Ref. No.: Ex/ME(M2)/PC/B/T/123/2024

B.E. MECHANICAL ENGINEERING FIRST YEAR SECOND SEMESTER EXAM – 2024

SUBJECT: STRENGTH OF MATERIALS

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

Any missing data may be assumed with suitable justification

Symbols/notations carry its usual meanings

For Question Q9, the figure must be drawn in GRAPH PAPER

All Questions Carry Equal Marks

ANSWER ANY TEN QUESTIONS

Q1. Two cylindrical rods, one of steel and the other of brass, are joined at C and restrained by rigid supports at A and E. For the loading shown (**Fig. Q1**) and knowing that E_s = 200 GPa and E_b = 105 GPa, determine **(a)** the reactions at A and E, **(b)** the deflection of point C. **[10] (CO1)**

Q2. For the composite bar made of bronze and aluminum (**Fig. Q2**), a 0.5 mm gap exists when the temperature is 30°C. Determine the temperature at which the normal compressive stress in the aluminum bar will be equal to 90 MPa. For bronze bar: A=1500 mm^2, E =105 GPa, α =21.6×10^{-6} /°C; For aluminum bar: A=1800 mm^2, E =73 GPa, α =23.2×10^{-6}/°C. **[10] (CO1)**

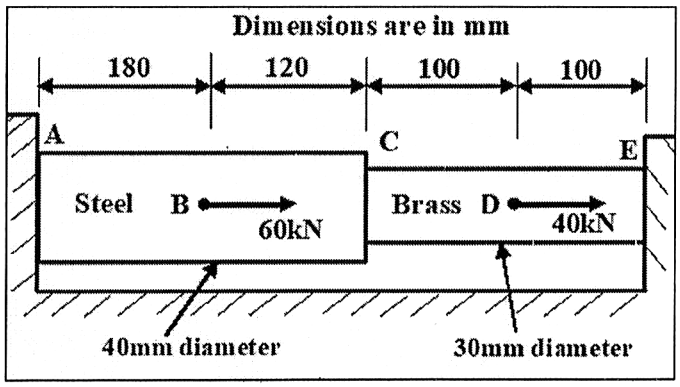

Fig. Q1

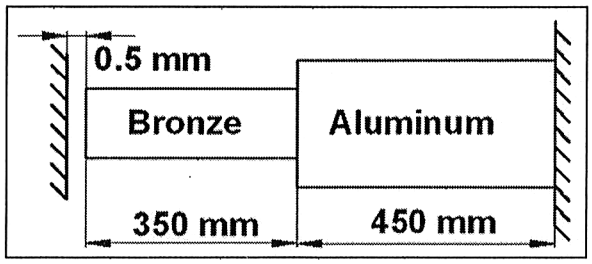

Fig. Q2

Q3.

(a) Deduce the expression of axial deflection for a close-coiled helical spring subjected to an axial load. **[5] (CO1)**

(b) A close-coiled helical spring is to exert a force of 3 kN; the mean diameter of the coils is to be 75 mm and the maximum stress is not to exceed 240 MPa. Calculate the diameter of the steel rod from which the spring should be made. **[5] (CO1)**

[Turn over

Q4. The aluminum rod *AB* ($G = 27$ GPa) is bonded to the brass rod *BD* ($G = 39$ GPa) (**Fig Q4**). Knowing that portion *CD* of the brass rod is hollow and has an inner diameter of 40 mm, determine the angle of twist at *A*. **[10] (CO1)**

Q5. Draw the complete shear fore and bending-moment diagrams for the beam and loading shown in **Fig. Q5**. **[10] (CO1)**

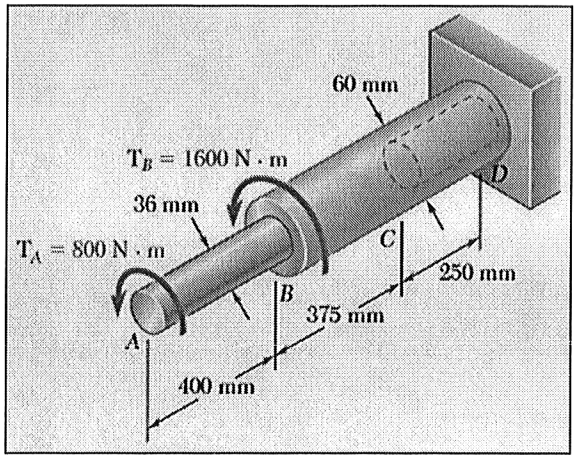

Fig. Q4

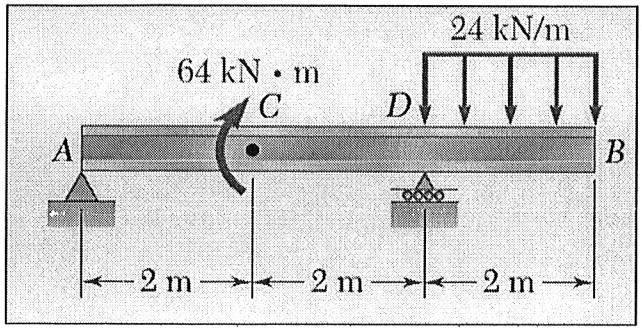

Fig. Q5

Q6. The beam is to be loaded as shown in **Fig. Q6**. If the ends support only vertical forces, determine the largest magnitude of *P* that can be applied. The value of the allowable normal stress is 25 MPa. **[10] (CO1)**

