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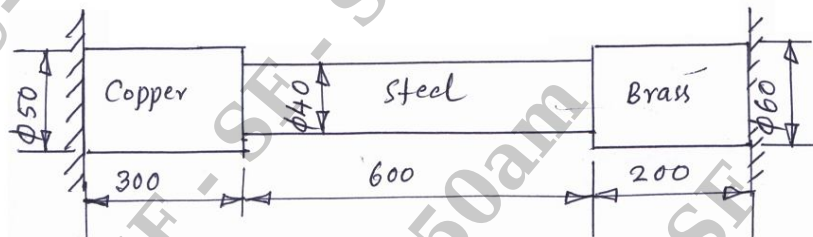
Third Semester B.E. Degree Examination, July/August 2021 Mechanics of Materials

Time: 3 hrs.

Max. Marks: 100

Note: Answer any FIVE full questions.

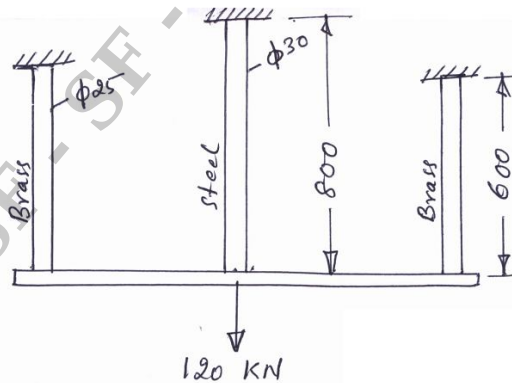
- 1 a. Define the terms : (i) Modulus of rigidity (ii) Factor of safety
(iii) True stress (iv) Volumetric strain (04 Marks)
- b. Deduce expression to determine the elongation of tapered rectangular bar of uniform thickness. (06 Marks)
- c. A composite bar made of copper, steel and brass is rigidly attached to the end supports as shown in Fig. Q1 (c). Determine the stresses in the three portions of the bar when the temperature of the composite system is raised by 70°C , considering that the supports are rigid. Take $E_c = 100 \text{ GPa}$, $E_s = 205 \text{ GPa}$, $E_b = 95 \text{ GPa}$, $\alpha_c = 18 \times 10^{-6} / ^{\circ}\text{C}$, $\alpha_s = 11 \times 10^{-6} / ^{\circ}\text{C}$, $\alpha_b = 19 \times 10^{-6} / ^{\circ}\text{C}$. (10 Marks)



All dimensions are in mm

Fig. Q1 (c)

- 2 a. Define Bulk modulus. Derive a relationship between Young's modulus, modulus of rigidity and Poisson's ratio. (10 Marks)
- b. Three equally spaced rods in the same vertical plane support a rigid bar AB. Two outer rods are of brass, each 600 mm long and of 25 mm in diameter. The central rod is of steel that is 800 mm long and 30 mm in diameter. Determine the forces in the rods due to an applied load of 120 kN through the mid point of the bar. The bar remains horizontal after the application of load. Take $\frac{E_s}{E_b} = 2$. The rigid bar system is shown in Fig. Q2 (b). (10 Marks)



Dimensions are in mm

Fig. Q2 (b)

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg. 42+8 = 50, will be treated as malpractice.

- 3 a. Define Principal plane. Deduce expressions for stresses on an inclined plane in a body subjected to bi-axial stress condition. (10 Marks)
- b. A thick cylinder has inner and outer diameters as 120 mm and 180 mm respectively. It is subjected to an external pressure of 9 MPa. Find the value of internal pressure which can be applied if the maximum stress is not to exceed 30 MPa. Draw the curves showing the variation of hoop and radial stresses through the material of the cylinder. (10 Marks)
- 4 a. What assumptions are taken in the analysis of thin cylinders? Deduce expressions for the circumferential and longitudinal stresses developed in thin cylinder. (10 Marks)
- b. A plane element is subjected to stresses as shown in Fig. Q4 (b). Draw the Mohr's circle and determine principal stresses, maximum shear stress and their planes. (10 Marks)

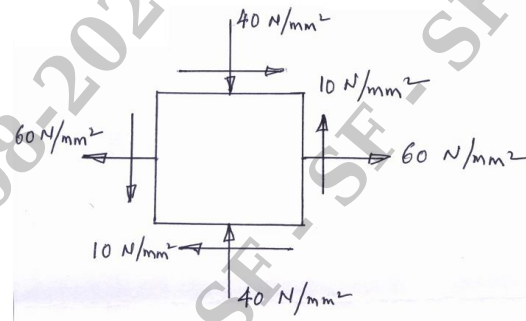


Fig. Q4 (b)

