Ref. No.: Ex/Che/ES/B/Mech/T/215/2024

B.E. CHEMICAL ENGINEERING SECOND YEAR FIRST SEMESTER EXAMINATION - 2024

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 Q10, the figure should be drawn in GRAPH PAPER

ANSWER ANY TEN QUESTIONS
(All Questions Carry Equal marks)

Q1. Rigid beam *AB* rests on the two short posts shown in **Fig. Q1**. *AC* is made of steel (E_{st} = 200 GPa) and has a diameter of 20 mm, and *BD* is made of aluminium (E_{al} = 70 GPa) and has a diameter of 40 mm. Determine the displacement of point *F* on *AB* if a vertical load of 90 kN is applied over this point.

Q2. A rod (**Fig. Q2**) consisting of two cylindrical portions *AB* and *BC* is restrained at both ends. Portion *AB* is made of steel (E_{st} = 200 GPa, α_{st} = 11.7 × 10^{-6}/°C) and portion *BC* is made of brass (E_{br} = 105 GPa, α_{br} = 20.9 × 10^{-6}/°C). Knowing that the rod is initially unstressed, determine the maximum stress developed in the rod when there is a temperature rise of 25°C.

Q3. The solid cylindrical rod *BC* of length *L* = 240 mm is attached to the rigid lever *AB* of length *a* =150 mm and to the support at *C* (**Fig. Q3**). Design specifications require that the displacement of *A* should not exceed 10 mm when a 200 N force *P* is applied at *A*. Determine the required diameter of the rod, knowing that the rod is made of steel with an allowable shearing stress of 90 MPa and a modulus of rigidity of 77.2 GPa.

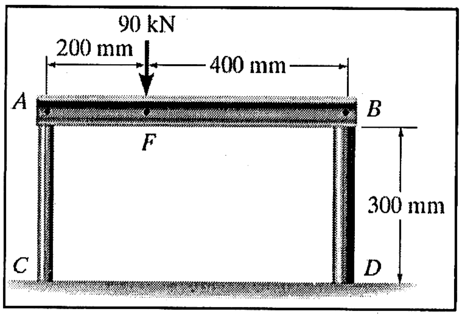

Fig. Q1

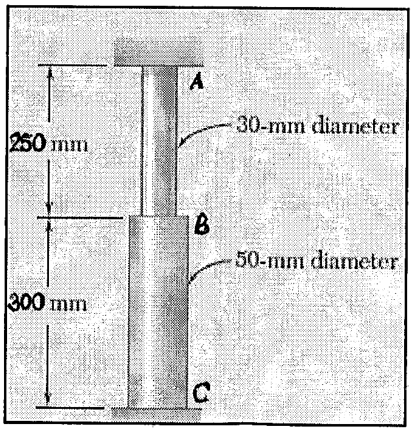

Fig. Q2

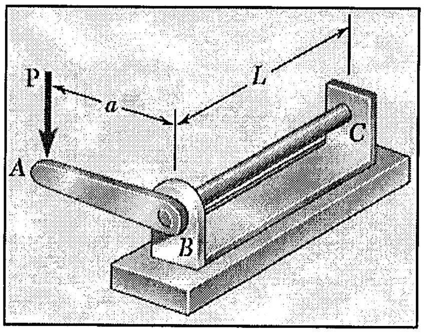

Fig. Q3

Q4. Two steel springs, vertically arranged in series, supports a tensile load *P*. The upper spring has 12 turns of 25 mm diameter wire on a mean radius of 100 mm. The lower spring consists of 10 turns of 20 mm diameter wire on a mean radius of 75 mm. If the maximum shear stress in either spring must not exceed 200 MPa, compute the maximum value of *P* and the corresponding total elongation of the assembly. Use *G* = 83 GPa.

[Turn over

Q5. A beam *ABC* with an overhang at one end supports a uniform load of intensity 12 kN/m and a concentrated moment of magnitude 3 kN-m at *C* (**Fig. Q5**). Draw the complete shear-force and bending-moment diagrams for this beam.

Q6. A timber beam (**Fig. Q6**) *AB* of length *L* and rectangular cross section carries a single concentrated load *P* at its midpoint *C*. Show that the ratio τ_{max}/σ_{max} of the maximum values of the shear and normal stresses in the beam is equal to $h/2L$, where *h* and *L* are, respectively, the depth and the length of the beam.

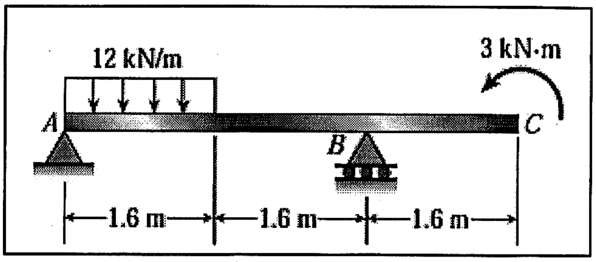

Fig. Q5

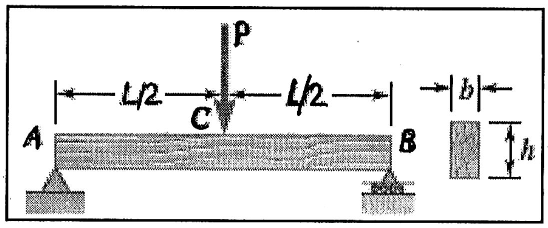

Fig. Q6

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

Q8. For the cantilever beam loaded as shown in **Fig. Q8**, determine the equation of the elastic curve and the maximum deflection.

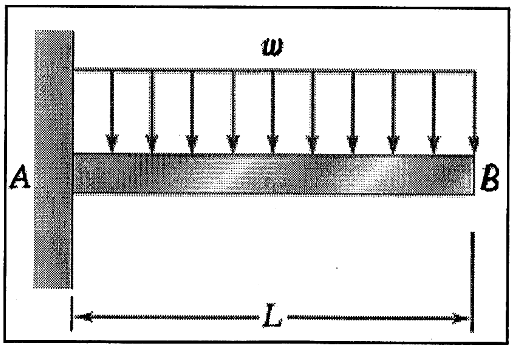

Fig. Q8

Q9. Derive Euler's critical load for the fundamental mode of a fixed-free column of length *L*. Take *EI*=constant.

Q10. **[6+4]**

(a) Draw the Mohr's circle on a graph paper for a state of plane stress defined by the following: σ_x = 150 MPa, σ_y = 30 MPa and τ_{xy} = 80 MPa.

(b) Using the Mohr's circle, find the maximum shear stress and the corresponding normal stress.

Q11. **[6+4]**

(a) Using the governing equation of membrane stresses, find the circumferential stress and longitudinal stress for a thin-walled cylindrical pressure vessel.

(b) A cylindrical pressure vessel is fabricated from steel plating that has a thickness of 20 mm. The outer diameter of the pressure vessel is 450 mm and its length is 2.0 m. Determine the maximum internal pressure that can be applied if the longitudinal stress is limited to 140 MPa, and the circumferential stress is limited to 60 MPa.

Q12. Answer any two: **[5 × 2 = 10]**

(i) Write short note on 'Thermal Stress'.

(ii) Prove that under uniaxial loading of a bar, the maximum shear stress is 0.5 times the uniaxial stress.

(iii) Draw and explain the Euler's curve for long columns.

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