Ref. No.: Ex/Met/ES/B/ME/T/213/2024

B.E. METALLURGICAL AND MATERIAL ENGINEERING SECOND YEAR FIRST SEMESTER EXAM 2024

SUBJECT: STRENGTH OF MATERIALS

Time: 3 Hours **Full Marks: 10 X 10 = 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 rigid bar *BDE* is supported by two links *AB* and *CD* (**Fig. Q1**). Link *AB* is made of aluminium (E = 70 GPa) and has a cross-sectional area of 500 mm^2. Link *CD* is made of steel (E =200 GPa) and has a cross-sectional area of 600 mm^2. For the 30 kN force shown, determine the deflection (i) of *B*, (ii) of *D*, and (iii) of *E*.

Q2. A plastic bar *ACB* having two different solid circular cross sections is held between rigid supports as shown in the **Fig. Q2**. The diameters in the left- and right-hand parts are 50 mm and 75 mm, respectively. The corresponding lengths are 225 mm and 300 mm. Also, the modulus of elasticity E is 6.0 GPa, and the coefficient of thermal expansion α is 100 X 10^{-6}/°C. The bar is subjected to a uniform temperature increase of 30°C. Calculate (i) the compressive force in the bar; (ii) the maximum compressive stress and (iii) the displacement of point *C*.

Q3. Two steel springs (G = 83 GPa) arranged in series as shown in the **Fig. Q3**, 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.

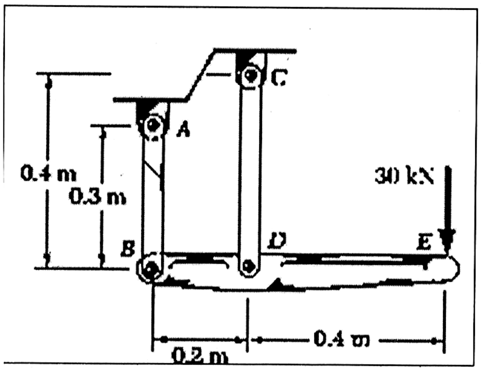

Fig. Q1

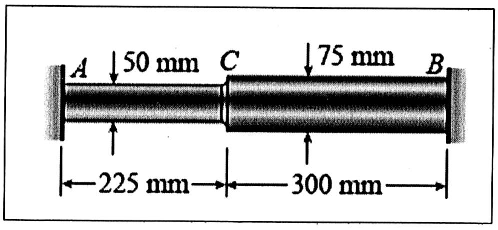

Fig. Q2

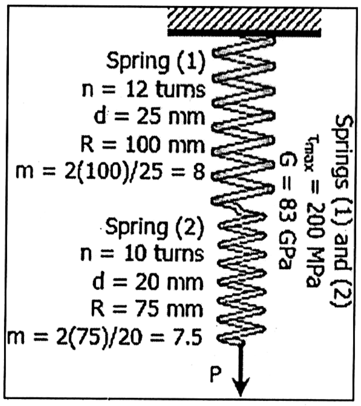

Fig. Q3

Q4. A hollow steel shaft (G = 80 GPa) transmits 200 kW of power at 150 rpm. The total angle of twist in a length of 5m of the shaft is 3^0. Find the inner and outer diameters of the shaft if the permissible shear stress is 60 MPa.

[Turn over

Q5. For the beam and loading shown in **Fig. Q5**, draw the complete shear force and bending moment diagram of the beam.

Q6. A wood beam *AB* supporting two concentrated loads *P* (**Fig. Q6**) has a rectangular cross section of width $b = 100$ mm and height $h = 150$ mm. The distance from each end of the beam to the nearest load is $a = 0.5$ m. Determine the maximum permissible value P_{max} of the loads if the allowable stress in bending is $\sigma_{allow} = 11$ MPa (for both tension and compression) and the allowable stress in horizontal shear is $\tau_{allow} = 1.2$ MPa.

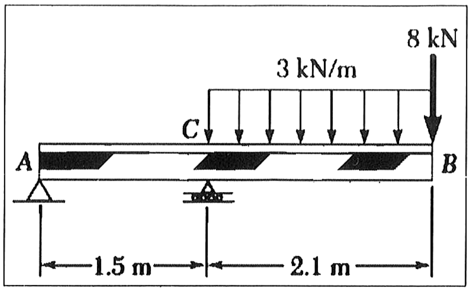

Fig. Q5

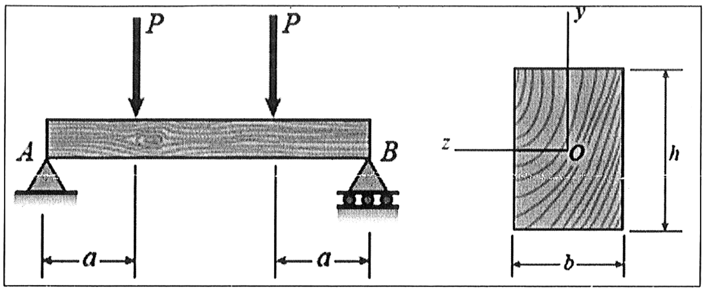

Fig. Q6

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

Q8. A cantilever beam of 4 m length carries a uniformly distributed load over the entire length. The deflection at the free end is 30 mm. Deducing the necessary relations, determine the slope of deflection curve at the free end.

Q9. For the state of plane stress shown in **Fig. Q9**, (a) construct Mohr's circle, determine (b) the principal planes, (c) the principal stresses, (d) the maximum shearing stress and the corresponding normal stress.

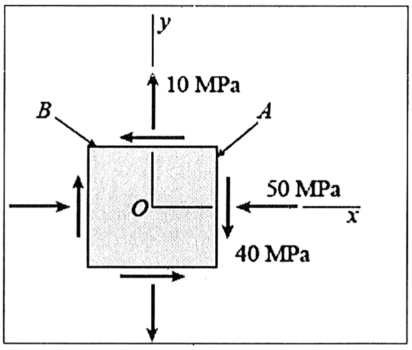

Fig. Q9

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 hinged-hinged column of length *L*. Take *EI*=constant.

Q12. Answer any two from the followings: **[5 × 2 = 10]**

(i) Write a short note on 'Section modulus'.

(ii) Write a short note on 'Bearing stress'.

(iii) Deduce the expression of deformation of a taper cylindrical bar under uniaxial loading.

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