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) 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.

(ii) Proof resilience is the maximum energy stored at
(a) plastic limit (b) proportionality limit
(c) elastic limit (d) yield point.

(iii) Variation of shear force in a cantilever beam carrying a load whose intensity varies uniformly from zero at the free end to w per unit at the fixed end is by
(a) cubic law (b) parabolic law
(c) linear law (d) uniform law.

(iv) Deformation of a bar under its own weight is _____ the deformation due to a direct load equal to the weight of the body applied at the lower end.
(a) double (b) four times
(c) half (d) equal to

(v) Modulus of toughness is the area of the stress-strain diagram up to
(a) rupture point (b) yield point
(c) proportionality limit (d) ultimate point.

(vi) A long column has the minimum load taking capacity when its ends conditions are as
(a) both ends are hinged (b) both ends are fixed
(c) one end is fixed other end is free (d) one end is fixed other end is hinged.

(vii) Polar modulus of a shaft is equal to
(a) product of polar moment of inertia and maximum radius of the shaft
(b) ratio of polar moment of inertia to maximum radius of the shaft
(c) sum of polar moment of inertia and maximum radius of the shaft
(d) difference of polar moment of inertia and maximum radius of the shaft.

(viii) The angle of twist of a circular shaft subjected to torque T, can be expressed as
(a) TL/J (b) T/CJ (c) CJ/TL (d) TL/CJ.

(ix) Torsional rigidity of a shaft is equal to
(a) product of modulus of rigidity and polar moment of inertia
(b) sum of modulus of rigidity and polar moment of inertia
(c) difference of modulus of rigidity and polar moment of inertia
(d) ratio of modulus of rigidity and polar moment of inertia.

(x) If the length of the beam carrying a simply supported load is doubled, the deflection at the centre will be
(a) doubled (b) four time (c) eight time (d) sixteen time.

Group–B

2. (a) A steel sleeve of 24 mm internal diameter and 36 mm external diameter encloses an aluminium rod of 22 mm diameter. The length of the rod is 0.4 mm longer than that of the sleeve which is 400 mm long as shown in Fig.1. Determine
(i) the compressive load up to which only the rod is stressed
(ii) the maximum load on the assembly if the permissible stresses in aluminium and steel are 130 MPa and 175 MPa, respectively
(iii) the deformation of the assembly under maximum load Take E_{Al}= 75 GPa and E_{St} = 205 GPa. *[(CO2)(Analyse/IOCQ)]*

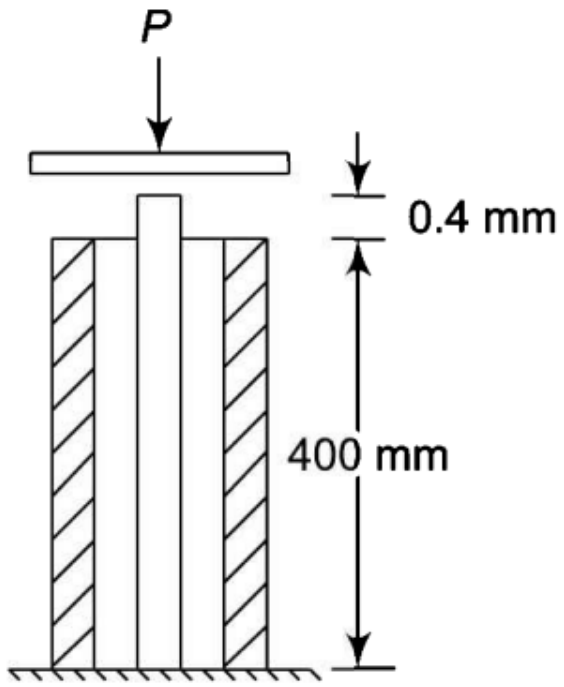

Fig.1

(b) A circular bar of magnesium alloy is 750 mm long. The stress-strain diagram for the material is shown in the Fig.2. The bar is loaded in tension to an elongation of 6.0 mm, and then the load is removed. (i) What is the permanent set of the bar? (ii) If the bar is reloaded, what is the proportional limit? (iii) Find the modulus of resilience both before and after reloading. *[(CO1)(Analyse/IOCQ)]*

