B.E. METALLURGICAL AND MATERIAL ENGG. 2ND YEAR 1ST SEM SUPPLEMENTARY EXAM 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. An aluminum rod is rigidly attached between a steel rod and a bronze rod as shown in the **Fig. Q1**. Axial loads are applied at the positions indicated. Find the maximum value of P that will not exceed a stress in steel of 140 MPa, in aluminum of 90 MPa, or in bronze of 100 MPa.

Q2. For the composite bar made of bronze and aluminum (**Fig. Q2**), a 0.5 mm gap exists when the temperature is 20^{0}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} /^{0}C; For aluminum bar: A=1800 mm^2, E =73 GPa, α =23.2×10^{-6} /^{0}C.

Q3. Show that the hollow circular shaft whose inner diameter is half the outer diameter has a torsional strength equal to 15/16 of that of a solid shaft of the same outside diameter.

Q4. A close-coiled helical spring has 100 mm coil diameter and is made of steel wire having a diameter of 30 mm with 20 complete turns. It is used to arrest a moving mass of 1.0 kg having maximum compression of 50 mm. Find the maximum velocity of the moving mass that can be arrested with the spring. At that instant, find the maximum theoretical stress that is developed within the spring. Assume G for spring material is 200 GPa.

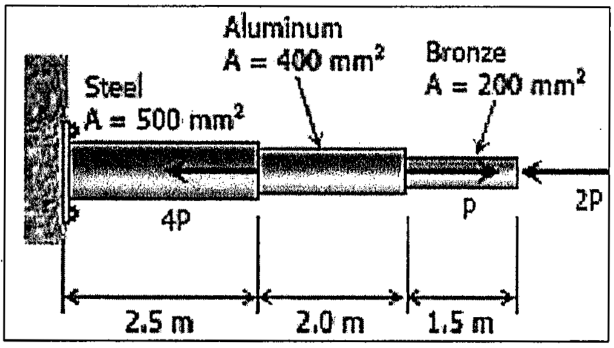

Fig. Q1

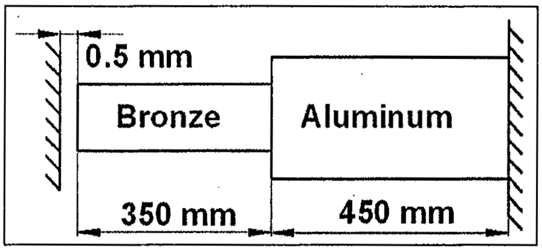

Fig. Q2

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

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

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

Q7. Considering that the beam shown in **Fig. Q6/7** has rectangular cross section with breadth of 100 mm and height of 200 mm, determine the maximum normal stress due to bending on a transverse section at *C*.

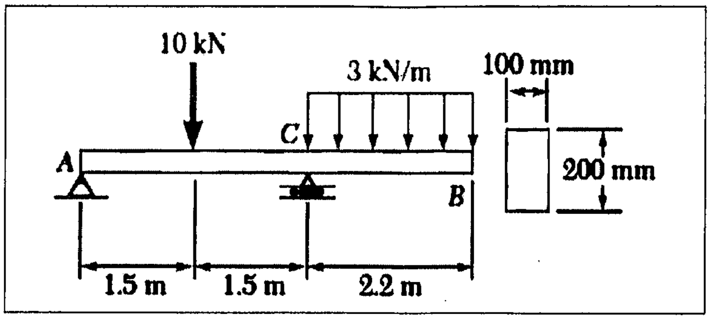

Fig. Q6/7

Q8. A cantilever beam carries a uniformly distributed load of 10 kN/m over its entire span of 9 m. Deducing the necessary relation, find its maximum deflection if the flexural rigidity is 1.5 x 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_y = -80 MPa and τ_{xy} = 50 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 fixed-free column of length *L*. Take *EI* = constant.

Q12. Answer any two: **[5 × 2 = 10]**

(i) Deduce the expression for elongation of a bar of rectangular section due to self-weight.

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

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

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