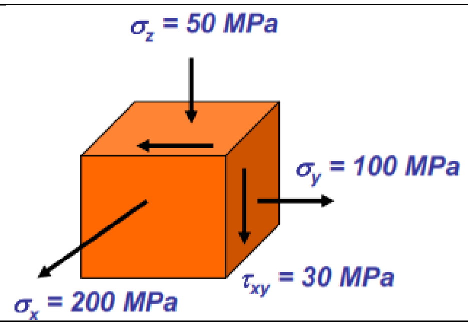
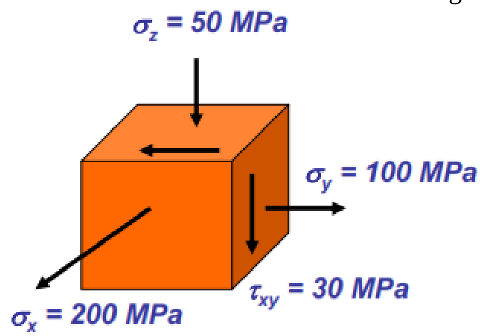
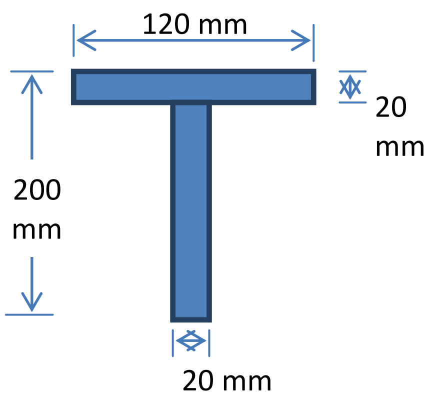
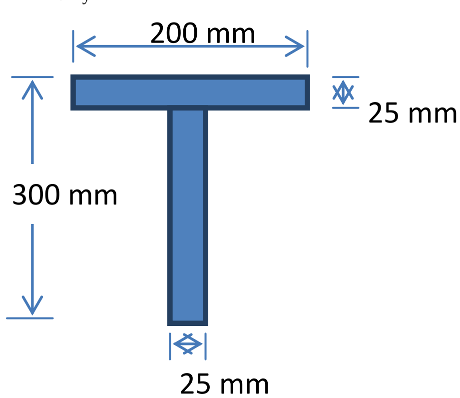
	$$\phi = \frac{3F}{4h}\left(xy - \frac{xy^3}{3h^2}\right) + \frac{P}{2}y^2$$ where h is half depth of the beam and F is the concentrated load.			
8	A cantilever beam loaded at its free end has a stress function $$\phi = Axy + B\frac{xy^3}{6}$$ Determine an expression for the vertical deflection curve.	Analyze & Evaluate	CO 2	BSTB02.06
9	Using Airy's stress function, $$\phi = B\left(y^3 + \frac{3}{4}yh^2\right) + F\frac{y^2}{8},$$ determinethe stress distribution at $0 < x < l$ for $y = \pm h$, where 'l' is the span of the beam, '$2h$' the depth of the beam and F the load.	Analyze & Evaluate	CO 2	BSTB02.07
10	Using the stress function $$\phi = \frac{3P}{4c}\left(xy - \frac{xy^3}{3c^2}\right),$$ determine the deflection at the free end of a cantilever, with the conditions $0 < x < l$ and $y = \pm c$.	Analyze & Evaluate	CO 2	BSTB02.07
UNIT – III				
EQUATIONS OF ELASTICITY AND TWO-DIMENSIONAL PROBLEMS OF ELASTICITY:				
Part - A (Short Answer Questions)				
1	Write the equations of equilibrium of the elemental tetrahedron, with three edges along the x, y and z-axes.	Remember	CO 3	BSTB02.08
2	Write the expression for normal stress on the inclined plane of an elemental tetrahedron the direction cosines of whose normal are *l*, *m* and *n*, and whose other faces lie in three coordinate planes.	Remember	CO 3	BSTB02.08
3	Give the equation of the stress ellipsoid and describe what their axes represent.	Understand	CO 3	BSTB02.08
4	What is stress-director surface?	Remember	CO 3	BSTB02.09
5	Give the cubic equation whose three roots are the principal stresses and whose coefficients are the stress-invariants?	Remember	CO 3	BSTB02.09
6	What do we mean by stress invariants? Explain why are they so called?	Remember	CO 3	BSTB02.09
7	Give the expressions for octahedral shear stress?	Remember	CO 3	BSTB02.09
8	Explain what is meant by homogeneous deformation and represent its conditions?	Understand	CO 3	BSTB02.10
8	Give the strain-displacement relations depicting both normal and shear strains.	Remember	CO 3	BSTB02.10
9	Write the three strain invariants, give their expressions.	Remember	CO 3	BSTB02.10
10	Write the equations of equilibrium of the elemental tetrahedron, with three edges along the x, y and z-axes.	Remember	CO 3	BSTB02.10
11	Write the differential equations of equilibrium at a point in an elastic body.	Understand	CO 3	BSTB02.11
12	Give the boundary conditions associated with the differential equations of equilibrium.	Remember	CO 3	BSTB02.11
13	Give the differential relations of the conditions of compatibility.	Remember	CO 3	BSTB02.11
14	Write the stress-compatibility equations in three dimensions, also called Beltrami-Michell equations, when the body forces are constant.	Remember	CO 3	BSTB02.12

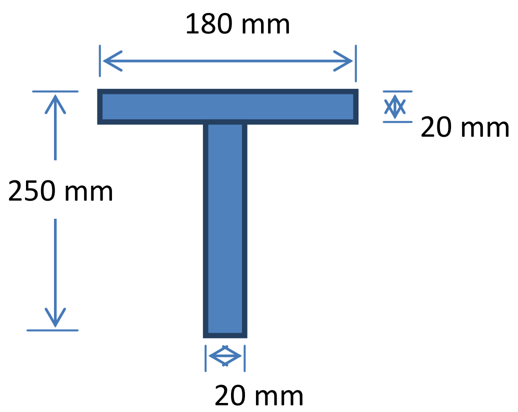
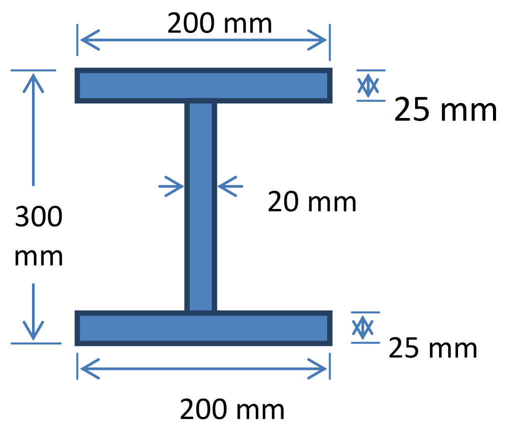
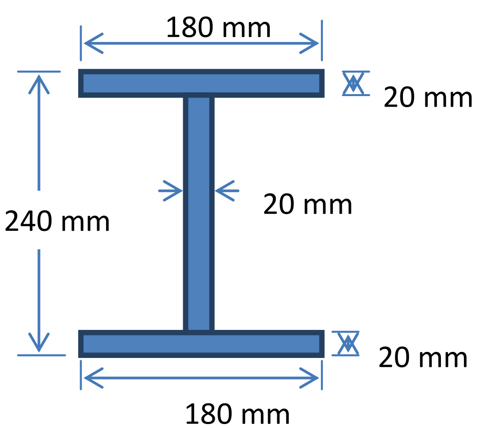
15	Give the equations of equilibrium in terms of displacements, also called as Navier equations for elasticity in solids.	Remember	CO 3	BSTB02.12
