Ref. No.: Ex/Met/ES/B/ME/T/213/2025

B.E. METALLURGICAL ENGINEERING SECOND YEAR FIRST SEMESTER EXAMINATION - 2025

SUBJECT: STRENGTH OF MATERIALS

Time: 3 Hours **Full Marks: 100 (10× 10)**

Any missing data may be assumed with suitable justification
The symbols/notations carry its usual meanings
For question Q9, the figure should be drawn in GRAPH PAPER

ANSWER ANY TEN QUESTIONS
(All Questions Carry Equal marks)

Q1. Both portions of the rod *ABC* (see **Fig. Q1**) are made of an aluminum for which E = 70 GPa. Knowing that the magnitude of P is 4 kN, determine (*a*) the value of Q so that the deflection at *A* is zero, (*b*) the corresponding deflection of *B*.

Q2. A rigid steel plate is supported by three posts of high strength concrete each having an effective cross-sectional area A = 40,000 mm^2 and length L= 2 m (see **Fig. Q2**). Before the load P is applied, the middle post is shorter than the others by an amount s = 1.0 mm. Determine the maximum allowable load P_{allow} if the allowable compressive stress in the concrete is σ_{allow} = 20 MPa. (Use E = 30 GPa for concrete.)

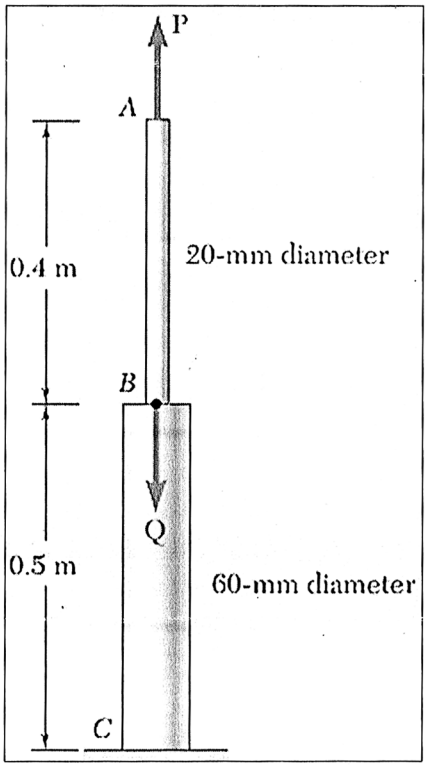

Fig Q1

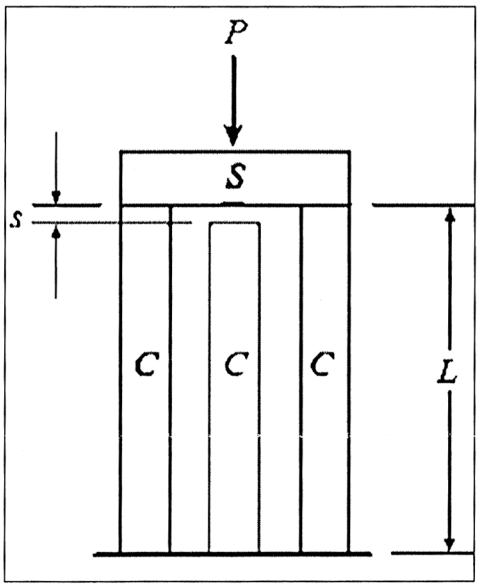

Fig Q2

[Turn over

Q3. The hollow steel shaft shown in **Fig. Q3** (G = 77.2 GPa, τ_{all} = 50 MPa) rotates at 240 rpm. Determine (*a*) the maximum power that can be transmitted, (*b*) the corresponding angle of twist of the shaft.

Q4. A closed-coil helical spring having 24 turns is made of 8 mm diameter wire. The mean diameter of the spring is 80 mm and it carries a load of 250 N. Deducing the necessary relations with neat sketches, determine the shear stress developed in the spring.

Q5. A beam *ABC* with an overhang at one end supports a uniform load of intensity 12 kN/m and a concentrated load of magnitude 2.4 kN (see **Fig. Q5**). Draw the complete shear-force and bending-moment diagrams for this beam.