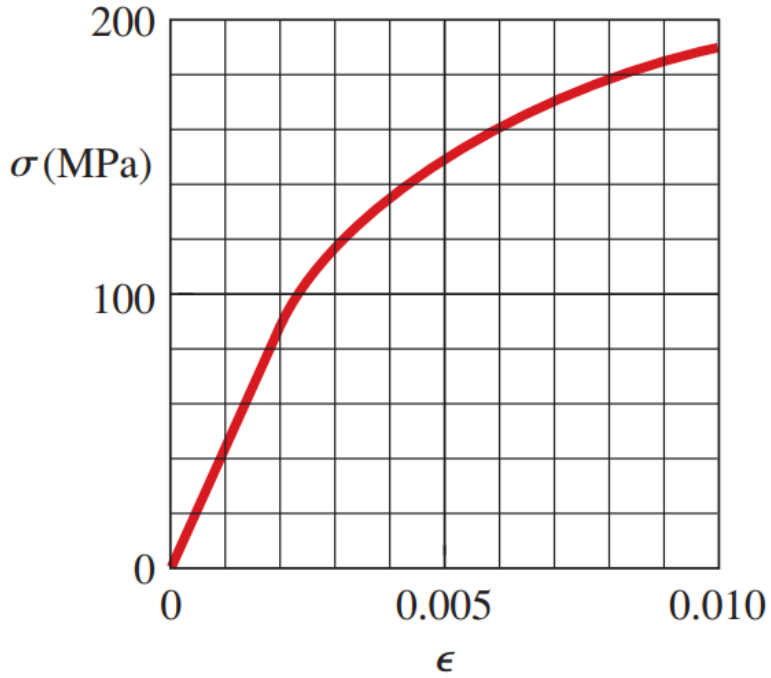

Fig.2

(2 + 3 + 2) + (2 + 1 + 2) = 12

3. (a) An axial load of 56 kN is applied to a bar of 36 mm diameter and 1 m length. The extension of the bar is measured to be 0.265 mm whereas the reduction in diameter is 0.003 mm. Calculate the Poisson's ratio and the value of Elastic Modulus, Shear Modulus & Bulk Modulus. *[(CO1)(Understand/LOCQ)]*

(b) A cylindrical assembly consisting of a brass core and an aluminiumtube is compressed by a load P (see Fig.3). The length of the aluminium tube and brass core is 350 mm, the diameter of the core is 25 mm, and the outside diameter of the tube is 40 mm. Also, the modulus of elasticity of the aluminium and brass are 72 GPa and 100 GPa, respectively.

(i) If the length of the assembly decreases by 0.1% when the load P is applied, what is the magnitude of the load?

(ii) What is the maximum permissible load P_{max} if the allowable stresses in the aluminium and brass are 80 MPa and 120 MPa, respectively? *[(CO2)(Analyse/IOCQ)]*

