(vii) The circumferential strain in case of thin cylindrical shell, when subjected to internal pressure(p) is
(a) more than diametral strain
(b) less than diametral strain
(c) equal to diametral strain
(d) have no relationship with diametral strain.

(viii) The equivalent length of a column fixed at both ends is
(a) 2L (b) L (c) 0.5L (d) 0.8L.

(ix) The flexural rigidity for the deflection of beams is expressed as
(a) I/E (b) E/I (c) EI (d) 1/EI.

(x) The strain energy stored due to torsion is (all symbols have their usual meanings)
(a) $\int \frac{\tau^2}{2G} dV$ (b) $\int \frac{\tau^2}{4G} dV$ (c) $\int \frac{\tau^2}{2E} dV$ (d) $\int \frac{\tau^2}{4K} dV$

Group – B

2. (a) A solid steel bar 500 mm long and 70 mm diameter is placed inside an aluminium tube having 75 mm inside diameter and 100 mm outside diameter. The aluminium cylinder is 0.15 mm longer than the steel bar. An axial load of 600 kN is applied to the bar and the cylinder through rigid cover plates. Find the stresses developed in the steel bar and aluminium tube. Also calculate the final lengths of Steel rod and Aluminium tube. Assume Young's modulii of elasticity for steel and Aluminium to be 200 and 70 GPa respectively.

(b) Determine the elongation of a bar hanging from a rigid ceiling due to its own weight.

(3 + 5) + 4 = 12

3. (a) At room temperature (20°C) a 0.5 mm gap exists between the ends of the rod shown in Fig.1. At a later time when the temperature has reached 140°C, determine (a) the normal stress in the aluminum rod (b) the change in length of the aluminum rod.

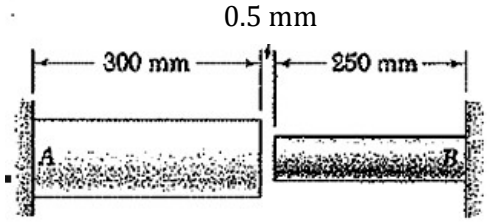


Figure 1

Group – D

6. (a) Draw the Shear Force and Bending Moment Diagrams for the beam and loading shown in Fig.5. Also determine the maximum normal stress due to bending on a transverse section at C.

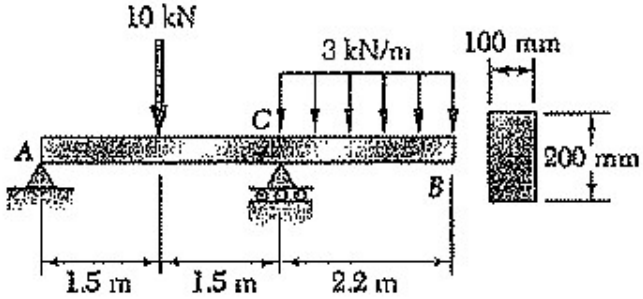
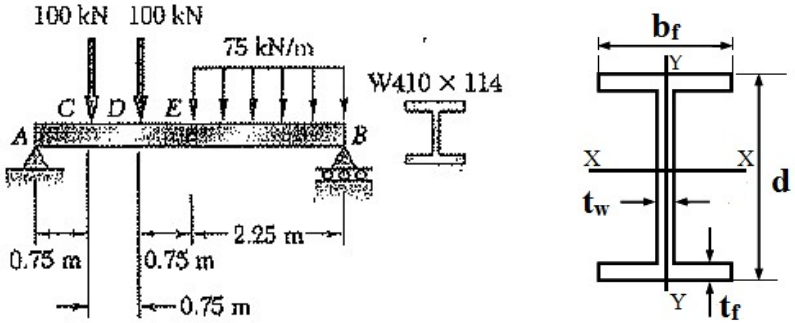


Figure 5

(b) Prove the relation M/I = σ/y = E/R where the symbols have their usual meaning.

(3 + 3 + 2) + 4 = 12

7. Draw the S.F and B.M diagrams for the beam and loading shown in Fig. 6(a). Also determine the maximum normal stress due to bending on a transverse section at C. Refer Fig. 6(b) and the Table.



(a) (b)

Fig. 6

Table: Dimensions of rolled steel W shape

Designation	Area A, mm^2	Depth d, mm	Flange		Web Thickness t_w, mm
			Width b_f, mm	Thickness t_f, mm	
W410 × 114	14600	420	261	19.30	11.6

(4 + 4 + 4) = 12

Group – E

8. (a) A hollow cylindrical steel shaft is 1.5 m long and has inner and outer diameters equal to 40 and 60 mm respectively (Fig. 7). (i) What is the largest torque T that can be applied to the shaft if the shearing stress is not to exceed 120 MPa? (ii) What is the corresponding minimum value of the shearing stress in the shaft?

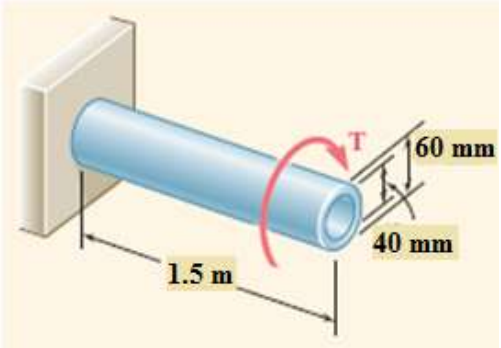


Fig. 7

(b) Determine the deflection δ for a closed coil helical spring by using the expression for strain energy of torsion.

(4 + 2) + 6 = 12

9. (a) Find out the expression for Euler's critical load for a column with both ends fixed.

