M. E. MECHANICAL ENGINEERING FIRST YEAR FIRST SEMESTER EXAMINATION - 2024

SUBJECT: THEORY OF ELASTICITY

Time: 3 Hours **Full Marks: 100**

Notations/Symbols carry its usual meaning
Any missing data/information may be assumed with suitable justification

ALL QUESTIONS CARRY EQUAL MARKS
ANSWER ANY FOUR QUESTIONS

Q1. **[10+8+7]**

(a) Derive Cauchy's formula for determining components of stress vector at any arbitrary direction.

(b) Show that the stress surface of Cauchy completely defines the state of stress at a point.

(c) Derive the governing equations for finding principal stresses and the corresponding principal directions.

Q2. **[5+8+12]**

(a) Derive the linear components of strain in rectangular Cartesian coordinates (x, y).

(b) Derive the differential equations of equilibrium in rectangular Cartesian coordinate system.

(c) Show that the normal strain (ε) at any point in any given direction (direction cosines: l, m, n) is given by, $\varepsilon = \varepsilon_{xx} l^2 + \varepsilon_{yy} m^2 + \varepsilon_{zz} n^2 + \gamma_{xy} lm + \gamma_{yz} mn + \gamma_{xz} ln$.

Q3. **[7+12+6]**

(a) Derive the compatibility relations in terms of strain in rectangular Cartesian coordinates.

(b) Show that Airy's stress function satisfies the biharmonic equation for plane elastic problems. Considering a suitable second degree polynomial for Airy stress function, determine and explain the stress fields for plane elastic problems.

(c) Explain plane stress problems of elasticity.

[Turn over

Q4. **[15+10]**

(a) For torsion problem of straight prismatic bars, show that the warping function ψ satisfies the following equation: $\frac{\partial^2 \psi}{\partial x^2} + \frac{\partial^2 \psi}{\partial y^2} = 0$.

(b) Considering a suitable stress function, derive the stress fields of a narrow section cantilever beam loaded by a point force at the free end.

Q5. Write short notes on the following (Any five): **[5 × 5]**

(a) State of stress.

(b) Lame's stress ellipsoid.

(c) Hydrostatic state of stress.

(d) Volumetric strain.

(e) Field equations of elasticity in two-dimensional field.

(f) Saint Venant's principle

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