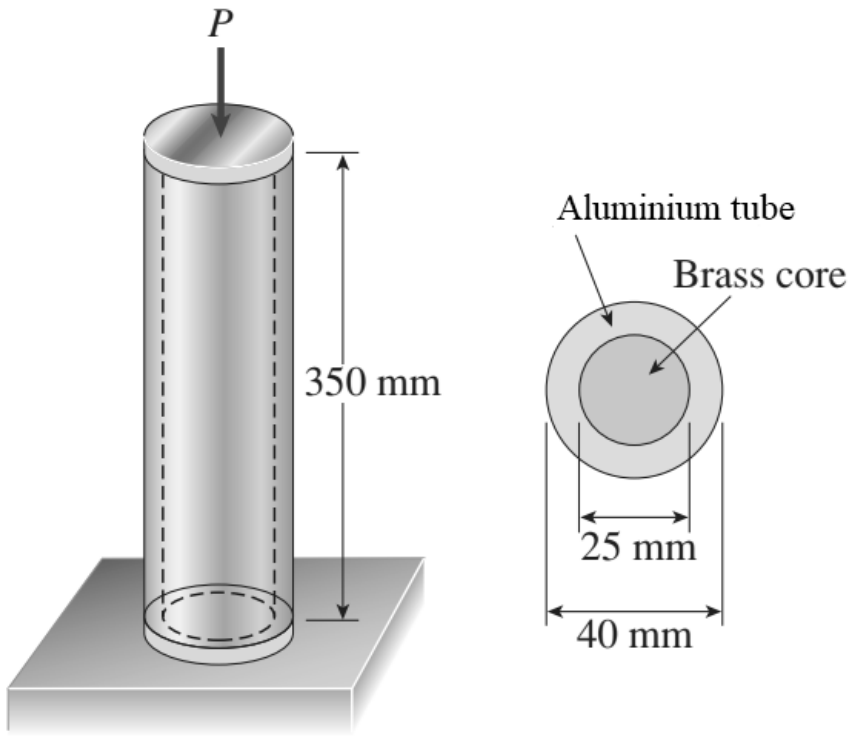

Fig. 3

6 + (3 + 3) = 12

Group - C

4. For the beam and loading shown in Fig.4, draw the SF and BM diagrams and design the cross section of the beam. Take allowable normal stress of 12 MPa. *[(CO5)(Evaluate/HOCQ)]*

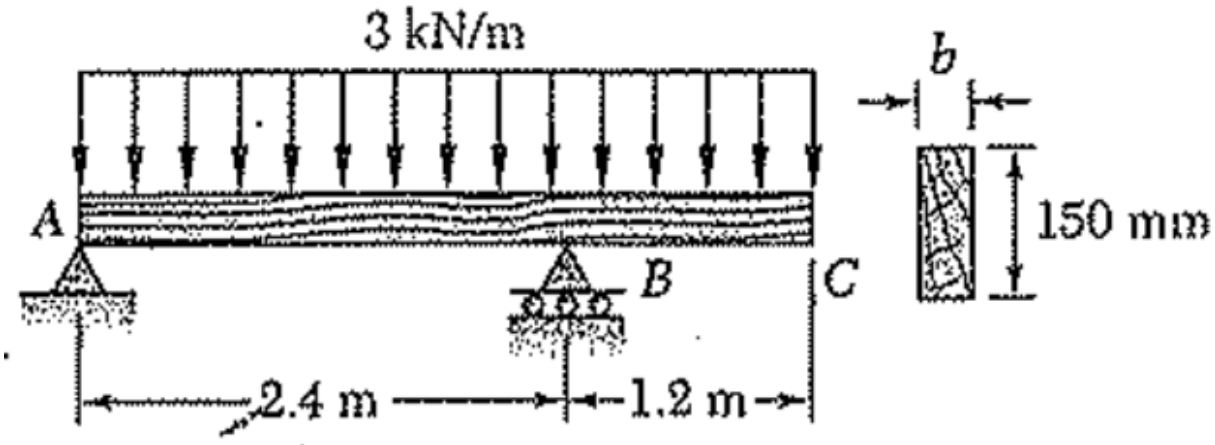

Fig.4

(6 + 6) = 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)(Evaluate/HOCQ)]