(b) A 2 m long pin-ended column with a square cross section is to be made of wood. Assuming E = 13 GPa, $\sigma_{allowable}$ = 12 MPa, and using a factor of safety of 2.5 to calculate Euler's critical load for buckling, determine the size of the cross section if the column is to safely support a 100 kN load.

6 + 6 = 12

STRENGTH OF MATERIALS
(MECH 2102)

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) A bolt is made to pass through a tube and both of them are tightly fitted with the help of washer and nut. If the nut is tightened, then
(a) bolt and tube are subjected to compressive load
(b) bolt and tube are subjected to tensile load
(c) bolt is subjected to compressive load, while tube is subjected to tensile load
(d) bolt is subjected to tensile load, while tube is subjected to compressive load.

(ii) The work done in producing strain on a material per unit volume is called
(a) resilience (b) ductility
(c) elasticity (d) plasticity.

(iii) The ratio of bulk modulus to modulus of elasticity for a Poisson's ratio of 0.25 would be
(a) 2/3 (b) 1/3 (c) 4/3 (d) 1.0.

(iv) If a composite bar is cooled, then the nature of stress in the part with high coefficient of thermal expansion will be
(a) tensile (b) zero (c) compressive (d) shear.

(v) When a body is subjected to a direct tensile stress σ in one plane, then the normal stress on an oblique section inclined at an angle θ with the normal of the section is
(a) $\sigma\sin\theta$ (b) $\sigma\cos\theta$ (c) $\sigma\sin^2\theta$ (d) $\sigma\cos^2\theta$.

(vi) The area under a stress strain diagram is known as
(a) Modulus of resilience (b) Proof resilience
(c) Modulus of toughness (d) Modulus of elasticity.

Aluminium	Stainless Steel
A = 2000 mm^2	A = 800 mm^2
E = 75 GPa	E = 190 GPa
α = 23 x10^{-6}/°C	α = 17.3 x 10^{-6}/°C

(b) A bar 1 metre in length is subjected to a pull such that the maximum stress is equal to 150 N/mm^2. Its area of cross-section is 200 mm^2 over a length of 950 mm and for the middle 50 mm length the sectional area is 100 mm^2. If E = 2 × 10^5 N/mm^2, calculate the strain energy stored in the bar. Refer to Fig. 2.

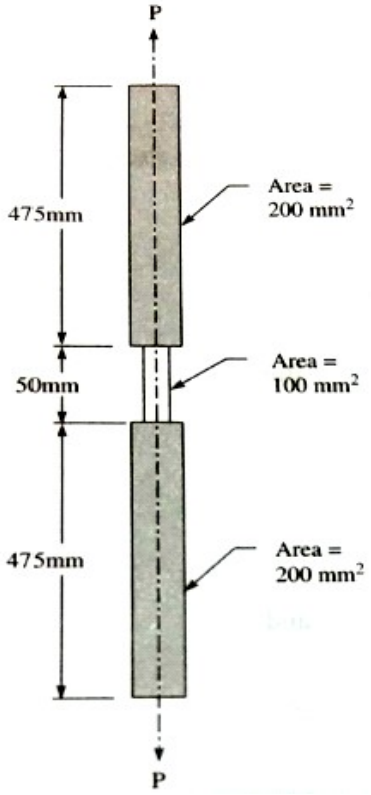


Fig. 2

(4 + 3) + 5 = 12

Group – C

4. (a) Find the deflection of a cantilever beam of length L and carrying a uniformly distributed load of *w* per unit length over the whole length. Assume suitable parameters. Use the relevant differential equation to solve your problem.

Also, find the free and deflection of the beam using Castigliano's theorem. Assume the beam possesses uniform flexural rigidity.

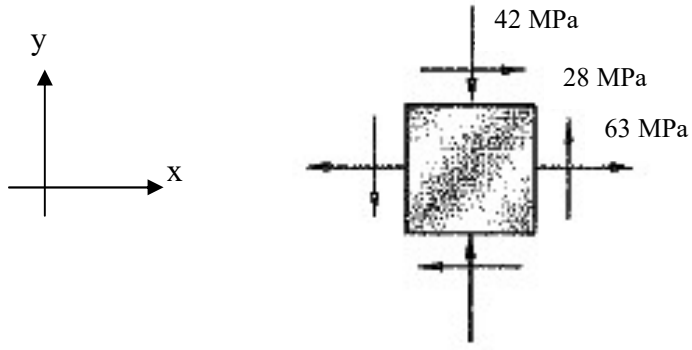


Figure 3

(b) For the state of plane stress shown in Figure 3 (σ_{xx} = +63 MPa, σ_{yy} = -42 MPa; τ_{xy} = -63 MPa) determine (i) the principal planes (ii) the principal stresses (iii) the maximum shearing stress and corresponding normal stress.

(3 + 3) + 6 = 12

5. (a) The overhanging steel beam ABC carries a concentrated load P at end C as shown in Fig.4. For portion AB of the beam (i) derive the equation of the elastic curve (ii) determine the maximum deflection (iii) evaluate y_{max} for the following data : I = 300 × 10^6 mm^4, E = 200 GPa, P = 200 kN, L = 4.5 m, a = 1.2 m.

Figure 4

(b) The air vessel of a torpedo is 530 mm external diameter and 10 mm thick, the length being 1830 mm. Find the change in the external diameter and the length when charged to 10.5 N/mm^2 internal pressure. Take E = 2.1 × 10^5 N/mm^2 and Poisson's ratio = 0.3.

(3 + 3 + 2) + (2 + 2) = 12