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) Toughness of a material signifies
(a) strength (b) softening (c) brittleness (d) fatigue resistance.

(ii) Young's modulus is defined as the ratio of
(a) Volumetric stress and volumetric strain
(b) Lateral stress and lateral strain
(c) Longitudinal stress and longitudinal strain
(d) Shear stress to shear strain.

(iii) When a member is subjected to bi-axial state of normal stress, the maximum shear stress on an inclined plane is equal to
(a) the sum of normal stresses
(b) half the sum of normal stresses
(c) the difference of normal stresses
(d) half the difference of normal stresses.

(iv) The stress produced by a suddenly applied load as compared to that produced by the same load when applied gradually is _____ times.
(a) 1.5 (b) two (c) three (d) four

(v) The shape of the bending moment diagram for a cantilever beam carrying a uniformly distributed load is
(a) a straight line (b) a hyberbola (c) an ellipse (d) a parabola.

(vi) The energy absorbed in a body, when it is strained within the elastic limits, is known as
(a) Strain energy (b) Resilience (c) Proof resilience (d) Modulus of resilience.

(vii) The neutral axis of the cross-section a beam is that axis at which the bending stress is
(a) Zero (b) Minimum (c) Maximum (d) Infinity.

(viii) The slenderness ratio is the ratio of _____
(a) Length of column to least radius of gyration
(b) Moment of inertia to area of cross-section
(c) Area of cross-section to moment of inertia
(d) Least radius of gyration to length of the column.

(ix) Ratio of diameters of two shafts joined in series is 2. If the two shafts have the same material and the same length, the ratio of their angle of twist is
(a) 2 (b) 4 (c) 8 (d) 16.

(x) If the load on a column is increased to a value that on its removal the deflection remains, the load is known as
(a) Critical load (b) Crippling load (c) Buckling load (d) Safe load.

Group- B

2. (a) A member ABCD is subjected to point loads, P_1, P_2, P_3, and P_4 as shown in Fig.1. Calculate the force P_2 necessary for equilibrium if P_1 = 45 kN, P_3 = 450 kN, P_4 = 130 kN. Determine the total elongation of the member assuming the modulus of elasticity to be 2.1×10^5 N/mm^2. [(CO2)(Remember/LOCQ)]

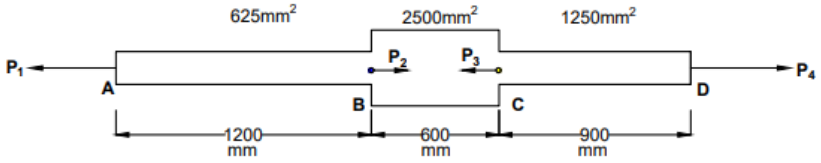

Fig. 1

(b) State Hooke's law. Draw the stress-strain curve for a ductile material. [(CO1)(Remember)/LOCQ)]

6 + (2 + 4) = 12

3. (a) A 2.74 kN tensile load is applied to a test specimen as shown in Fig.2 made of 1.6 mm flat steel plate (E = 200 Gpa, ν = 0.30). Determine the resulting change (i) in the 50 mm gauge length, (ii) in the width portion AB of the test specimen, (iii) in the thickness of portion AB, (iv) in the cross-sectional area of portion AB. [(CO1)(Analyse/IOCQ)]

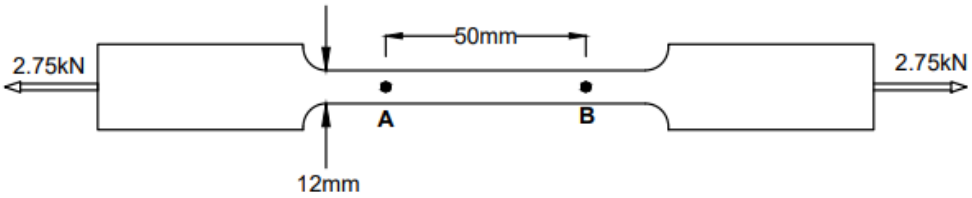

Fig. 2

(b) Derive the expression for elongation of a bar hanging under its own weight. [(CO1)(Understand/LOCQ)]

8 + 4 = 12

Group - C

4. (a) Define the term 'Principal Stress'. [(CO4)(Remember)/LOCQ)]

(b) An elemental cube is subjected to tensile stresses of 30 N/mm² and 10 N/mm² acting on two mutually perpendicular planes and a shear stress of 10 N/mm² (effecting in counter-clockwise direction on the plane bearing bigger tensile stress) on these planes as shown in Fig. 3. Draw the Mohr's circle of stresses and hence determine the magnitudes and directions of principal stresses and also the greatest shear stress. [(CO4)(Evaluate)/HOCQ)]

