# STRENGTH OF MATERIALS
# (MECH 2201)

**Time Allotted : 3 hrs** **Full Marks : 70**

***Figures out of the right margin indicate full marks.***

***Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.***

***Candidates are required to give answer in their own words as far as practicable.***

## Group – A
## (Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) In terms of Poisson's ratio (μ) the ratio of Young's Modulus (E) to Shear Modulus (G) of elastic materials is
(a) 2 (1 + μ) (b) 2 (1 - μ) (c) (1 + μ) / 2 (d) (1 - μ) / 2.

(ii) The change in the unit volume of a material under tension with increase in its Poisson's ratio will
(a) increase (b) decrease
(c) remain same (d) increase initially and then decrease.

(iii) In simply supported beams, the slope is _____ at supports.
(a) Minimum (b) Zero (c) Maximum (d) Uniform.

(iv) The stress necessary to initiate yielding, is considerably
(a) More than that necessary to continue it
(b) Less than that necessary to continue it
(c) More than that necessary to stop it
(d) Less than that necessary to stop it.

(v) In most cases, for a given loading maximum stress and deflection of an indeterminate structure are _____ than that of a determinate one.
(a) Larger (b) Smaller
(c) Larger for small load (d) Smaller for larger load

(vi) Maximum torque T that can be transmitted by a solid shaft of diameter D, when subjected to a shear stress $\boldsymbol{\tau}$ is equal to:

(a) $\frac{\pi}{16}\tau D^2$ (b) $\frac{\pi}{16}\tau D^3$ (c) $\frac{\pi}{32}\tau D^2$ (d) $\frac{\pi}{32}\tau D^3$

(vii) In a loaded beam, the point of contra-flexure occurs at a section where
(a) Bending moment is minimum
(b) Bending moment is zero or changes sign
(c) Bending moment is maximum
(d) Shearing force is maximum.

(viii) A material subjected to uni-axial tensile stress experiences maximum shear stress on a plane inclined at
(a) 90° with the normal (b) 60° with the normal
(c) 45° with the normal (d) 30° with the normal.

(ix) Which of the following stresses can be determined using Mohr's circle method?
(a) Torsional stress (b) Bending stress
(c) Principal stress (d) All of the above.

(x) Long columns fail due to
(a) Direct stress (b) Buckling stress
(c) Lateral stress (d) Tensile stress.

## Group – B

2. (a) In the arrangement shown in Fig.1, a gap of 0.5mm exists at the left end of the bronze bar at a temperature of $20^0$C. Find the temperature at which the normal stress in the aluminium bar will be 75N/mm$^2$. Find also the corresponding length of the aluminium bar. Use the following data, $A_b$ = 1500mm$^2$, $E_b$ = 10.3 × $10^4$N/mm$^2$, $\alpha_b$ = 18 × $10^{-6}$ per $^0$C, $A_a$ = 1750mm$^2$, $E_a$ = 7.28 × $10^4$ N/mm$^2$, $\alpha_a$= 23 × $10^{-6}$ per $^0$C.

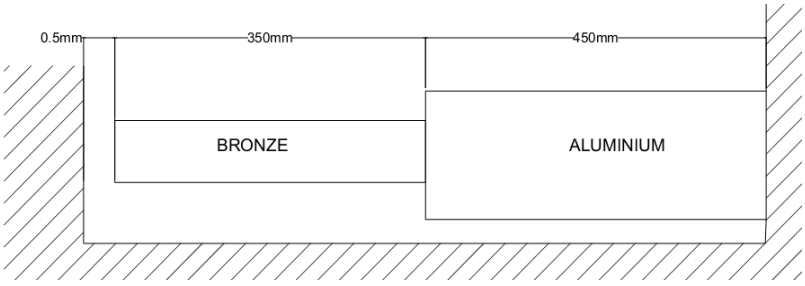


***Fig.1***

(b) Find out the expression for elongation of a tapered rod having smallest and largest diameters d and D respectively and length 'L' under tensile centric load 'P'. If d = 9 mm, D = 18 mm, L = 900 mm, P = 15 kN find its elongation. Take E = 200 GPa.

