STRENGTH OF MATERIALS
(MECH 2201)

Time Allotted : 2½ hrs **Full Marks : 60**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 4 (four) from Group B to E, taking one from each group.

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

Group – A

1. Answer any twelve: **12 × 1 = 12**

Choose the correct alternative for the following

(i) For a Poisson's ratio 0.4 for a material, the ratio of the shear modulus to modulus of elasticity is
(a) $\frac{14}{5}$ (b) $\frac{5}{7}$ (c) $\frac{7}{5}$ (d) $\frac{5}{14}$

(ii) Temperature stress is a function of
(a) modulus of elasticity (b) coefficient of linear expansion
(c) change in temperature (d) all of these.

(iii) In case of biaxial stresses, the maximum value of in-plane shear stress is
(a) difference of normal stresses (b) half the difference of normal stresses
(c) sum of normal stresses (d) half the sum of normal stresses.

(iv) Modulus of resilience is
(a) percentage of elongation of an elastic body
(b) strain energy stored in the elastic body
(c) strain energy per unit volume of the elastic body
(d) none of these.

(v) The strain energy stored in a bar is given by
(a) $\frac{PL}{AE}$ (b) $\frac{PL^2}{2AE}$ (c) $\frac{P^2L}{AE}$ (d) $\frac{P^2L}{2AE}$

(vi) The point of contraflexure lies where
(a) shear force changes sign (b) bending moment is zero or changes sign
(c) shear force is zero (d) bending moment is maximum.

(vii) Four wires of same material are applied the same load. In which of the following cases, the elongation will be maximum (length, diameter)?
(a) 2m, 1m (b) 4m, 2m (c) 8m, 4m (d) 12m, 6m.

(viii) Which of the following is not an assumption in derivation of torsion equation for circular shafts?
(a) Circular shaft remains circular after twisting
(b) Plane section of the shaft remain plane after twisting
(c) Material of shaft is isotropic
(d) Angle of twist is proportional to radius.

(ix) The variation of shear force due to a uniformly distributed load is by
(a) Cubic law (b) Parabolic law (c) Linear law (d) Uniform law.

(x) The buckling load for a given material depends upon
(a) Poisson's ratio and slenderness ratio
(b) Poisson's ratio and modulus of elasticity
(c) Slenderness ratio and cross-sectional area
(d) Slenderness ratio and modulus of elasticity.

Fill in the blanks with the correct word

(xi) Deformation of a bar under its own weight is _____ the deformation due to a direct load equal to weight of the body applied at the lower end.

(xii) Neutral axis in a beam carries _____ bending stress.

(xiii) Deflection of the free end of a cantilever beam of length ***l***, having a point load ***W*** at the free end is _____.

(xiv) The ratio of the polar moment of inertia to the radius of the shaft is known as _____.

(xv) The slenderness ratio is the ratio of _____.

Group - B

2. (a) A steel circular bar has three segments a shown in Fig. 1. Determine (i) the total elongation of the bar. (ii) the length of the middle segment to have zero elongation of the bar. (iii) the diameter of the last segment to have zero elongation of the bar. Take E = 200 GPa. *[(CO1)(Apply/IOCQ)]*

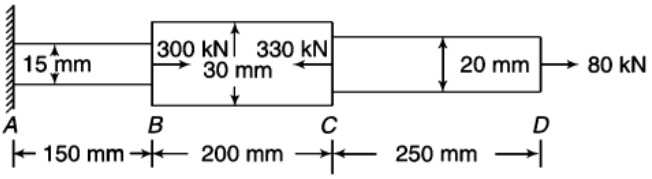

Fig. 1

(b) A suspended bar system consists of two cross-sections as shown in Fig. 2. Initially before 40 kN load is applied as shown in the figure, its surface is 0.8 mm above the ground surface. Determine the reaction of the lower support and the stresses in each section when a load of 40 kN is applied. Take E = 200 GPa. *[(CO2)(Apply/IOCQ)]*

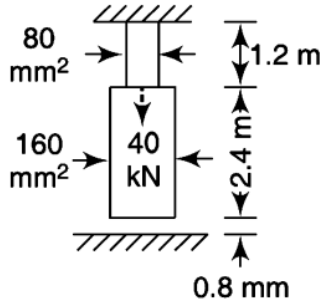

Fig. 2

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

3. (a) Derive the expression of elongation of a bar hanging under its own weight. *[(CO2)(understand/LOCQ)]*

(b) A rigid steel plate is supported by three posts of high-strength concrete each having an effective cross-sectional area A = 40,000 mm^2 and length L = 2 m as shown in Fig. 3. Before the load P is applied, the middle post is shorter than the others by an amount s = 1.0 mm. Determine the maximum allowable load P_{allow} if the allowable compressive stress in the concrete is σ_{allow}= 20 MPa. (Use E = 30 GPa for concrete.) *[(CO2)(Apply/IOCQ)]*