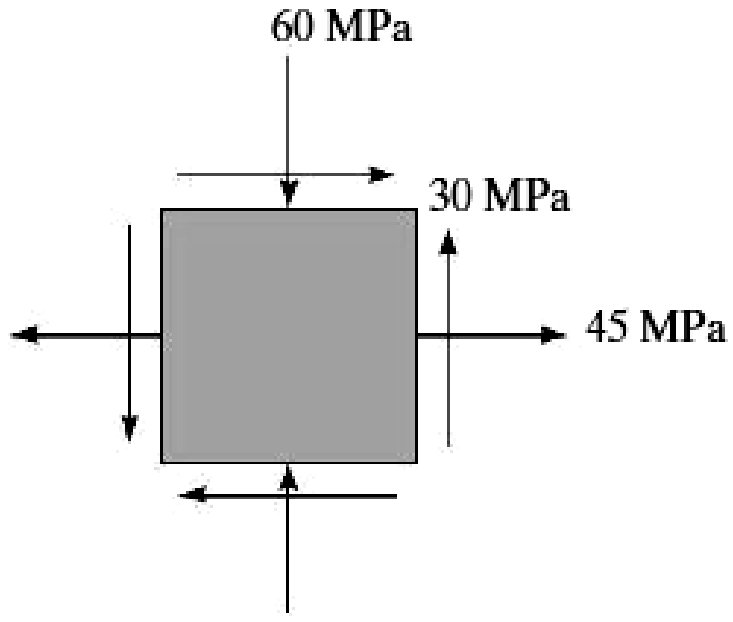

Fig.5

(6 + 6) = 12

Group - D

6. (a) Derive the expression for the slope at the ends of simply supported beam of length l having a concentrated load W at the middle. Assume all necessary requirements. *[(CO5)IOCQ/Analyze]*

   (b) A cantilever of length 3 m is carrying a point load of 50 kN at a distance of 2 m from the fixed end. If I = 10^8 mm^4 and E = 2 × 10^5 N/mm^2, find
   (i) slope at the free end
   (ii) deflection at the free end. *[(CO5)IOCQ/Analyse]*

6 + 6 = 12

7. (a) A beam of length 5 m and of uniform rectangular section is supported at its ends and carries uniformly distributed load over the entire length. Calculate the depth of the section if the maximum permissible bending stress is 8 N/mm^2 and central deflection is not to exceed 10 mm. *[(CO5)IOCQ/ Analyse]*

   (b) A cantilever of length 3 m carries a uniformly distributed load over the entire length. If the deflection at the free end is 40 mm, find the slope at the free end. *[(CO5)IOCQ/Analyze]*

6 + 6 = 12

Group - E

8. (a) A steel shaft ABCD shown in Fig.6, having a total length of 2.4 m consists of three lengths having different sections as follows:
   AB is hollow having outside and inside dia. of 80 mm and 50 mm, respectively and BC and CD are solid, BC having a diameter of 80 mm and CD a diameter of 70 mm. If the angle of twist is the same for each section, determine the length of each section and total angle of twist if the maximum shear stress in the hollow portion is 50 N/mm^2.

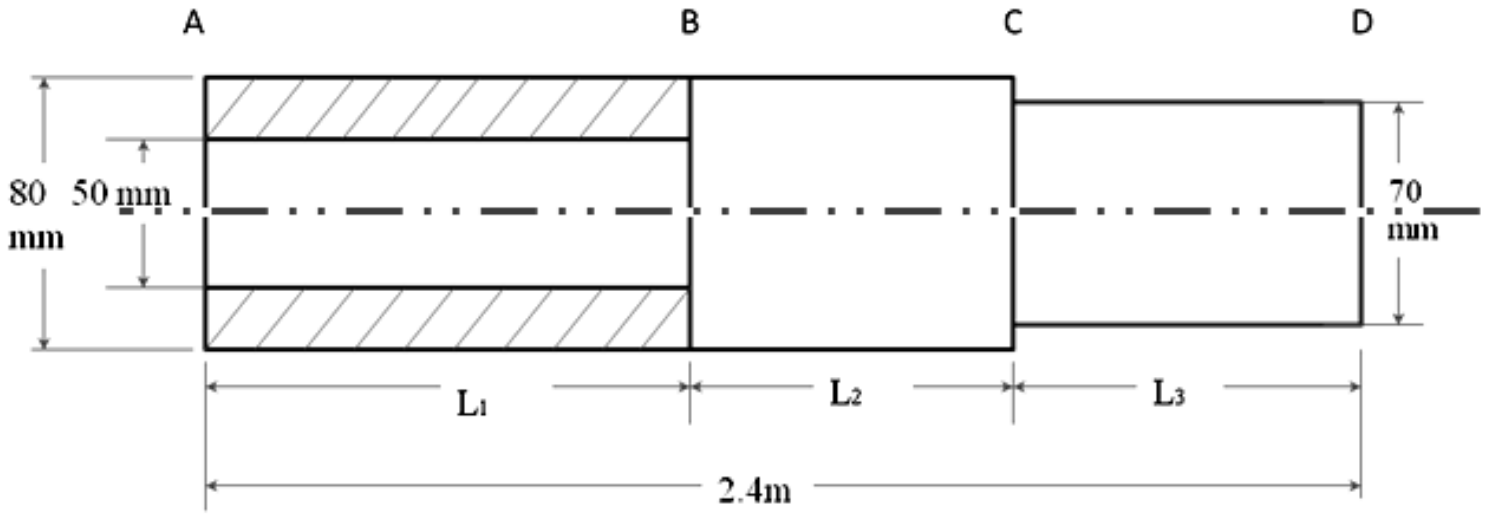

Fig.6

[(CO3)HOCQ/Evaluate]

