FUNDAMENTALS OF STRENGTH OF MATERIALS
(CIV2101)

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) In a right-angled triangle, the centroid is located
(a) At the midpoint of the hypotenuse
(b) On the hypotenuse
(c) Two-thirds the distance from each vertex along each median
(d) At the intersection of the angle bisectors

(ii) What is the elongation of a bar hanging freely from the top under its own self weight
(a) $\delta l^2/2E$ (b) $\delta l^2/2G$ (c) $\delta l^2/3E$ (d) δ

(iii) A steel bar of square cross-section with each side equal to 10 mm and length 1 m is subjected to an axial load of 120 kN. If the Young's modulus of elasticity of the bar is 200 GPa, the flexibility of the bar is:
(a) 5×10^{-5} mm/N (b) 5×10^{-5} N/mm
(c) 20×10^{3} N/mm (d) 5×10^{-3} mm/N

(iv) At the point of contraflexure
(a) Bending moment is zero (b) Bending moment is zero
(c) Shear force is zero (d) Bending moment changes its sign

(v) A two dimensional element is subjected to pure shear of magnitude 40 MPa. What is the value of the major principal stress?
(a) 40 MPa (b) 60 MPa (c) 80 Mpa (d) 100 MPa

(vi) The bending stress in a simply supported beam subjected to a central point load is maximum:
(a) At the supports (b) At the midpoint of the span
(c) At one-quarter of the span length from the supports (d) At the ends of the beam

(vii) For a determinate pin-jointed plane frame, the relation between the number of joints (j) and Members (m) is given by:
(a) m=2j-3 (b) m=3j-6 (c) m>2j- 3 (d) m> 3j-6

(viii) A shaft is subjected to a twisting moment of 4 kN.m and a bending moment of 3 kN.m. What is the magnitude of the equivalent bending moment?
(a) 8 kN-m (b) 10 kN-m (c) 2 kN-m (d) 4 kN-m

(ix) In the Double Integration Method, the first integration of the bending moment equation *M(x)* with respect to *x* gives:
(a) The shear force in the beam (b) The deflection of the beam
(c) The slope of the beam (d) The bending stress in the beam

(x) A long column has maximum crippling load when it's
(a) both ends are hinged (b) both ends are fixed
(c) one end fixed and other end hinged (d) one end fixed and other end free

Fill in the blanks with the correct word

(xi) Strain energy is defined as the _____ stored in a material due to deformation under load.

(xii) In a beam subjected to shear forces, the maximum shear stress occurs at the _____ of the beam's cross-section.

(xiii) The bending moment diagram is constructed by integrating the _____ force diagram with respect to the length of the beam.

(xiv) The tendency of a long column to fail under axial compressive load by lateral deflection is called _____.

(xv) For both ends hinged, the effective length of a column is equal to _____.

Group - B

2. (a) Find the centroid of the lamina shown in Fig. 1 (All dimensions are in mm.)

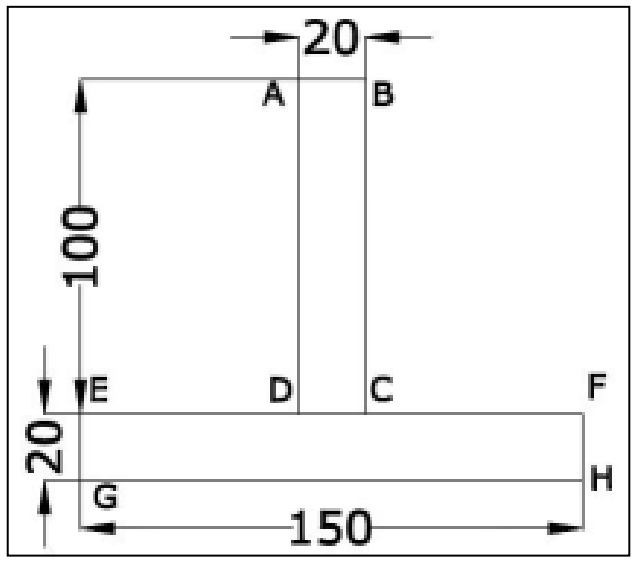

Fig. 1

(b) Determine the value of moment of inertia of the section mentioned in Fig. 1 along both the axes. *[(CIV2101.3)(Analyse/HOCQ)]* *[(CIV2101.4)(Remember/LOCQ)]*

6 + 6 = 12

3. (a) A member ABCD is subjected to point loads P_1,P_2, P_3 and P_4 as shown in the Fig. 2 below.