16	State the uniqueness theorem associated with the solution of the differential equations of equilibrium.	Remember	CO 3	BSTB02.12
17	Explain the Betti's Reciprocal theorem of displacements used in the theory of elasticity.	Understand	CO 3	BSTB02.12
	Part - B (Long Answer Questions)			
1	A rectangular bar of length a, breadth b and height h is standing under its own weight. Determine the stress distribution in the bar.	Apply	CO 3	BSTB02.08
2	A prismatic bar of 2a x 2b cross-section is bent by two equal and opposite couples. Determine the equations for the bent shape of the prismatic bar.	Apply	CO 3	BSTB02.08
3	Derive the vector form of the equilibrium equations	Apply	CO 3	BSTB02.08
4	Show that for an irrotational deformation of a body, the displacement vector is the gradient of a scalar potential function.	Apply	CO 3	BSTB02.09
5	Derive the expression for the Octahedral shear stress.	Apply	CO 3	BSTB02.09
6	Derive the differential equations of equilibrium in three dimensional cartesian coordinates using a rectangular parallelepiped element.	Understand	CO 3	BSTB02.10
7	Derive the conditions of compatibility in terms of strains in three dimensional cartesian coordinate system.	Understand	CO 3	BSTB02.10
8	Derive the conditions of compatibility in terms of stresses in three dimensional cartesian coordinate system from the strain compatibility equations.	Understand	CO 3	BSTB02.11
9	Derive the Navier equations in elasticity, which are the equations of equilibrium in terms of displacements.	Understand	CO 3	BSTB02.11
10	Explain the principle of superposition applicable for the body and surface forces in the differential equations of equilibrium.	Understand	CO 3	BSTB02.12
Part - C (Problem Solving and Critical Thinking Questions)				
1	Derive the expression for normal stress on the inclined plane on an elemental tetrahedron, which has three faces along the coordinate planes.	Analyze & Evaluate	CO 3	BSTB02.08
2	Derive the equation for obtaining the principal stresses for a three dimensional stress system.	Analyze & Evaluate	CO 3	BSTB02.08
3	Derive the expressions for the displacements of a prismatic bar by its own self-weight considering a three dimensional stress system	Analyze & Evaluate	CO 3	BSTB02.09
4	Derive the equations of equilibrium of a stressed element in cylindrical coordinates.	Analyze & Evaluate	CO 3	BSTB02.09
5	Derive the expressions for the components of the rotation vector.	Analyze & Evaluate	CO 3	BSTB02.10
6	The state of strain at a point within a material is given by: $$\begin{bmatrix} 200 & 100 & 0 \\ 100 & 300 & 400 \\ 0 & 400 & 0 \end{bmatrix} \times 10^{-6}$$ For E = 200 GPa and G = 80 GPa, ascertain the components of stress tensor.	Apply	CO 3	BSTB02.10
7	The state of stress at a point is given by $$\sigma_x = 100, \sigma_y = 200, \quad \sigma_z = -100$$ $$\tau_{xy} = -200, \quad \tau_{yz} = 100, \quad \tau_{zx} = -300 \text{ kPa.}$$ Determine the principal stresses and the direction cosines of the principal planes.	Apply	CO 3	BSTB02.11
