CBCS SCHEME

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18ME32

Third Semester B.E. Degree Examination, Jan./Feb. 2023
Mechanics of Materials

Time: 3 hrs. Max. Marks: 100

Note: Answer any FIVE full questions, choosing ONE full question from each module.

Module-1

1 a. Derive an expression for extension of the uniformly tapered rectangular bar subjected to an axial load. **(10 Marks)**

b. A steel circular bar has three segments as shown in Fig.Q1(b). Determine :
(i) The total elongation of the bar
(ii) The length of the middle segment to have zero elongation of the bar.
Take $E = 2.05 \times 10^5$ N/mm^2.

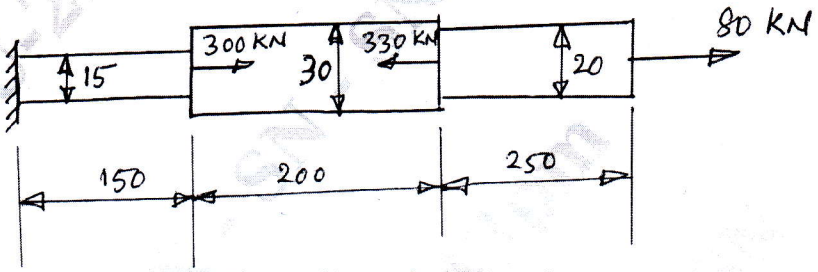

Fig.Q1(b) Dimensions in mm **(10 Marks)**

OR

2 a. Derive relationship between modulus of elasticity and modulus of rigidity. **(10 Marks)**

b. A 15 mm diameter steel rod passes centrally through a copper tube 50 mm external diameter and 40 mm internal diameter. The tube is closed at each end by rigid plates of negligible thickness. If the temperature of the assembly is raised by 60°C, calculate the stresses developed in copper and steel. Neglect the effect of tightening the nut. Take $E_s = 210$ GPa, $E_c = 105$ GPa, $\alpha_s = 12 \times 10^{-6}$/°C, $\alpha_c = 17.5 \times 10^{-6}$/°C. **(10 Marks)**

Module-2

3 a. For the element subjected to biaxial stress state, derive expressions for normal and tangential stresses acting on a plane inclined at an angle θ with the Y-axis. **(10 Marks)**

b. A thin cylindrical shell 2 m long has 200 mm internal diameter and thickness of the metal 10 mm. It is filled completely with a fluid at atmospheric pressure. If an additional 25000 mm^3 fluid is pumped in, find the pressure developed and hoop stress developed. Also find the change in diameter. Take $E = 2 \times 10^5$ N/mm^2 and Poisson's ratio $\frac{1}{m} = 0.3$. **(10 Marks)**

OR

4 a. A point in a machine is subjected to the stresses as shown in Fig.Q4(a). Draw the Mohr's circle and determine:
(i) Stresses on a plane which is at an angle of 60° with respect 80 MPa stress plane.
(ii) Magnitude of principal stresses and their orientations
(iii) Maximum and minimum shear stresses and orientations of their planes.

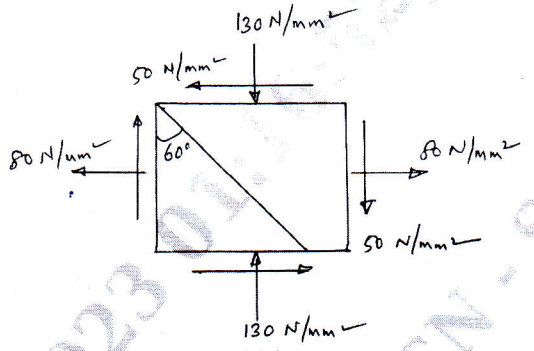

Fig.Q4(a) **(10 Marks)**

b. A thick cylindrical pipe of outside diameter 300 mm and internal diameter of 200 mm is subjected to an internal fluid pressure of 20 N/mm^2 and external fluid pressure of 5 N/mm^2. Determine the maximum hoop stress developed and draw the variation of hoop stress and radial stress across the thickness. **(10 Marks)**

Module-3

5 a. Draw the shear force and bending moment diagrams for the overhanging beam carrying uniformly distributed load of 2 kN/m over the entire length and a point load of 2 kN as shown in Fig.Q5(a). Locate the point of contra flexure.

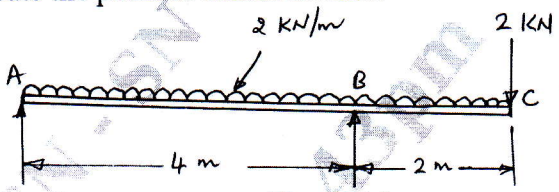

Fig.Q5(a) **(10 Marks)**

b. Derive the equation $\frac{M}{I} = \frac{\sigma_b}{Y} = \frac{E}{R}$ with usual notations. State the assumptions in the derivation. **(10 Marks)**

OR

6 a. Draw the shear force and bending moment diagrams for the cantilever beam shown in Fig.Q6(a).

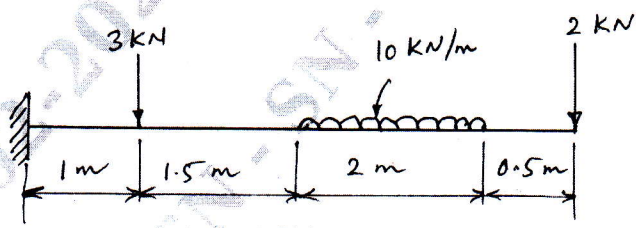

Fig.Q6(a) **(10 Marks)**

b. A beam of an I-section 200 mm × 300 mm has web thickness 10 mm and flange thickness 10 mm. It carries a shearing force of 10 kN at a section. Sketch the shear stress distribution across the section. **(10 Marks)**

Module-4

7 a. Derive the torsion equation $\frac{T}{J} = \frac{\tau}{r} = \frac{G\theta}{L}$ with usual notations. State the assumptions made in the derivation. **(10 Marks)**

b. The load on a bolt consists of an axial pull of 10 kN together with a transverse shear force of 5 kN. Find the diameter of the bolt :
(i) Maximum principal stress theory
(ii) Maximum shear stress theory **(10 Marks)**

OR

8 a. Determine the diameter of a solid shaft which transmits 300 kW at 250 rpm. The maximum shear stress should not exceed 30 N/mm^2 and twist should not be more than 1° in a shaft length of 2 m. Take modulus of rigidity $G = 1 \times 10^5 N/mm^2$. **(10 Marks)**

b. A hollow shaft is to transmit 250 KW power at 100 rpm. If the shear stress is not to exceed 60 MPa and internal diameter is 0.6 times the external diameter, find the external and internal diameters, assuming that the maximum torque is 1.4 times the mean torque. **(10 Marks)**

Module-5

9 a. Derive Euler's buckling equation for a long column when both ends are hinged. Also state the assumptions made in the derivation. **(10 Marks)**

b. Determine the buckling load for a strut of T-section, the flange width being 100 mm, overall depth 80 mm and both flange and stem 10 mm thick. The strut is 3 m long and is hinged at both ends. Take $E = 200 GN/m^2$. **(10 Marks)**

OR

10 a. Derive expressions for strain energy due to: (i) axial load (ii) torsion **(10 Marks)**

b. State and prove Castigliano's first theorem. **(10 Marks)**

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