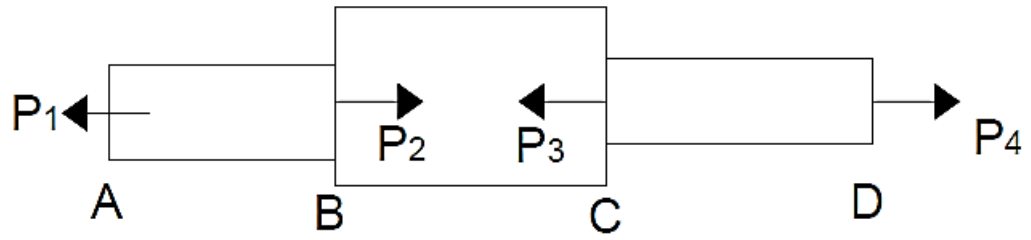

Fig. 2

The area and lengths of respective parts are given below:
(i) AB (area= 625 mm^2 and length =120cm.)
(ii) BC (area= 2500 mm^2 and length =60 cm.)
(iii) CD (area= 1250 mm^2 and length =90 cm.)
Calculate the forces necessary for equilibrium if P_1= 45kN, P_3= 450kN and P_4=130 kN. Determine the total elongation of the member, assuming E= 2.1 X 10^5 N/mm^2 *[(CIV2101.1)(Analyse/HOCQ)]*

(b) A rigid bar AB, 9m long, is suspended by two vertical rods at it's ends and hangs in a horizontal position under it's own weight as shown in Fig. 3. The rod at A is brass; length 4m, cross sectional area 20 cm^2, modulus of elasticity = 10^6 kg/cm^2. The rod at B is steel; length 5m, cross sectional area= 6 cm^2, modulus of elasticity= 2 x 10^6 kg/ cm^2. At what distance 'X' from A may a vertical load P can be applied if the bar is to remain horizontal after the load is applied? *[(CIV2101.1)(Analyze/HOCQ)]*

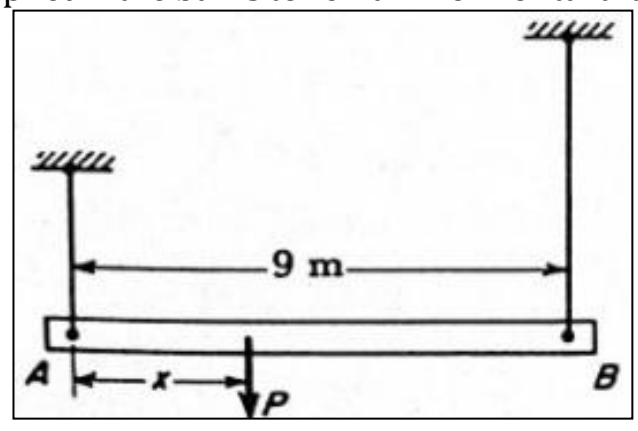

Fig. 3

7 + 5 = 12

Group - C

4. (a) Construct the shear force and bending moment of the following beam shown in Fig. 4. *[(CIV2101.3)(Analyse/HOCQ)]*

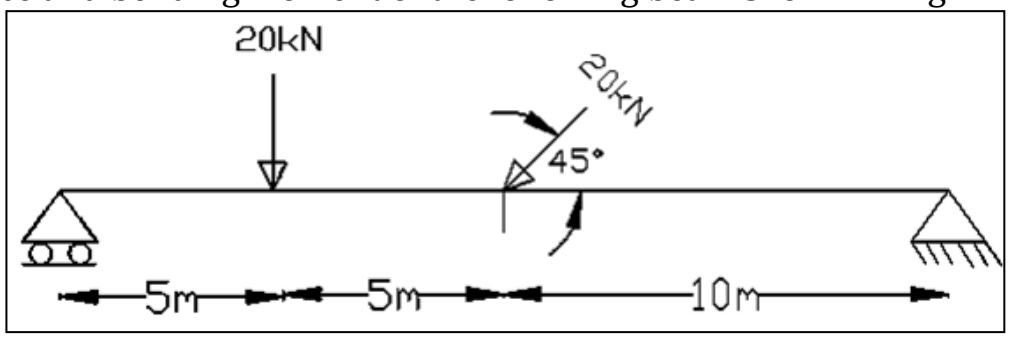

Fig. 4

(b) Construct the shear force and bending moment diagram of the following beam shown in Fig. 5. *[(CIV2101.4)(Remember/LOCQ)]*