8	The state of strain at a point is given by $$\varepsilon_x = 0.001, \varepsilon_y = -0.003, \varepsilon_z = 0.002,$$	Apply	CO 3	BSTB02.11

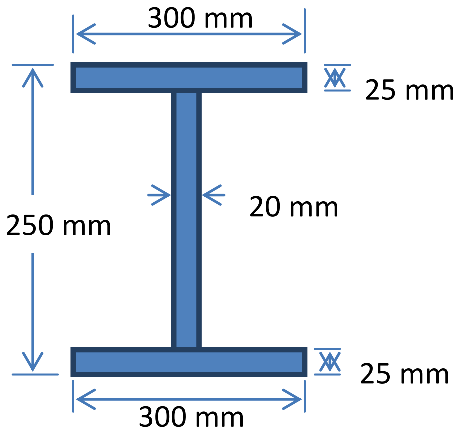
	$\gamma_{xy} = 0.001, \gamma_{yz} = 0.0005, \gamma_{yz} = -0.002$ Determine the strain invariants and the prinicipal strains.			
9	The given displacement components are: $u_x = cx(y+z)^2, u_y = cy(x+z)^2, u_z = cz(x+y)^2$, where c is a constant. Find (a) the components of linear strain. (b) the components of rotation.	Apply	CO 3	BSTB02.12
10	The displacement field in a body is specified as: $u_x = (x^2+3) \times 10^{-3}$ $u_y = 3y^2 z \times 10^{-3}$ $u_z = (x+3z) \times 10^{-3}$ Determine the strain components at a point whose co-ordinates are (1, 2, 3)	Apply	CO 3	BSTB02.12
UNIT – IV				
TORSION OF PRISMATIC BARS:				
Part - A (Short Answer Questions)				
1	Give the torsion equation for circular cross-section and explain its terms.	Remember	CO 4	BSTB02.13
2	Write the Poisson's equation for torsion of prismatic bars of non-circular cross-sections, explaining the various terms.	Remember	CO 4	BSTB02.13
3	Write the expressions for the angle of twist and the torsional rigidity for a bar of elliptical cross-section, with major and minor axes of 2a and 2b, respectively.	Understand	CO 4	BSTB02.14
4	For a bar of cross-section of an equilateral triangle of side 'a', what is the relationship between torque, T, and angle of twist per unit length? G is the modulus of rigidity.	Remember	CO 4	BSTB02.14
5	State and explain the Bredt's formula for torsion of thin walled tubes.	Remember	CO 4	BSTB02.15
6	Write the simple bending equation for symmetrical cross-sections of a beam.	Remember	CO 4	BSTB02.16
7	Give the governing differential equation of bending of a cantilever by load P at its free end, when the cantilever has a non-uniform cross-section.	Understand	CO 4	BSTB02.17
8	Give the governing differential equation of bending of a bar of circular cross-section in terms of stress functions	Remember	CO 4	BSTB02.18
9	Give the governing differential equation of bending of a bar of an elliptical cross-section in terms of stress functions	Remember	CO 4	BSTB02.19
10	Give the governing differential equation of bending of a bar of a rectangular cross-section in terms of stress functions	Understand	CO 4	BSTB02.20
	Part - B (Long Answer Questions)			
1	Using St. Venant's theory derive the Poisson's equation for torsion of prismatic bars of non-circular cross-sections.	Understand	CO 4	BSTB02.13
2	Derive the expressions for the angle of twist and the torsional rigidity for a bar of elliptical cross-section, with major and minor axes of 2a and 2b, respectively.	Understand	CO 4	BSTB02.13
3	Derive the relationship between torque, T, and angle of twist per unit length for a bar of cross-section of an equilateral triangle of side 'a'.	Remember	CO 4	BSTB02.14
4	Derive the torsion equation of a thin rectangular section..	Understand	CO 4	BSTB02.14
5	Derive the torsion equation of a hollow cylinder.	Understand	CO 4	BSTB02.15
6	Derive the simple bending equation for symmetrical cross-sections	Understand	CO 4	BSTB02.16

	of a beam.			
