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B.M.S. College of Engineering, Bengaluru-560019

Autonomous Institute Affiliated to VTU

May 2023 Semester End Make-Up Examinations

Programme: B.E. **Semester: V**
Branch: Civil Engineering **Duration: 3 hrs.**
Course Code: 20CV5PETOE **Max Marks: 100**
Course: Theory of Elasticity **Date: 17.05.2023**

Instructions: 1. Answer any FIVE full questions, choosing one full question from each unit.
2. Missing data, if any, may be suitably assumed.

UNIT - I

1 a) The components of stress at a point are: σ_x = 20 N/mm^2, σ_y = -40 N/mm^2, σ_z = 80 N/mm^2, τ_{xy} = 40 N/mm^2, τ_{yz} = -60 N/mm^2, τ_{zx} =20 N/mm^2. Determine (a) The principal stresses at the point (b) Deviatoric and spherical stress tensors. **10**

b) When the stress tensor at a point with reference to axes (x, y, z) is given by the array, $\begin{bmatrix} 9 & 6 & 3 \\ 6 & 5 & 2 \\ 3 & 2 & 4 \end{bmatrix}$ MPa **10**
show that by transformation of the axes by 45^0 about the z-axis, the stress invariants remain unchanged.

UNIT - II

2 a) The following strains were measured in a structure during the test by means of 45^o strain rosette, ε_0 = 700 x 10^{-6}, ε_{45} = -100 x 10^{-6} and ε_{90} = 200 x 10^{-6}. Determine the magnitude and direction of principal strains. **10**

b) The displacement field imposed at a point in a body is given by u = 0.01xy + 0.02y^2, v = 0.02x^2 + 0.01z^{3}y, w = 0.01xy^2 + 0.05z^2. **10**
Obtain the strain components at the point (3, 2, -5). What is the octahedral normal and shearing strains.

UNIT - III

3 a) Explain plane-stress and plane-strain conditions. Give examples. Derive stress strain relation for plane-stress condition. **10**

b) A square plate with 800 mm sides parallel to the x and y-axes has a uniform thickness of 10 mm and is made of an isotropic steel (E = 82.6 GPa and μ = 0.29). The plate is subjected to plane strain state. If $\sigma_x = \sigma_1$ = 500 MPa and $\varepsilon_x = 2\varepsilon_y$, determine the magnitude of $\sigma_y = \sigma_2$ and $\sigma_z = \sigma_3$, assuming linearly elastic conditions. **10**

UNIT - IV

4 a) Show that for a cantilever beam, length L, depth h and unit width, loaded by a concentrated load at free end, the Airy's stress function ø = A (xy^3–3/4 xyh^2) is satisfying the loading condition. Find the stresses in the beam. **10**

b) Derive the biharmonic equation in Cartesian coordinates for a two-dimensional plane stress state neglecting body forces. Use Airy's stress function. **10**

OR

5 a) The following are the Airy's stress functions, figure out what problems they solve by calculating the stresses. Plot the stress variations along the x and y directions. **08**

i. ø = axy^3
ii. ø = bxy
iii. ø = axy^3+bxy
iv. ø = ay^3

b) Show that the Airy's stress function, ø = a/6 xy^3+cxy represents stress distribution in a simply supported beam subjected to central concentrated load. The cross-section of the beam is b x 2h. where '2h' is the depth of the beam. **12**

UNIT - V

6 a) A thick cylinder of inner radius 10 cm and outer radius 15 cm is subjected to an internal pressure of 12 MPa. Determine the radial and hoop stresses in the cylinder at the inner and outer surfaces. **10**

b) Given the stress function in polar coordinates determine the stress components and check for compatibility. **10**

$$\phi = \frac{P}{\pi} r\theta \cos\theta$$

OR

7 Show that the maximum stress concentration for an infinite plate with a circular hole $\sigma_\theta = 3\sigma_0$ when the plate is subjected to uniform tension far away from the hole. **20**

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