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

B.E. CHEMICAL ENGINEERING 2nd YEAR 1st SEMESTER SUPPLEMENTARY EXAMINATION - 2023

SUBJECT: STRENGTH OF MATERIALS

Time: 3 Hours **Full Marks: 100**

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. The circular section rod ABC is made of Aluminum (**Fig. Q1**) for which $E = 70$ GPa. Knowing that $P = 6$ kN and $Q = 42$ kN, find the stresses in the segments AB and BC.

Q2. A steel railroad track ($E = 205$ GPa, $\alpha = 11 \times 10^{-6}$ /°C) was laid out at a temperature of 24°C. Determine the normal stress in the rail when the temperature reaches 80°C, assuming that the rails (a) are welded to form a continuous track, (b) are 32 m long with 8 mm gaps between them.

Q3. A 2.5 m long steel shaft is to transmit 10 kW at a frequency of 25 Hz. Determine the required diameter of the shaft, knowing that that the allowable shear stress is 30 MPa, and that the angle of twist must not exceed 4°. Take $G = 77.2$ GPa.

Q4. Two steel springs ($G = 83$ GPa) arranged in series as shown in the **Fig. Q4**, supports a 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 shearing stress in either spring must not exceed 200 MPa, compute the maximum value of P, total elongation and equivalent spring stiffness of the assembly.

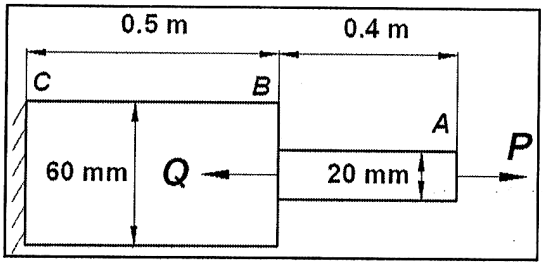


Fig. Q1

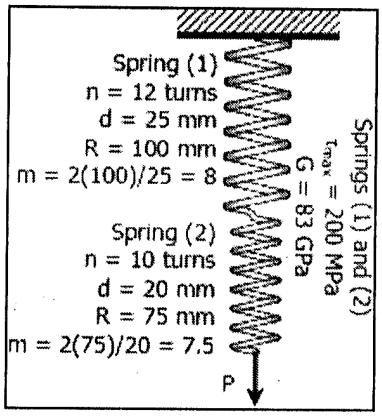


Fig. Q4

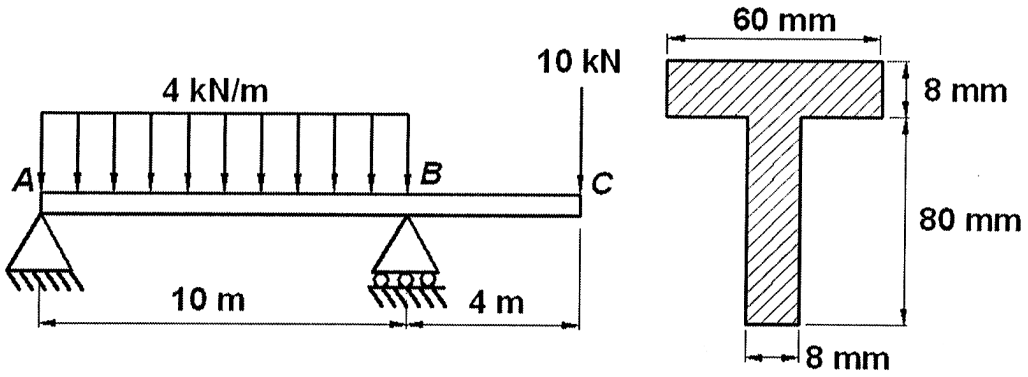
Q5. Stating the assumptions, derive the following relation for pure bending of beams:

$$\frac{M}{I} = \frac{\sigma_x}{y} = \frac{E}{\rho}$$

[Turn over

Q6. For the beam loaded as shown in **Fig. Q6/7(a)**, draw the complete shear force and bending moment diagrams by writing appropriate equations.

Q7. Considering that the beam shown in **Fig. Q6/7(a)** has the T-shaped cross section shown in **Fig. Q6/7(b)**, determine the maximum tensile and compressive bending stresses.



(a) (b)

Fig. Q6/7

Q8. A 6 m long simply supported beam carries a point load W at the mid-span. If the slope at the ends of the beam is not to exceed 1^0, determine the maximum deflection of the beam.

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 = -10 MPa and τ_{xy} = - 40 MPa. Find the principal stresses and the maximum shear stress 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. Derive Euler's critical load for the fundamental mode of a pinned-pinned column of length L. Take EI = constant.

Q12. Answer any two: **[5 × 2 = 10]**

(i) Explain statically indeterminate problems in brief with example.

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

(iii) Deduce an expression to determine deformation of a taper cylindrical bar under uniaxial loading.

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