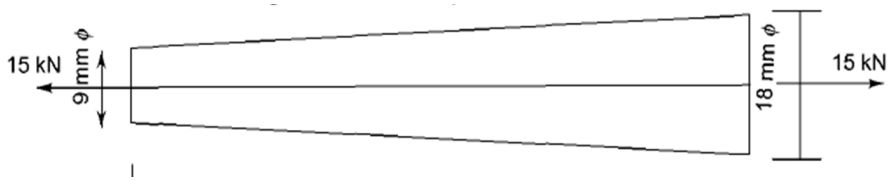


***Fig.2***

**(3 + 4) + 5 = 12**

3. (a) An aluminum specimen shown in Fig.3 has a diameter of $d_o$ = 25 mm and a gauge length of $L_o$ = 250mm. If a force of 165 kN elongates the gauge length

1.20 mm, determine the modulus of elasticity. Also, determine by how much the force causes the diameter of the specimen to contract. Take $G_{al}$ = 26 GPa and $\sigma_y$ = 440 MPa.

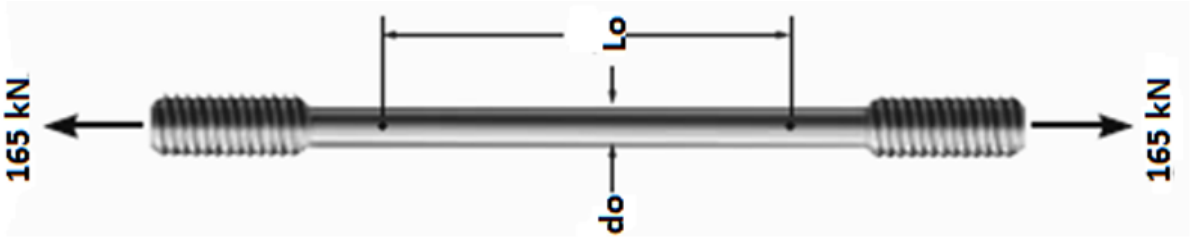


*Fig.3*

(b) Two copper rods and one steel rod together support a load as shown in the Fig. 4. If the stresses in copper and steel are not to exceed 60N/mm² and 120 N/mm² respectively, find the safe load(P) of the block (assuming to be horizontal all the time), that can be supported. Young's Modulus for steel is twice that of copper. $A_{cu}$ = (30 × 30)mm², $A_{st}$ = (40 × 40)mm².

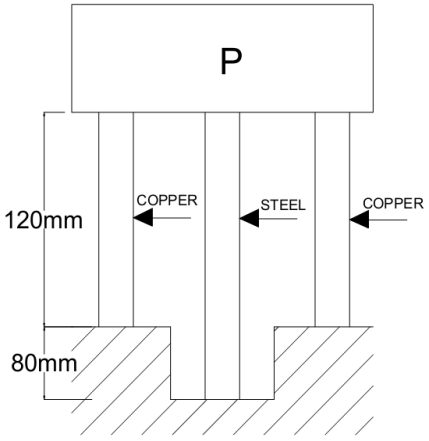


*Fig.4*

**(4 + 3) + 5 = 12**

## Group – C

4. For the state of plane stress shown in Fig.5 draw Mohr's circle to determine (i) the principal planes (ii) the principal stresses (iii) the maximum shearing stress and corresponding normal stress.

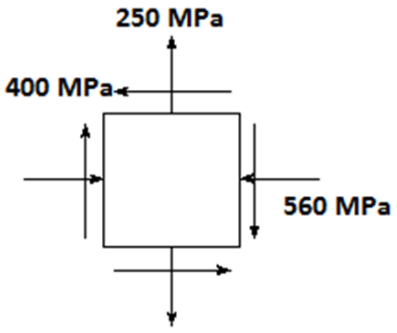


*Fig.5*

**(4 + 4 + 4) = 12**

5. Draw the Shear Force and Bending Moment diagrams for the beam loaded as shown in Fig.6a. Also find the maximum bending stress generated. The dimensions of cross-section is shown in Fig.6b.

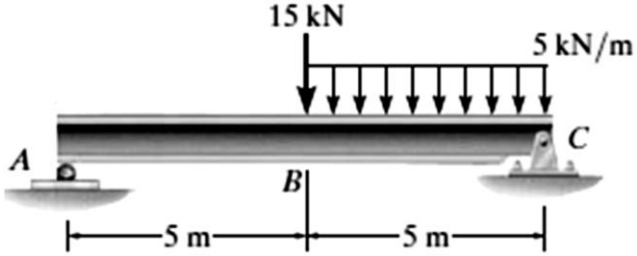


*Fig.6a*

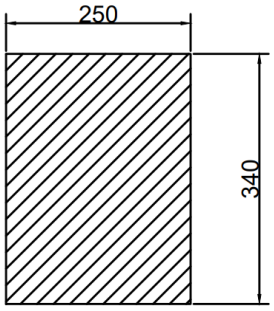


*Fig.6b*

**(4 + 4 + 4) = 12**

## Group – D

6. An overhanging beam of span 8 m between supports and overhang length of 2 m carries a UD load 40 kN/m over the whole length as shown in Fig.7. Find the slope at the supports, deflection at the free end, and maximum deflection. Take EI = $11.2 \times 10^6$ $Nm^2$.