7	Derive the governing equation of bending of a cantilever, with a non-uniform cross-section, subjected to load P at its free end.	Understand	CO 4	BSTB02.17
8	Derive the governing differential equation of bending of a bar of circular cross-section in terms of stress functions	Understand	CO 4	BSTB02.18
9	Derive the governing differential equation of bending of a bar of an elliptical cross-section in terms of stress functions	Remember	CO 4	BSTB02.19
10	Derive the governing differential equation of bending of a bar of a rectangular cross-section in terms of stress functions	Understand	CO 4	BSTB02.20
Part - C (Problem Solving and Critical Thinking Questions)				
1	A square shaft rotating at 250 rpm, transmits torque to a crane which is designed to lift maximum load of 150 kN at a speed of 10m/min. If the efficiency of crane gearing is 65% estimate the size of the shaft for the maximum permissible shear stress of 35MPa. Also calculate the angle of twist of the shaft for a length of 3m. Take G=100 GPa.	Apply	CO 4	BSTB02.14
2	A 300 mm steel beam with flanges and web 12.5mm thick, flange width 300mm is subjected to a torque of 4 kN m. Find the maximum shear and angle of twist per unit length. G =100 GPa.	Apply	CO 4	BSTB02.14
3	An elliptical shaft of semi axes a = 0.05 m, b = 0.025m and G = 80 GPa is subjected to a twisting moment of 1200 π Nm. Determine the maximum shearing stress and the angle of twist per unit length.	Apply	CO 4	BSTB02.15
4	A hollow aluminium section of external dimensions 100 mm x 50 mm and thickness 5 mm is designed for a maximum shear stress of 35 Mpa. Find the maximum permissible twisting moment for this section and the angle of twist under this moment per metre length. G = 28 GPa.	Apply	CO 4	BSTB02.15
5	A hollow circular torsion member has an outside diameter of 22mm and inside diameter of 18mm, with mean diameter D = 20mm and t/D=0.10. Calculate the torque and angle of twist per unit length if shearing stress at mean diameter is 70MPa. Calculate these values if a cut is made through the wall thickness along the entire length. G = 77.5 GPa.	Apply	CO 4	BSTB02.15
6	A prismatic bar of length 5m and a rectangular cross-section of 80mm x100mm is fixed at one end as a cantilever. At the free end, 1 kN load acting in the plane of the cross-section but inclined at 30^o to the vertical is applied. Determine the maximum stress in the cantilever beam.	Apply	CO 4	BSTB02.16
7	A prismatic bar of circular cross-section of radius 25 mm is subjected to a terminal load of 5 kN. Determine the stresses in the bar at the end of the horizontal diameter. Compare the result with the elementary solution. Assume poisson’s ratio = 0.3.	Apply	CO 4	BSTB02.17
8	A prismatic bar of elliptical cross-section has its semi-minor axes as40 mm and 20 mm respectively. This bar is subjected to an end loadof 2500 N. Determine the stresses in the bar at the end of major and minor axes. Assumepoisson’s ratio = 0.28.	Apply	CO 4	BSTB02.18
9	A prismatic bar of rectangular cross-section 50 mm x 30 mm issubjected to an end load of 4500 N. Determine the stresses at thecentre of the bar and the corner. Assume ν = 0.3	Apply	CO 4	BSTB02.19
10	A rectangular beam 120 mm x 100 mm is 3 min length and is simplysupported at the ends. It carries a load of 5 kN at mid-span inclined at 45° with the vertical axis and passing through the centroid.Determine the maximum bending stress in the beam.	Apply	CO 4	BSTB02.20

UNIT – V				
PLASTIC DEFORMATION:				
Part - A (Short Answer Questions)				
1	What is meant by yield criteria in the theory of plasticity?	Remember	CO 5	BSTB02.22
