ME-302

STRENGTH OF MATERIAL

Time Allotted: 3 Hours | Full Marks: 70

The questions are of equal value.
The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

GROUP A
(Multiple Choice Type Questions)

1. Answer any *ten* questions. 10×1 = 10

(i) Elongation of a conical bar under its own weight is _____ that of a rectangular section of the same length

(A) two-third (B) one-third (C) half (D) equal to

(ii) The bulk modulus of a material having E = 200 GPa and G = 80 GPa is

(A) 233.3 GPa (B) 133.3 GPa (C) 250 GPa (D) 160 GPa

(iii) A spherical vessel with an inside diameter of 2 m is made of material having an allowable stress in tension is 60 MPa. The thickness of a shell to withstand a pressure of 2.5 MPa would be

(A) 50 mm (B) 100 mm (C) 25 mm (D) 12.5 mm

(iv) In a freely supported beam at its end is loaded by a central concentrated load, the maximum bending moment is M. If the same weight be equally distributed over the beam then its maximum bending moment will be

(A) M (B) M/2 (C) M/3 (D) 2M

(v) A circular shaft with diameter D is subjected to bending moment M and torque T. The expression for the maximum principal stress at any section is

(A) $\frac{16}{\pi D^3}\sqrt{(M^2+T^2)}$ (B) $\frac{2M+T}{\pi D^3}$

(C) $\frac{16\pi}{D^3}(M+\sqrt{M^2+T^2})$ (D) $\frac{16}{\pi D^3}(M+\sqrt{M^2+T^2})$

(vi) The energy stored in a closed coiled helical spring when subjected to an axial twist is given by

(A) $\frac{\sigma_b^2}{6E}$ × volume of the spring (B) $\frac{\sigma_b^2}{8E}$ × volume of the spring

(C) $\frac{\sigma_b^2}{4E}$ × volume of the spring (D) $\frac{\sigma_b^2}{2E}$ × volume of the spring

(vii) Euler's formula works for

(A) elastic limit only (B) plastic limit only

(C) elastic and plastic limit both (D) none of these

(viii) Maximum shear stress of 50 N/mm^2 is developed in a hollow circular shaft of outer diameter 20 cm and inner diameter 8 cm while subjected to a twisting moment. The shear stress at the inner radius of the is

(A) 20 N/mm^2 (B) 30 N/mm^2 (C) 40 N/mm^2 (D) 50 N/mm^2

(ix) About the diagonal the M.I. of a square of side d is

(A) $d^4/6$ (B) $d^4/8$ (C) $d^4/16$ (D) $d^4/12$

(x) A load of 10000 N applied to copper cylinder 200 mm long, 50 mm in diameter causes the length to increase by 0.4 mm and diameter to decrease by 0.04 mm. The Poisson's ratio for copper will be

(A) 0.4 (B) 0.36 (C) 0.24 (D) 0.22

(xi) The point of contra-flexure is a point where

(A) The S.F is maximum (B) The S.F is zero

(C) The B.M is maximum (D) The B.M is zero

(xii) In a thin cylindrical shell closed at ends and experiencing internal fluid pressure the ratio of hoop stress and the axial stress is

(A) 3:1 (B) 4:1 (C) 2:1 (D) 1:2

GROUP B
(Short Answer Type Questions)

Answer any *three* questions. 3×5 = 15

2. Prove that the strain energy stored in a two dimensional body is given by $U = \frac{1}{2E}\left(\sigma_1^2 + \sigma_2^2 - 2\nu\sigma_1\sigma_2\right)$ per unit volume. The symbols have usual meanings.

3. Determine the diameter of solid shaft which will transmit 440 kW at 280 rpm. The angle of twist must not exceed one degree per meter length and the maximum torsional shear stress is to be limit to 40 N/mm^2. Assume G = 84 kN/mm^2.

4. Prove that a hollow shaft can withstand higher torque than a solid shaft of same length and weight if the two shafts are made of the same material.