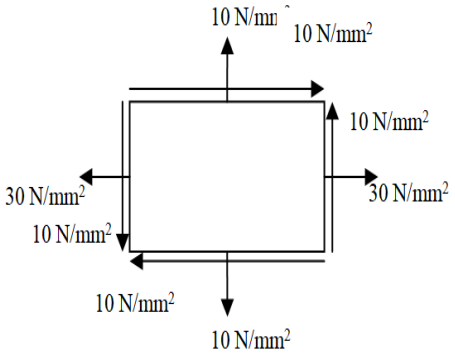

Fig. 3

2 + (4 + 4 + 2) = 12

5. A cantilever 1.5m long as shown in the Fig. 4, is loaded with a uniformly distributed load of 2 kN/m run over a length of 1.25 m from the free end. It also carries a point load of 3 kN at a distance of 0.25 m from the free end. Draw the shear force and bending moment diagrams of the cantilever.
If the beam section is a square one and the maximum bending stress is not to exceed 100 MPa, then find the section size. Also, calculate the stress developed at the bottom fiber of the beam at point C. What is its nature? [(CO5)(Analyze)/IOCQ)]

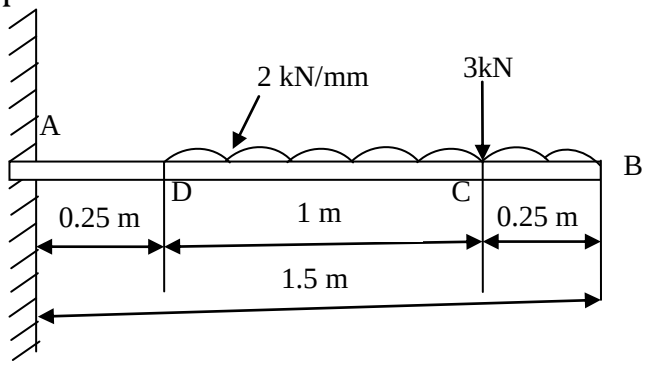

Fig. 4

(6 + 4 + 2) = 12

Group - D

6. The overhanging steel beam ABC carries a concentrated load P at end C as shown in Fig. 5. For the 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 × 10⁶ mm⁴, E = 200 GPa, P = 200 kN, L = 4.5 m, a = 1.2 m. [(CO5)(Analyse/IOCQ)]

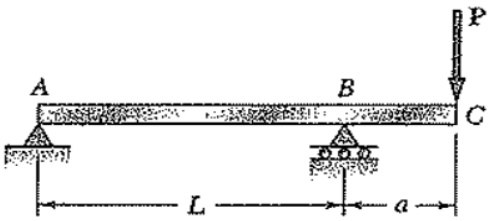

Fig. 5

(6 + 3 + 3) = 12

7. (a) Using the method of work and energy, determine the deflection at point C caused by the load P as shown in Fig. 6. [(CO5)(Apply/IOCQ)]

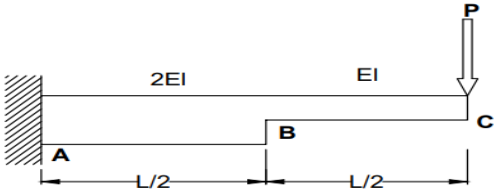

Fig. 6

(b) (i) State the Castigliano's theorem and also write it's mathematical form. [(CO5)(Remember)/LOCQ)]

(ii) The cantilever beam AB supports a uniformly distributed load *w* and a concentrated load P as shown in Fig. 7. Knowing that L = 2 m, *w* = 4 kN/m, P = 6 kN and EI = 5 MN-m^2, determine the deflection at A using Castigliano's Theorem. [(CO5)(Apply/IOCQ)]

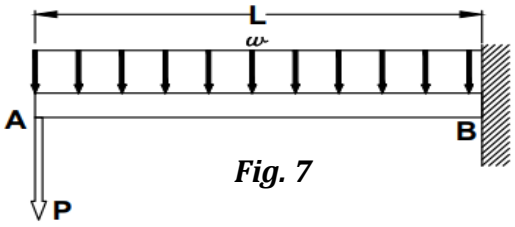

Fig. 7

6 + (2 + 4) = 12

Group - E

8. (a) A 20 m long composite shaft is made up of a steel shaft of 240 mm diameter surrounded by a closely fitted 30 mm thick bronze tube. If the shear stress in the steel shaft is not to exceed 20 MPa, determine the maximum power transmitted by the shaft at 180 rpm. G_s = 84 GPa and G_b = 42 GPa. [(CO6)(Analyse/IOCQ)]

(b) A hollow shaft transmits 280 kW of power at 150 rpm. If the outside diameter of the shaft is 125 mm and the maximum stress developed is 70 MPa, determine the inside diameter of the shaft. [(CO3)(Analyze)/IOCQ)]

6 + 6 = 12

9. A 5 m long simply supported beam is applied a uniformly distributed load of 40 kN/m over the entire span. The deflection at the midspan is observed to be 23 mm. Find the crippling load when this beam is used as a column with one end fixed and the other end hinged. Also, find the crippling load if both the ends are pin joined. [(CO6)(Evaluate/HOCQ)]

(6 + 6) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	20.83	56.25	22.92

Course Outcome (CO):

After the completion of the course students will be able to
1: Define different types of stresses / strains and analyse relationships among them.
2: Classify and analyse 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.