2	Give the yield conditions in the theory of plasticity?	Remember	CO 5	BSTB02.22
3	Give the assumptions in plastic analysis.	Understand	CO 5	BSTB02.21
4	What are residual stresses in plastic bending?	Remember	CO 5	BSTB02.21
5	Define shape factor and load factor?	Remember	CO 5	BSTB02.21
6	What is a plastic hinge?	Understand	CO 5	BSTB02.21
7	Give the Tresca's yield criteria in the theory of plasticity	Remember	CO 5	BSTB02.21
8	Give the Von-Mises yield criteria.	Understand	CO 5	BSTB02.22
9	What are the tangent and plastic moduli?	Remember	CO 5	BSTB02.22
10	Define the Plastic hinge and Plastic Moment Capacity in plastic analysis of beams	Remember	CO 5	BSTB02.21
	Part - B (Long Answer Questions)			
1	Explain the Tresca's yield criteria giving the diagram of the yield envelop.	Understand	CO 5	BSTB02.22
2	Explain the Mises's yield criteria giving the diagram of the yield envelop.	Understand	CO 5	BSTB02.22
3	Explain the various flow models of plasticity: perfectly plastic, elastoplastic and strain hardening.	Remember	CO 5	BSTB02.21
4	State and explain the Bauschinger effect.	Understand	CO 5	BSTB02.21
5	Derive the expression for shape factor for a rectangular beam cross-section.	Understand	CO 5	BSTB02.21
6	Derive the expression for shape factor for a circular beam cross-section.	Remember	CO 5	BSTB02.21
7	Derive the expression for shape factor for a triangular beam cross-section.	Understand	CO 5	BSTB02.21
8	Derive the expression for shape factor for a symmetric I -section.	Understand	CO 5	BSTB02.22
9	Draw and comparatively explain the conventional or engineering stress-strain diagram and true stress – true strain diagram.	Remember	CO 5	BSTB02.22
10	Derive the relationship between true strain and the conventional linear strain.	Understand	CO 5	BSTB02.22
	Part - C (Problem Solving and Critical Thinking Questions)			
1	A tensile specimen with a 12 mm initial diameter and 50 mm gauge length reaches maximum load at 90 kN and fractures at 70 kN. The maximum diameter at fracture is 10 mm. Determine engineering stress at maximum load (the ultimate tensile strength), true fracture stress, true strain at fracture and engineering strain at fracture.	Apply	CO 5	BSTB02.21
2	Stress analysis of a structural member gives the state of stress shown below. If the part is made from aluminium alloy whose yield stress, σ = 500 MPa, will it exhibit yielding as per Von Mises criteria? If not, what is the safety factor?	Apply	CO 5	BSTB02.21

				
3	Use the maximum-shear-stress criterion to establish whether yielding will occur for the stress state shown in the figure. 	Apply	CO 5	BSTB02.21
4	Calculate the shape factor of the T-section as shown in the figure. The yield stress, f_y = 250 N/mm^2. 	Apply	CO 5	BSTB02.22
5	Calculate the shape factor of the T-section as shown in the figure. The yield stress, f_y = 300 N/mm^2. 	Apply	CO 5	BSTB02.22

6	Calculate the shape factor of the T-section as shown in the figure. The yield stress, $f_y = 275\ N/mm^2$. 	Apply	CO 5	BSTB02.22
7	Calculate the shape factor of the I-section as shown in the figure. The yield stress, $f_y = 250\ N/mm^2$. 	Apply	CO 5	BSTB02.22
8	Calculate the shape factor of the I-section as shown in the figure. The yield stress, $f_y = 200\ N/mm^2$. 	Apply	CO 5	BSTB02.22
9	Calculate the shape factor of the I-section as shown in the figure. The yield stress, $f_y = 300\ N/mm^2$.	Apply	CO 5	BSTB02.22

				
10	Draw and comparatively discuss the yield loci for Tresca's (Maximum shear stress) and Von Mises yield criteria.	Apply	CO 5	BSTB02.22

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