5. For two dimensional stress system, show that $\sigma_1 = \frac{E}{1-\nu^2}(\epsilon_1 + \nu\epsilon_2)$ and

$\sigma_2 = \frac{E}{1-\nu^2}(\nu\epsilon_1 + \epsilon_2)$

6. Draw S.F and B.M diagram for the following cantilever beam. (Fig. 1)

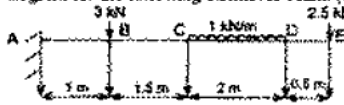

Fig. 1

GROUP C
(Long Answer Type Questions)

Answer *any three* questions. 3×15 = 45

7. (a) A weight of 2600 N is dropped on a closely coiled helical spring consisting of 16 turns. Find the height by which the weight is dropped before striking the spring so that the spring may be compressed by 220 mm. The coils have a mean radius of 120 mm and diameter of spring wire is 30 mm. 5

(b) A close coiled helical spring has a stiffness of 10 N/mm. Its length when fully compressed, with adjacent coils touching each other is 400 mm. The modulus of rigidity of the material of the spring is 8×10^4 N/mm^2. Determine 10

(i) wire diameter and mean coil diameter if their ratio is 1/10.

(ii) the maximum load that can be applied before the spring becomes solid, if the gap between any two adjacent coils is 2 mm.

(iii) the corresponding maximum shear stress in the spring.

8. (a) Find the normal and the shear stresses on a plane which has an inclination of 30 degree anticlockwise with x-axis. (Fig 2). 5

(b) Find the principal stresses and the orientation of the plane of maximum shear and normal stresses on it. 5

(c) Draw Mohr's circle of stress for the figure and show on sketch the different planes and the stresses acting on them. 5

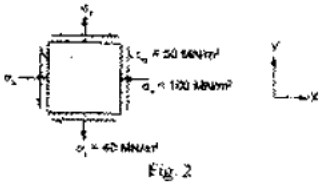

Fig. 2

9. (a) Direct tensile stresses of 120 MPa and 70 MPa act on a body on mutually perpendicular planes. What is the magnitude of the shearing stress that can be applied so that the major principal stress at a point on it does not exceed 135 MPa? Determine the value of the minor principal stress and the maximum shearing stress. 7

(b) The splined ends and the gears attached to the steel shaft are subjected to the torques as shown in the Figure 3 below. Find out the angle of twist of end B with respect to the end A. Also find out the maximum shear stress in each portion of the shaft. Assume the shear modulus of the material of the shaft to be 75 GPa. 8

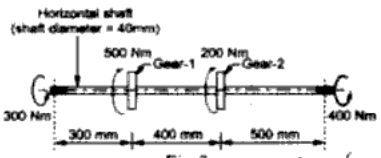

Fig 3

10.(a) Derive an expression for the critical load in a long column when its one end is fixed and other is hinged. 5

(b) A hollow circular column of steel, of outer diameter 200 mm and thickness 5 mm has a length of 4 m, with both ends fixed. Find the Euler critical load if E = 200 GPa. If the yield stress is 300 MPa, determine the length below which Euler's formula cannot be applied. 5

(c) A cantilever of length l carries a point load W at its free end. The member is circular in section having diameter D for a distance $l/2$ from the fixed end and a diameter D/2 for the remaining length. Show that the deflection at the free end is $\frac{23Wl^3}{384EI}$ where I is the moment of inertia of the smaller section. 5

11.(a) A compound shaft 1.5 m long fixed at one end is subjected to a torque of 15 kNm at the free end and of 20 kNm at the junction point as shown in Fig. 4. Determine 7+8

(i) the maximum shearing in each portion of the shaft.

(ii) the angle of twist at the junction of the two sections and at the free ends. Take G = 0.82×10^5 N/mm^2.

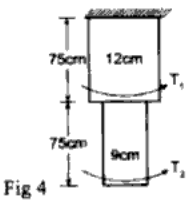

Fig 4

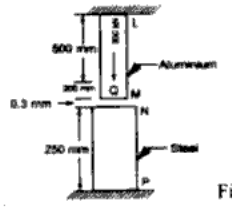

Fig 5

(b) A 700 mm length of aluminium alloy bar is suspended from the ceiling so as to provide a clearance of 0.3 mm between it and 250mm length of steel bar as shown in Fig 5. A_{Al} = 1250 mm^2, E_{Al} = 70 GN/m^2, A_s = 2500 mm^2, E_s = 210 GN/m^2. Determine the stress in the aluminium and in the steel due to a 300 kN load applied 500 mm from the ceiling.