(b) Determine the maximum strain energy stored in a solid shaft of diameter 10 cm and of length 1.25 m, if the maximum allowable shear stress is 50 N/mm^2. Take modulus of rigidity = 8×10^4 N/mm^2. *[(CO3)IOCQ/Evaluate]*

(3 + 3) + 6 = 12

9. (a) Calculate the safe maximum load that can be applied on to the following structure given in Fig.7, without causing bending of any member. Assume each member is of same material (having modulus of elasticity = E) and of same cross-sectional area = A. Every member can be assumed to be pin connected. *[(CO5)IOCQ/Analyse]*

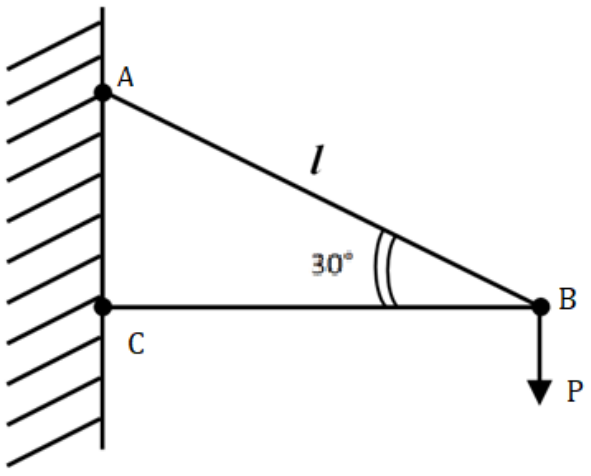

Fig.7

(b) Determine Euler's crippling load for an I section joist 40 cm × 20 cm × 1 cm and 5 cm long shown in Fig.8, which is used as a strut with both ends fixed. Assume E for the joist as 2.1×10^5 N/mm^2.

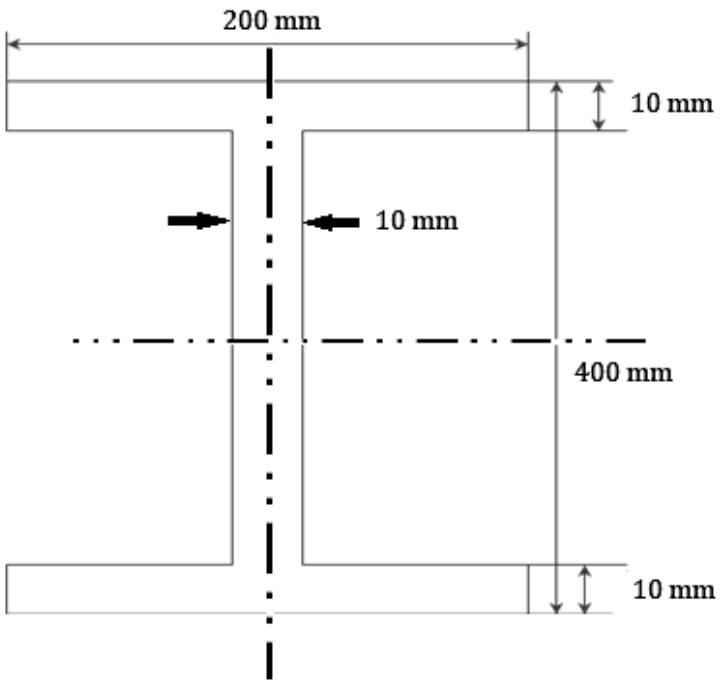

Fig.8

[(CO5)HOCQ/Evaluate]

6 + 6 = 12

Cognition Level	*LOCQ*	*IOCQ*	*HOCQ*
Percentage distribution	*6.25*	*56.25*	*37.5*

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 the 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*