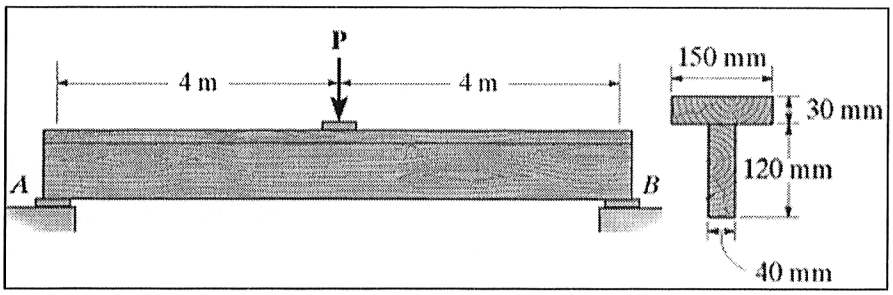

Fig. Q6

Q7. A simply supported beam of span of length *L* is subjected to a point load *P* at its mid-point. Find the equation of the elastic curve, the maximum deflection and the maximum slope. Take *EI*= Constant. **[10] (CO1)**

Q8.

(a) Using the governing equation of membrane stresses, find the circumferential stress and longitudinal stress of a thin-walled cylindrical pressure vessel. **[5] (CO2)**

(b) Determine the hoop and longitudinal stresses set up in a thin cylindrical boiler shell, 5 m long and of 1.3 m internal diameter when the internal pressure reaches a value of 240 kN/m^2. The wall thickness of the boiler is 25mm. **[5] (CO2)**

Q9. Draw the Mohr's circle for the given state of stress (**Fig. Q9**), and determine **(a)** the principal planes, **(b)** the principal stresses, directly from the Mohr's circle. **[10] (CO2)**

Q10. A 60 mm diameter shaft supported in bearings carries a 750 mm diameter pulley weighing 2500 N at an overhanging end of the shaft as shown in **Fig. Q10**. Calculate the principal tensile stress at the section ***mn*** if the horizontal belt tensions are as shown in the figure. **[10] (CO2)**

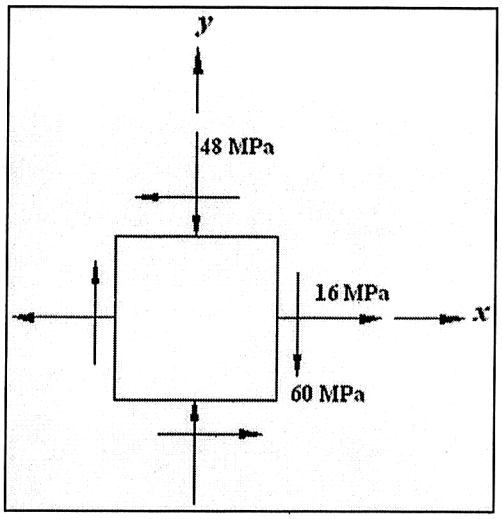

Fig. Q9

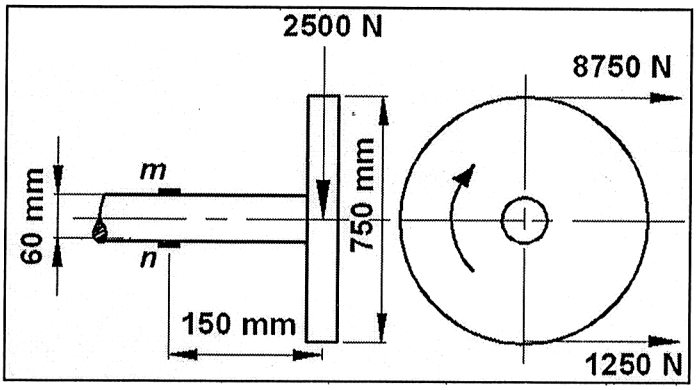

Fig. Q10

Q11. Derive an expression for the Euler's critical load of a column with both ends fixed with usual notations along with neat sketches. State the assumptions made. **[10] (CO3)**

Q12. **Answer any two:** **[5+5] (CO4)**

(a) Draw and explain the stress-strain diagram of mild steel.

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

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

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