Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S4 (S, FE) / S2 (PT) (S, FE) Examination May 2023 (2015 Scheme)

Course Code: ME202

Course Name: ADVANCED MECHANICS OF SOLIDS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer any three questions. Each question carries 10 marks.

1 a) At a point in a loaded member, the stresses relative to an x, y, z coordinate system are given by (6)

$$[\sigma] = \begin{bmatrix} 60 & 20 & 10 \\ 20 & -40 & -5 \\ 10 & -5 & 30 \end{bmatrix} (MPa)$$

Calculate the principal stresses.

b) For the above state of stress, determine the stress components and stress invariants relative to the coordinate system (x', y', z') defined by rotating x, y axes through an angle of 30^0 counterclockwise about the z- axis as shown in Fig.1 (4)

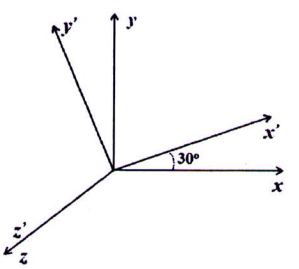

Fig.1

2 a) The state of stress at a point P in a loaded body in Cartesian co-ordinate system is given as (4)

$$[\sigma] = \begin{bmatrix} 40 & 40 & 30 \\ 40 & 20 & 0 \\ 30 & 0 & 20 \end{bmatrix} (MPa)$$

Determine the normal stress and shearing stress on a plane whose outward normal is oriented at angles of 40^0, 75^0, 54^0 with the x, y, and z axes respectively.

b) Define displacement field, and write the strain tensor elements in terms of displacement. (3)

c) Check whether the following system of plane strains is compatible at (1, 0, -1) (3)

$\varepsilon_x = 5xy + 6z$, $\varepsilon_y = 2xy^2$ and $\gamma_{xy} = 2xy^2$

3 a) Write the stress-strain relations for plane stress and plain strain problem. (3)

b) Obtain the expression for stress compatibility equation for a plane stress from the 2D equilibrium equation. (7)

4 Derive the bending and shear stress distribution in a cantilever beam loaded at its free end by Airy's stress function method. (10)

PART B

Answer any three questions. Each question carries 10 marks

5 a) For an infinite plate with a circular hole under uniaxial tension, write the expression for stress distribution ($\sigma_{\theta\theta}$) and plot it for the plane perpendicular to the loading direction. (3)

b) Derive the equilibrium equation in radial direction in polar co-ordinate system. (7)

6 A thick cylinder with 100 mm inside diameter, and a 200 mm outer diameter is subjected to an internal pressure of 60 MPa. Determine the tangential stress at the inside and outside surfaces, (ii) plot the radial and tangential stress distribution across the thickness (iii) Determine the increase in inside radius if the material is steel with for which E = 210 GPa and Poisson's ratio = 0.3. (10)

7 a) Define shear center. Determine the shear center (e) of a uniform thickness channel section shown in Fig. 2. Given b = 10 cm, web and flange thickness = 1 cm and h = 15 cm. (4)

b) Determine the circumferential stress at points A and B of the crane hook of rectangular cross section shown in the Fig. 3. (6)

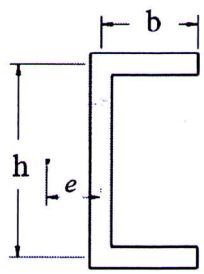

Fig. 2

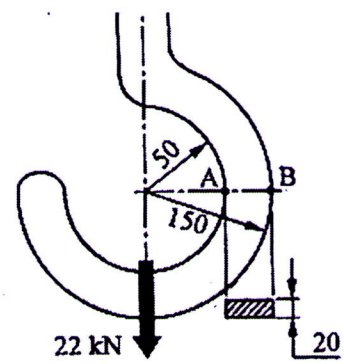

Fig. 3

8 a) What do you mean by unsymmetrical bending? Explain with an example. (4)

b) Derive the expression for strain energy due to torque in a circular bar. (6)

PART C

Answer any four questions. Each question carries 10 marks.

9 a) State and explain Maxwell's reciprocal theorem. (4)

b) State and explain minimum potential energy theorem. (6)

10 A cantilever beam of length L supports a uniformly distributed load w *(per unit length)* and a concentrated load P at the free end. (10)

(i) Obtain the expression for deflection at the free using Castigliano's theorem

(ii) Determine the deflection at the free end for the given parameters;

L = 2 m, w = 6 kN/m, P= 8 kN and EI = 5 MN-m^2.

11 a) Explain the principle of virtual work (3)

b) Obtain an expression for vertical deflection of point B of the structure if a vertical force P is applied as shown in the Fig. 4. The cross-sectional area of the members BC and BD of equal length (l) be A and take the Young's Modulus of the material as E. (7)

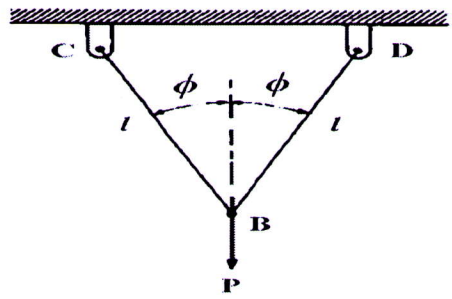

Fig. 4

12 Formulate the governing equation and boundary condition for torsion of a non-circular section using Saint Venant's method. Also write the assumptions made. (10)

13 a) Describe membrane analogy (4)

b) How can the torsion of thin rectangular section be extended for the analysis of rolled sections under torsion? Explain. (6)

14 A multi-cell aluminum structure made of thin sections as shown in Fig. 5. The uniform wall thickness is 3 mm. If a pure torque (T) of 12 N-m is applied to the section, determine the shear stresses in the thin webs and angle of twist per unit length. (G = 28 GPa). (10)

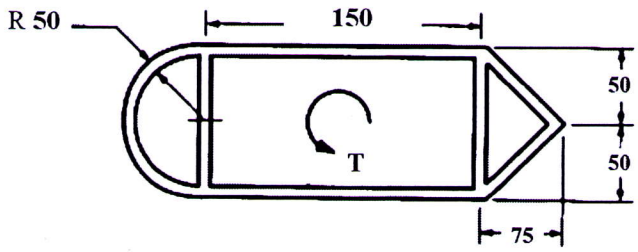

Fig. 5

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