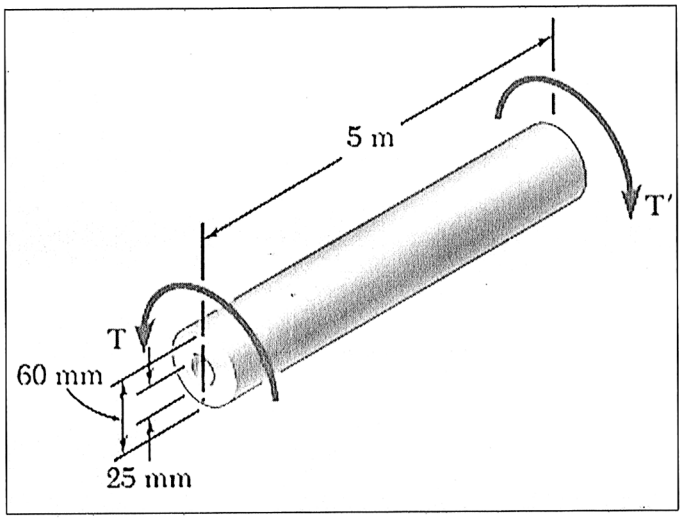

Fig Q3

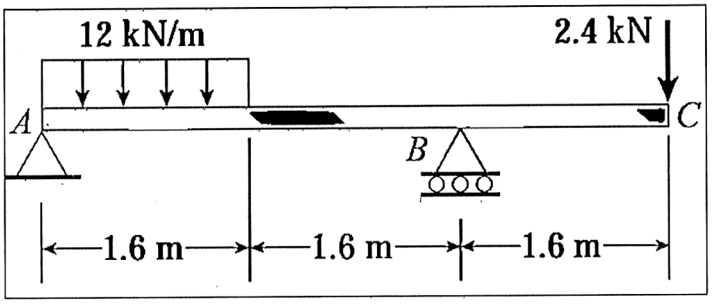

Fig Q5

Q6. Determine the maximum tensile stress (σ_t) and maximum compressive stress (σ_c) resulting from the load *P* applied on the simply supported beam AB with an inverted T-section as its cross-sectional shape (see **Fig. Q6**). Data are as follows: *P* = 5.4 kN, *L* = 3.0 m, *d* = 1.2 m, *b* = 75 mm, *t* = 25 mm, *h* = 100 mm, and h_1 = 75 mm.

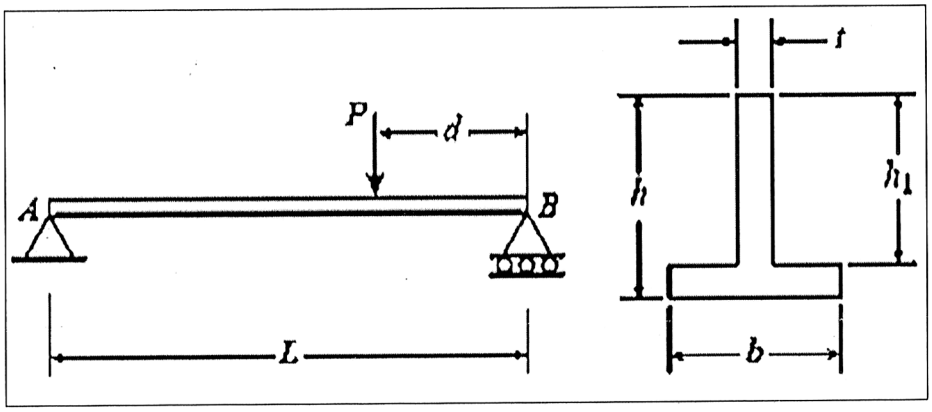

Fig Q6

Q7. For a cantilever beam with flexural rigidity EI and length L, subjected to a concentrated load P at the free end, derive the equation of the elastic curve. Additionally, determine the maximum deflection and the maximum slope.

Q8. Derive Euler's critical load for the fundamental mode of a fixed-free column of length L. Take EI = constant.

Q9. Draw the Mohr's circle on a graph paper for a state of plane stress defined by the following: σ_x = - 50 MPa, σ_y = 30 MPa and τ_{xy} = - 40 MPa. Find the principal stresses and principal planes using Mohr's circle.

Q10. Draw suitable neat sketches and derive the membrane stress equation for an axisymmetric thin-walled pressure vessel subjected to internal pressure.

Q11. Stating the assumptions, derive the following relation for torsion of a uniform cylindrical shaft:

$$\frac{\tau}{\rho} = \frac{T}{J} = \frac{G\phi}{L}.$$

Q12. Answer any two: **[5 × 2 = 10]**

(i) Write short note on Thermal Stress.

(ii) Deduce the expression of deformation of a taper cylindrical bar under uniaxial loading.

(iii) Prove that he maximum shear stress in a rectangular section beam is 1.5 times the average shear stress.

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