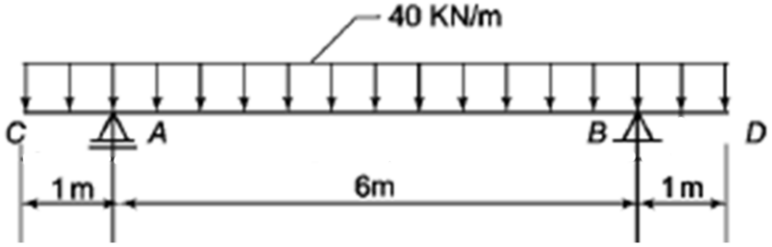


*Fig.7*

**(5 + 4 + 3) = 12**

7. (a) A simply supported beam carries a point load P eccentrically on the span as shown in Fig.8. Find the deflection of the beam at the position of the point load. Assume uniform flexural rigidity. Castigliano's theorem to be used.

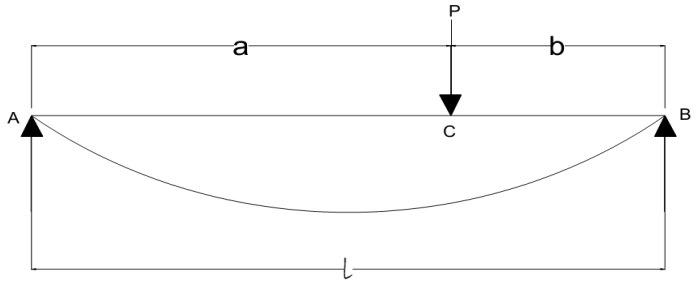


*Fig.8*

(b) A cantilever AB of length l carries three point loads, W each at distance l/3, 2 l/3 and l from the fixed end A. Determine the slope and deflection at the free end B.

**6 + 6 = 12**

## Group – E

8. (a) The maximum allowable shear stress in a hollow shaft of external diameter equal to twice the internal diameter, is 80 $N/mm^2$. Determine the diameter of the shaft if it is subjected to a torque of $4 \times 10^6$ N-mm.

(b) A hollow, circular copper shaft of 60 mm external and 30 mm internal diameter and a steel solid shaft of 50 mm radius are rigidly connected in series and

subjected to a torque of 5000 Nm as shown in Fig.9. Determine the maximum stresses in the two shafts. G = 80 GPa for steel and 40 GPa for copper. Length of the copper shaft is 0.45 m and that of the steel shaft is 0.45 m.

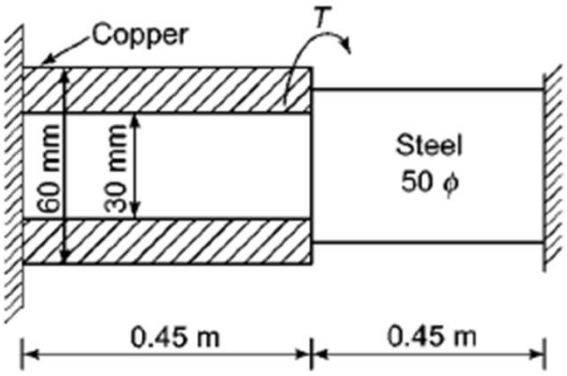


*Fig.9*

**4 + 8 = 12**

9. (a) A bar of circular section 300 mm diameter and a length of 4 m is extended by 0.025 mm when a tensile load of 100 kN is applied. Find the Euler critical load of this bar used as a column with one end fixed and the other hinged.

(b) A hollow steel strut, 2.4 m long, is pin-jointed at the ends. It has an outer diameter of 40 mm and a thickness of *5* mm. If the yield stress is 320 $N/mm^2$ and E = 2 × $10^5$ $N/mm^2$, compare the crippling load given by Euler's and Rankine's formulae. Also determine the minimum l/r ratio for which Euler's formula applies.

**5 + (3 + 4) = 12**

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