- 5 a. Draw the shear force and bending moment diagrams for a Cantilever subjected to forces as shown in Fig. Q5(a). (10 Marks)

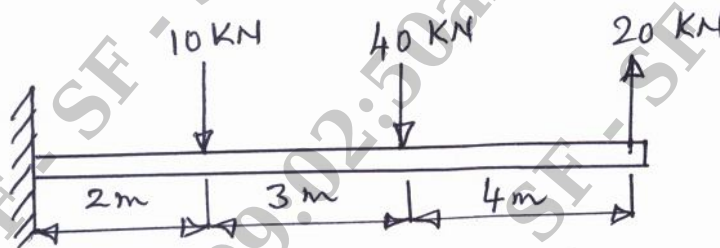


Fig. Q5 (a)

- b. Prove the relation $\frac{\sigma_y}{y} = \frac{M}{I} = \frac{E}{R}$ for simple bending. (10 Marks)

- 6 a. A 10 m long simply supported beam is loaded as shown in Fig. Q6 (a). Draw the shear force and bending moment diagrams. (10 Marks)

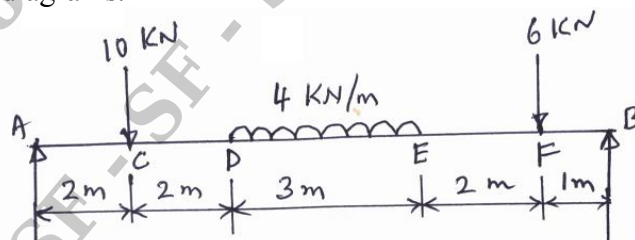


Fig. Q6 (a)

- b. A 200 mm × 80 mm I-beam is to be used as a simply supported beam of 6.75 m span. The web thickness is 6 mm and the flanges are of 10 mm thickness. Determine what concentrated load can be carried at a distance of 2.25 m from one support if the maximum permissible stress is 80 MPa. (10 Marks)

- 7 a. A bolt is acted upon by an axial pull of 16 kN along with a transverse shear force of 10 kN. Determine the diameter of the bolt required according to (i) Maximum principal stress theory (ii) Maximum shear stress theory. **(10 Marks)**
- b. Deduce the torsion equation with usual notations, stating the assumptions made. **(10 Marks)**
- 8 a. A shaft transmits 280 kW of power at 160 rpm. Determine
- (i) The diameter of solid shaft to transmit the required power.
 - (ii) The inner and outer diameters of a hollow circular shaft if the ratio of the inner to the outer diameter is $\frac{2}{3}$.
 - (iii) The percentage saving in the material on using a hollow shaft instead of a solid shaft.
- Take the allowable stress as 80 MPa and the density of the material 78 kN/m³. **(10 Marks)**
- b. A thin walled 800 mm long member has the cross section as shown in Fig. Q8 (b). Determine
- (i) The maximum torque if the angle carried by the section is limited to 4°.
 - (ii) The maximum shear stress induced for the maximum torque.
- Take $G = 82 \text{ GPa}$. **(10 Marks)**

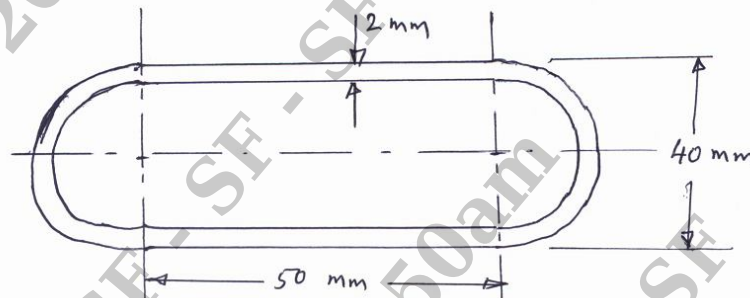


Fig. Q8 (b)

- 9 a. Derive an expression for Euler's critical load for a column with both ends hinged. **(10 Marks)**
- b. A 4-m long hollow alloy tube with inside and outside diameters as 36 mm and 48 mm elongates by 3 mm under a tensile force of 50 kN. Determine the buckling load for the tube when it is used as a column with both ends pinned (hinged) and a factor of safety of 5. **(10 Marks)**
- 10 a. Derive an expression for strain energy for a member subjected to axial load. **(05 Marks)**
- b. Explain Castigliano's theorem – I. **(05 Marks)**
- c. Two elastic bars of equal length and of the same material ; one is of circular cross section of 80 mm diameter and the other of square cross section of 80 mm side. Both absorb the same amount of strain energy under axial forces. Compare the stresses in the two bars. **(10 Marks)**
