B.E. METALLURGICAL AND MATERIAL ENGINEERING
FIRST YEAR SECOND SEMESTER EXAM 2019 (Old)

STRENGTH OF MATERIALS **Time : Three hours** **Full Marks : 100**

Answer any ***five*** questions.

All questions carry equal marks.

1. Sketch a representative stress-strain diagram for a ductile material, and explain the following in brief with reference to the diagram: yield point, ultimate tensile strength, toughness.

   A uniform bar [Fig Q-1] is subjected to axial loading where P_1 = 30 kN, P_2 = 20 kN and P_3 = 15 kN. Find the distance x (in metres) where P_1 should be applied so that the net change in length of the bar is zero.

2. Derive the torsion formula for a ductile material, stating necessary assumptions.

   Two close-coiled helical springs of core diameters 10 cm and 7.5 cm are placed vertically and coaxially between rigid plates. The assembly is subjected to an axial compressive force of 1000 N. If the springs are wound from the same wire of diameter 12 mm, and have the same number of coils, determine the maximum shear stress (in MPa) induced in the springs.

3. Sketch the shear force and bending moment diagrams for the beam shown in Fig Q-3, marking important points on the diagram, including point(s) of contraflexure, if any.

4. Prove that the neutral axis of the cross-section of a beam under pure bending passes through the centroid of the section.

   A simply supported beam of span 3 m carries a uniformly distributed load over the entire span. The cross-section of the beam is rectangular with a width of 20 cm and depth of 30 cm. If the maximum normal stress due to bending is 11.5 MPa, calculate the maximum shear stress in MPa.

5. Find the diameter (in mm) of a vertical cylindrical gasoline tank made of 20 mm thick steel plate and subjected to a pressure of 1 MPa, if the allowable stress, factor of safety and joint efficiency are 240 MPa, 3 and 85% respectively.

   Draw Mohr's circle for the state of plane stress shown in Fig Q-5, and find the values of the principal stresses and corresponding aspect angles.

6. Deduce an expression for the critical buckling stress for a column with pinned ends, in terms of its modulus of elasticity and slenderness ratio.

   A cantilever beam fixed at one end is acted upon by a concentrated force at the free end. If the deflection at the midpoint is 2.2×10^{-3} m, find the deflection at the free end in metres.

7. A simply supported beam has a length of 8 m, and a T-shaped cross-section as shown in Fig Q-7. The beam carries a uniformly distributed load of w KN/m. If the maximum permissible bending stresses in tension and compression are 30 MN/m^2 and 45 MN/m^2 respectively, find w.

8. Prove any *two* of the following:

   a) If a solid shaft transmitting certain torque is made hollow with the inner diameter as half the outer, the maximum shear stress will rise by about 6%, while the weight reduction will be by about 25%.

   b) The elongation of a bar hanging under its own weight (W) is half what it would be if the bar was weightless and W was acting at its end.

   c) $dM_x / dx = V_x$, $dV_x / dx = - w$, where the symbols have their usual meaning.

Figures

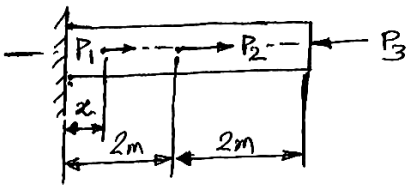

Fig Q-1

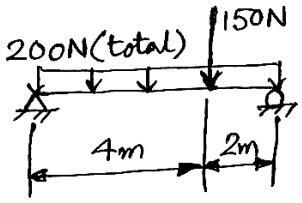

Fig Q-3

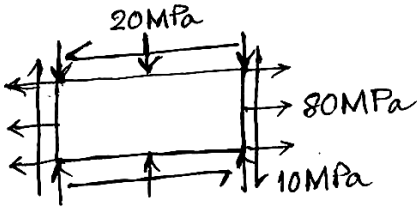

Fig Q-5

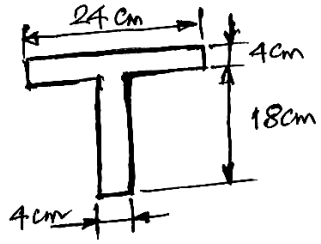

Fig Q-7