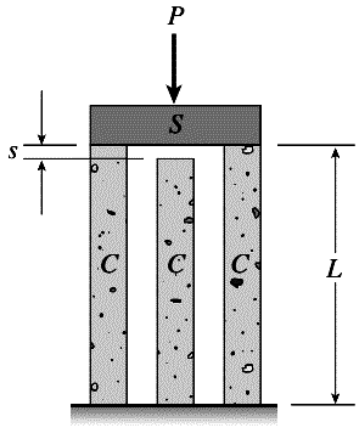

Fig. 3

5 + 7 = 12

Group - C

4. (a) Draw the shear force and bending moment diagrams for the overhang beam as shown in Fig. 4 *[(CO3)(Analyse/IOCQ)]*

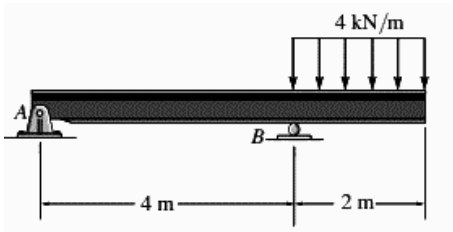

Fig. 4

(b) Write the assumptions made in pure bending. *[(CO3)(Remember/LOCQ)]*

(4 + 4) + 4 = 12

5. The state of stress at a point is shown in Fig. 5 on the element. Determine (i) the principal stress and (ii) the maximum in-plane shear stress and average normal stress at the point. Specify the orientation of the element in each case. *[(CO4)(Analyse/HOCQ)]*

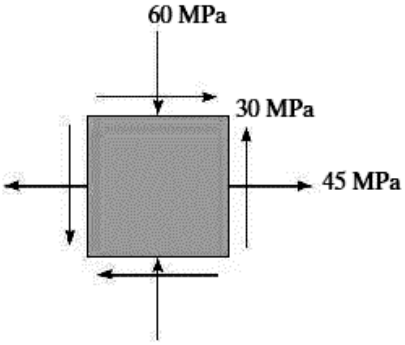

Fig. 5

(4 + 4 + 4) = 12

Group - D

6. For the timber beam and loading shown in Fig. 6, determine (i) the slope at end A, (ii) the deflection at the midpoint C. Use E = 12 GPa. *[(CO5)(Analyse/HOCQ)]*

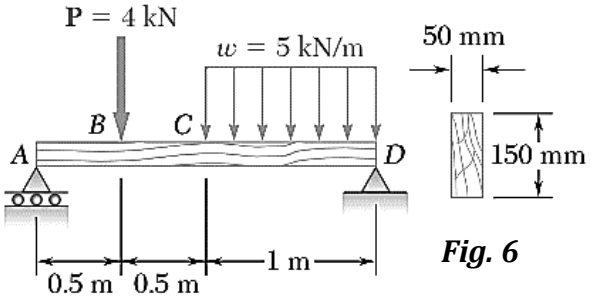

Fig. 6

(6 + 6) = 12

7. The cantilever beam AB supports a uniformly distributed load w as shown in Fig. 7. Determine the deflection and slope at A using Castigliano's theorem. *[(CO5)(Analyse/HOCQ)]*

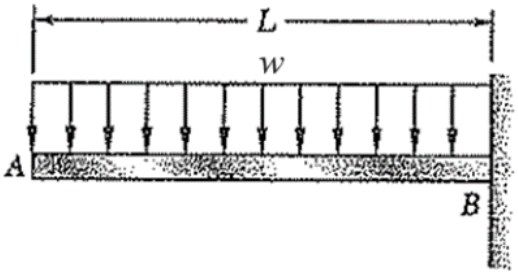

Fig. 7

(6 + 6) = 12

Group - E

8. (a) Calculate the diameters of a hollow shaft of the same length and same cross-sectional area as a solid shaft of 15 cm diameter if the strain energy in the hollow shaft is 25 % greater than that of solid shaft transmitting the same torque at the same maximum shear stress. *[(CO3)(Analyse/HOCQ)]*

(b) Two shafts of the same material and of same lengths are subjected to the same torque, if the first shaft is of a solid circular section and the second shaft is of hollow circular section, whose internal diameter is 2/3 of the outside diameter and the maximum shear stress developed in each shaft is the same, compare the weights of the shafts. *[(CO3)(Analyse/HOCQ)]*

(c) Define the following term-(i) Torsional or polar sectional moments (ii) Torsional rigidity. *[(CO3)(Remember/LOCQ)]*

4 + 6 + 2 = 12

9. (a) A column of timber section 15 cm × 20 cm is 6 metre long both ends being fixed. If the Young's modulus for timber = 17.5 kN/mm^2, determine : (i) Crippling load and (ii) Safe load for the column if factor of safety = 3. *[(CO6)(Analyse/HOCQ)]*

(b) Derive the equation for crippling load of a long column whose both ends are hinged using Euler's buckling theory. *[(CO6)(Remember/IOCQ)]*

(c) Define the following term- (i) Slender ratio (ii) Critical or buckling load. *[(CO6)(Remember/LOCQ)]*

4 + 6 + 2 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	13.5	34.4	52.1

Course Outcome (CO):

After the completion of the course students will be able to
1: Define different types of stresses / strains and analyze relationships among them.
2: Classify and analyze statically determinate and indeterminate problems.
3: Examine circular members in torsion and members subject to flexural loadings.
4: Determine the principal stresses and orientations of principal planes for structural members.
5: Assess the governing differential equation for elastic curve of a beam.
6: Interpret the concept of buckling as being a kind of instability and evaluate columns subjected to axial loads.

**LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question.*