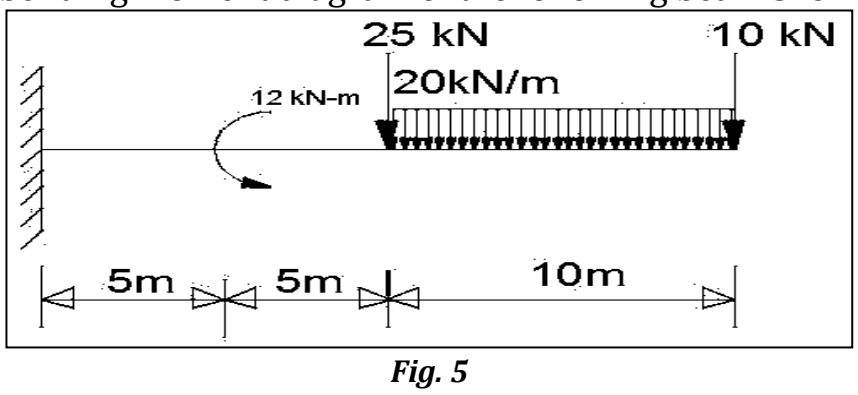

Fig. 5

6 + 6 = 12

5. (a) The state of stress at a point in a body is shown on an infinitesimal rectangular element considered around the point as depicted in the figure in (x, y) coordinate system in Fig. 6. Determine the normal, and shear stresses acting on a plane, the normal to which makes an angle of 40° with the x-axis. Solve the problem using transformation relations.

[(CIV2101.3)(Analyse/HOCQ)]

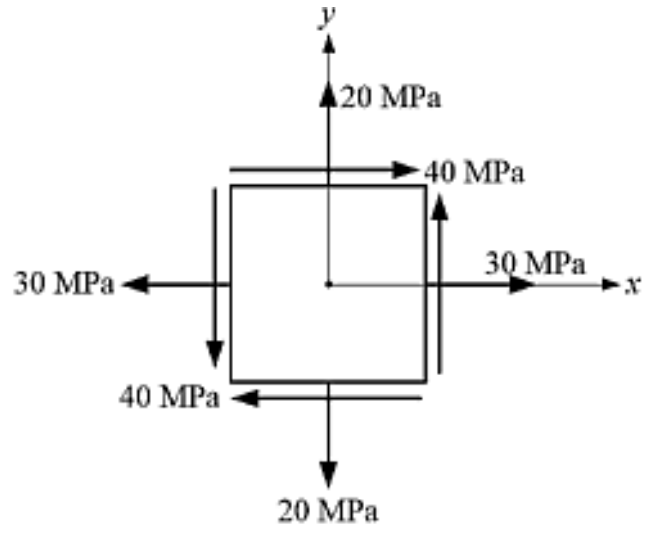

Fig. 6

(b) A thin cylinder of inner radius 500 mm and thickness 10 mm is subjected to an internal pressure of 5 MPa. What is the maximum in-plane shear stress and the maximum shear stress. *[(CIV2101.4)(Analyse/HOCQ)]*

6 + 6 = 12

Group - D

6. (a) A beam is simply supported over a length of 6m. It carries a udl of 12 kN/m and a point load of 9 kN at 2.5 m from the left support. If the bending stress in the timber does not exceed 8 MPa. Design a suitable section making the depth twice the width. *[(CO3)(Analyse/HOCQ)]*

(b) A hollow shaft of external diameter 90 mm and internal diameter 60 mm is subjected to a torque of 8000 Nm. Find the maximum shearing stress. Find also the diameter of the solid shaft to resist the same torque at the same maximum shear stress as for the hollow shaft. *[(CIVL2101.5)(Analyse/HOCQ)]*

