



MAULANA ABUL KALAM AZAD UNIVERSITY OF TECHNOLOGY, WEST BENGAL

Paper Code : PC-ME502 Solid Mechanics

Time Allotted : 3 Hours

Full Marks :70

The Figures in the margin indicate full marks.

Candidate are required to give their answers in their own words as far as practicable

Group-A (Very Short Answer Type Question)

1. Answer any ten of the following :

[1 x 10 = 10]

(i) How many elements are there in C_{ijklm} ?

$$\sigma_{ij} = C_{ijkl} \epsilon_{kl}$$

- (ii) In axi-symmetric problem, in which direction the stresses remained unchanged
- (iii) In rotating disc cause of elastic deformation is
- (iv) The strain energy of a rod of cross section A, length L, Load P and Elastic Modulus E
- (v) How many effective Components are there in Stress Tensor?
- (vi) How many set of equations constitute Generalized Hooke's Law for Homogeneous & isotropic medium?
- (vii) Forging process is an example of Plane Stress/ strain problem?
- (viii) Prandtl stress function forms a second order differential equation, is called
- (ix) Castigliano's second Theorem find the _____ from strain Energy
- (x) The ratio of E/G
- (xi) The principal components of stresses are -100Mpa, 100MPa and 200 MPa. The dimension of bigger Mohr's Circle is if 1Mpa=1cm
- (xii) λ and μ in the equation are known as?

$$\sigma_{ij} = \lambda \delta_{ij} \epsilon_{kk} + 2\mu \epsilon_{ij}$$

Group-B (Short Answer Type Question)

Answer any three of the following

[5 x 3 = 15]

- 2. Draw a cuboid and show all stress tensor on that with proper directions. [5]
- 3. What is Superposition Theorem in Elasticity? What is Saint Venant's Principle? Clear with Example. [5]
- 4. Prove that $E=2G(1+\text{Poisson's Ratio})$ where E & G are Elastic and Shear Modulus respectively. [5]
- 5. Find the Airy's stress function for 2D plate undergoing normal stress in X and Y- direction respectively with a shear. [5]
- 6. compute the stress tensor [5]

Show that $\phi = x_1^4 x_2 + 4x_1^2 x_2^3 - x_2^5$ is a valid Airy stress function, that is, that $\nabla^4 \phi = 0$, and compute the stress tensor for this case assuming a state of plane strain with $\nu = 0.25$.

Group-C (Long Answer Type Question)

Answer any three of the following

[15 x 3 = 45]

7. a) Find an expression for 2D compatibility equation in terms of stresses.
 b) Find an expression Cubic Equation for find out principal stresses from a given stress tensor.
8. (a) Derive Navier's Equation from Stress Equilibrium equations?
 (b) Find the constant C_1 , C_2 and C_3 in the displacement field

[7]

[8]

Consider a problem with body forces given by

$$\mathbf{f} = \begin{bmatrix} f_1 \\ f_2 \\ f_3 \end{bmatrix} = \begin{bmatrix} -6Gx_2x_3 \\ 2Gx_1x_3 \\ 10Gx_1x_2 \end{bmatrix},$$

where $G = \frac{E}{2(1+\nu)}$ and $\nu = 1/4$.

Assume displacements given by

$$\mathbf{u} = \begin{bmatrix} u_1 \\ u_2 \\ u_3 \end{bmatrix} = \begin{bmatrix} C_1x_1^2x_2x_3 \\ C_2x_1x_2^2x_3 \\ C_3x_1x_2x_3^2 \end{bmatrix}.$$

[4+4+4+3]

9. A stress Tensor is given by,
- Find the stress Invariants
 - Find the Principal stresses
 - Draw the Mohr's Cicles
 - Find Direction of Maximum Principal stresses

$$\tau_{ij} = \begin{pmatrix} 200 & 100 & 300 \\ 100 & 0 & 0 \\ 300 & 0 & 0 \end{pmatrix} Pa$$

10. Determine the stress function for Axi-symmetric problem with respect to function of radial distance r .
11. Determine the stress function and shear stresses of an elliptical cross section of semi major axis a and semi-minor axis b <https://www.makaut.com>

[15]

[15]

The elliptical cross section shown is transmitting a torsional moment T .

(a) Determine the stress function, the shear stress equations, the maximum shear stress and its location, and the angle of twist per unit length.

(b) Determine the maximum shear stress and angle of twist per unit length if $a = 10 \text{ mm}$, $b = 20 \text{ mm}$, $T = 400 \text{ N}\cdot\text{m}$, $E = 200 \text{ GPa}$, and $\nu = 0.3$.

*** END OF PAPER ***