Ref. No.: Ex/Che/ES/B/Mech/T/215/2023

B.E. CHEMICAL ENGINEERING SECOND YEAR FIRST SEMESTER EXAMINATION - 2023

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. A uniform and homogenous bar (**Fig.Q1**) 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.

Q2. At room temperature (20^0 C), a 0.5-mm gap exists between the ends of the rods shown in **Fig Q2**. At a later time when the temperature has reached 140^0 C, determine (***i***) the normal stress in the aluminum rod, (***ii***) the change in length of the aluminum rod.

Q3. The aluminum rod *BC* (*G*=26 GPa) is bonded to the brass rod *AB* (*G*=39 GPa) (**Fig. Q3**). Knowing that each rod is solid and has a diameter of 12 mm, determine the angle of twist (***i***) at *B*, (***ii***) at *C*.

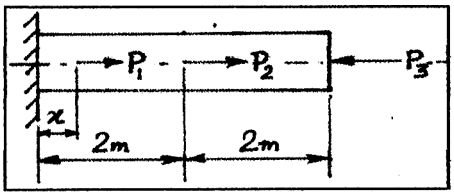

Fig. Q1

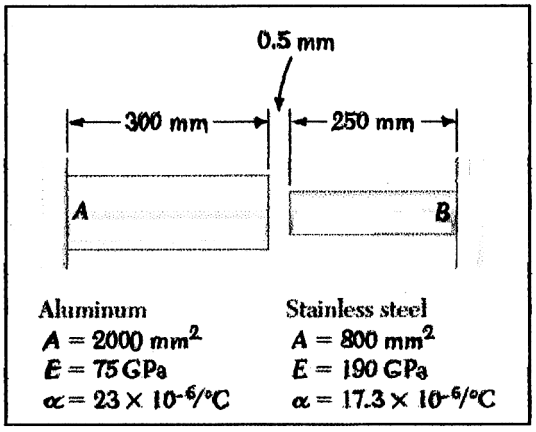

Fig. Q2

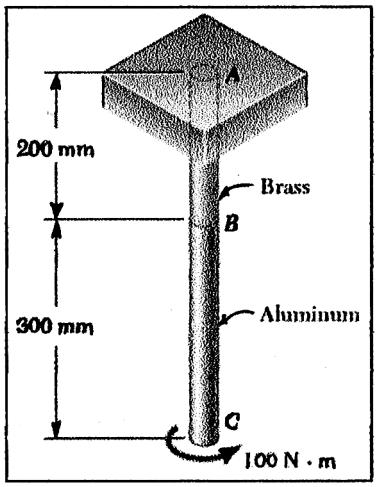

Fig. Q3

Q4. **[6+4]**

(a) Deduce the expression of axial deflection for a close-coiled helical spring under the action of an axial load.

(b) A close-coiled 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. Determine the maximum shear stress developed, the deflection and the stiffness of the spring. Take G = 84 GPa.

Q5. For the beam loaded as shown in **Fig. Q5**, draw the complete shear force and bending moment diagrams by writing appropriate equations.

Q6. The beam shown in **Fig. Q6** is made of a nylon for which the allowable stress is 24 MPa in tension and 30 MPa in compression. Determine the largest couple **M** that can be applied to the beam.

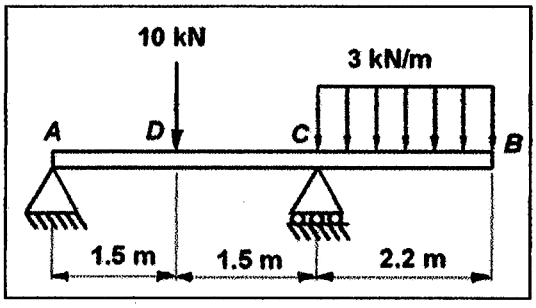

Fig. Q5

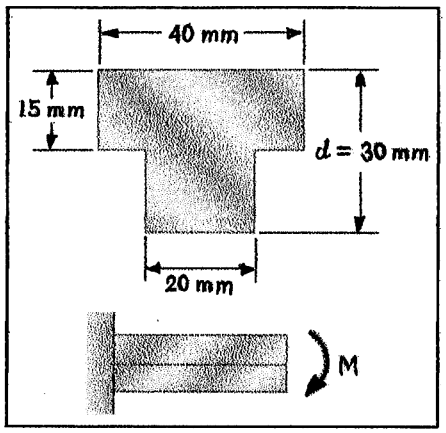

Fig. Q6

Q7. Stating the assumptions, derive the following relation for pure bending of a beam: $\frac{M}{I} = \frac{\sigma_x}{y} = \frac{E}{\rho}$

Q8. A cantilever beam carries a uniformly distributed load of intensity 10 kN/m over its entire span of 9 m. Deducing the necessary relation, find its maximum deflection if the flexural rigidity (EI) is 1.5×10^6 kN-m^2.

Q9. Draw the Mohr's circle on a graph paper for a state of plane stress defined by the following: σ_x = 120 MPa, σ_y = 60 MPa and τ_{xy} = - 45 MPa. Find the principal stresses and principal planes using Mohr's circle.

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

Q11. Derive Euler's critical load for the fundamental mode of a fixed-pinned column of length L. Take EI = constant.

Q12. Answer any two: **[5 × 2 = 10]**

(i) Write a short note on 'Bearing Stress'.

(ii) Establish the relation between bending moment and shear force in beams.

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

X