7 + 5 = 12

7. Determine the forces in various members of truss as shown in Fig. 7.

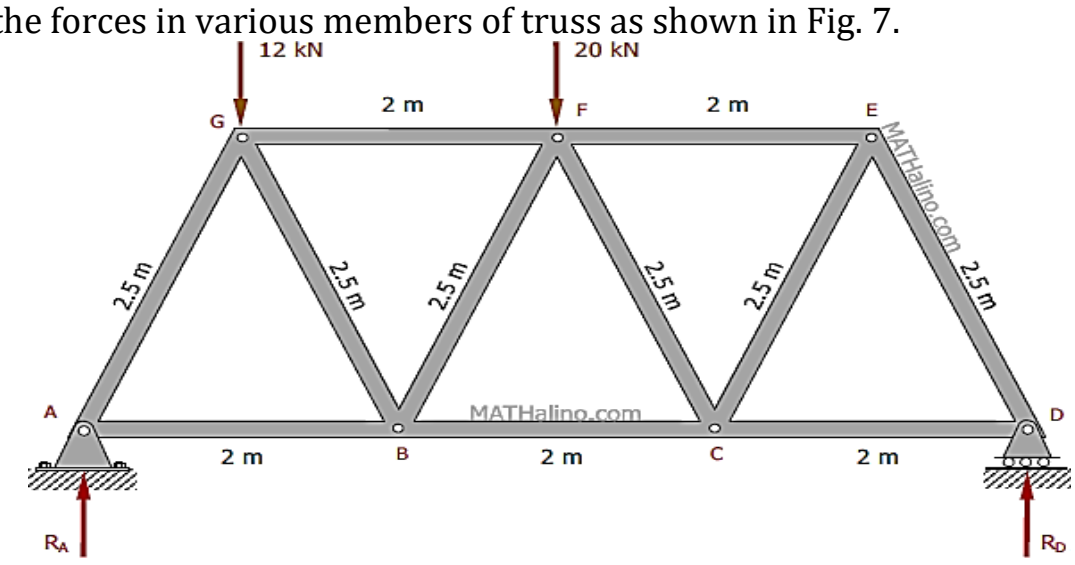

Fig. 7

[(CIVL2101.5)(Analyse/HOCQ)]

12

Group - E

8. (a) Calculate the value of deflection and rotation at the free end of the cantilever beam as shown in Fig. 8 using double integration method. Assume EI to be constant throughout. *[(CIV2101.3)(Analyse/HOCQ)]*

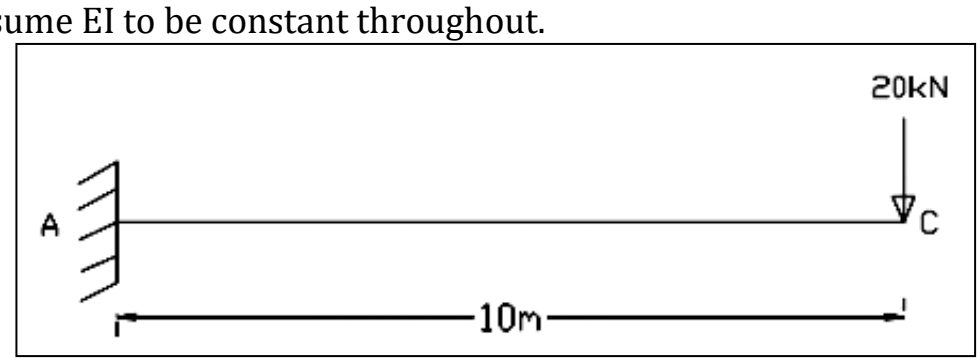

Fig. 8

(b) Derive the expression of strain energy stored in a beam due to bending. *[(CIV2101.4)(Remember/LOCQ)]*

10 + 2 = 12

9. (a) A square column of wood is 2.5 m long with pinned ends. Taking factor of safety as 2.5 in computing Euler critical load and also taking the allowable compressive stress as 12 N/mm^2, find the size of cross section, if the column has to safely support (i) 150 kN, (ii) 275 kN. Take E= 1.3 x 104 N/mm^2. *[(CIV2101.5)(Analyse/HOCQ)]*

(b) Derive the Euler's column buckling for a column with both ends hinged. *[(CIV2101.5)(Remember/LOCQ)]*

7 + 5 = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	19.79	0	80.21