FUNDAMENTALS OF STRENGTH OF MATERIALS
(CIVL 2101)

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) Section modulus of a rectangular section having width b and depth d is given by
(a) $bd^2/6$ (b) $bd^3/8$ (c) $bd/6$ (d) $b^2d/6$.

(ii) A material is referred to as perfectly rigid if modulus of elasticity of the material is
(a) infinity (b) zero (c) equal to carbon (d) unity.

(iii) Maximum shear stress in the transverse section of a beam occurs at
(a) topmost layer of the section
(b) bottom most layer of the section
(c) at the neutral axis
(d) middle layer between neutral axis and topmost layer.

(iv) Maximum deflection of a cantilever beam carrying a point load *P* at the free end with length *l* and Young's modulous E and moment of inertia I is given by
(a) Pl/3EI (b) 3Pl/EI (c) Pl^3/EI (d) $Pl^3/3EI$.

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

(vi) Maximum bending moment in a simply supported beam carrying an udl (w kN/m) is
(a) $wl^2/8$ (b) $wl^2/4$ (c) $wl^3/4$ (d) $wl^2/2$.

(vii) Wherever the bending moment is maximum the shear force is
(a) zero (b) also maximum
(c) minimum (d) does not depend on shear force.

(viii) Torque required to produce unit rotation per unit length of the shaft is expressed as
(a) EI (b) EA (c) GJ (d) GI.

(ix) The ratio of critical buckling load for columns with both ends hinged to columns with both ends fixed is
(a) 0.25 (b) 4 (c) 0.5 (d) 2.

(x) The loading on the conjugate beam is
(a) the load actually applied on the given beam
(b) the shear force diagram/EI
(c) the elastic curve of the beam under the given load system
(d) the bending moment diagram/EI.

Group- B

2. Determine the location of centroid of the area shown in Fig. 1 and also moment of inertia about the centroidal axis.

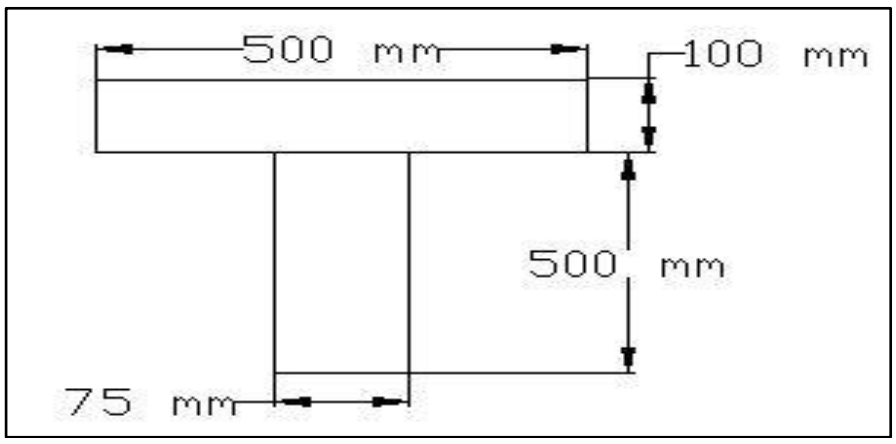

Fig. 1

[(CO1)(Evaluate/HOCQ)]
12

3. (a) What is ductile material and brittle material? [(CO2)(Remember/LOCQ)]
(b) A hollow steel cylinder of length L = 35 cm., inside diameter d = 15 cm. and uniform wall thickness t = 0.3 cm. is filled with concrete and compressed between rigid parallel plates by a load P = 40000 kg. Calculate the compressive stress in each material and the total shortening of the cylinder if modulus of elasticity of steel is 2×10^6 kg/cm^2 and modulus of elasticity of concrete is 2×10^5 kg/cm^2. Assume that, both materials obey Hooke's law. [(CO3) (Evaluation/HOCQ)]
(c) What is bulk modulus? [(CO2) (Remember/LOCQ)]
2 + 8 + 2 = 12

Group - C

4. Apply the concept of shear force and bending moment to draw the SFD and BMD of the following:
(a)

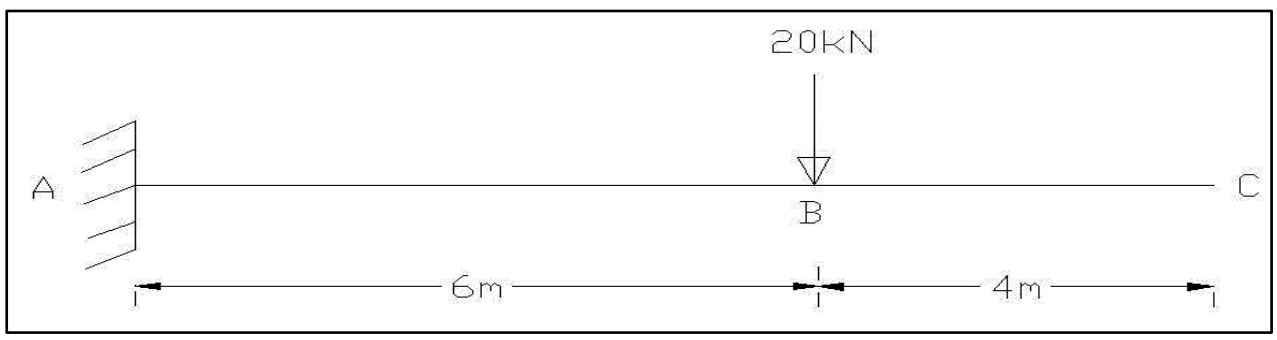

Fig.2

(b)

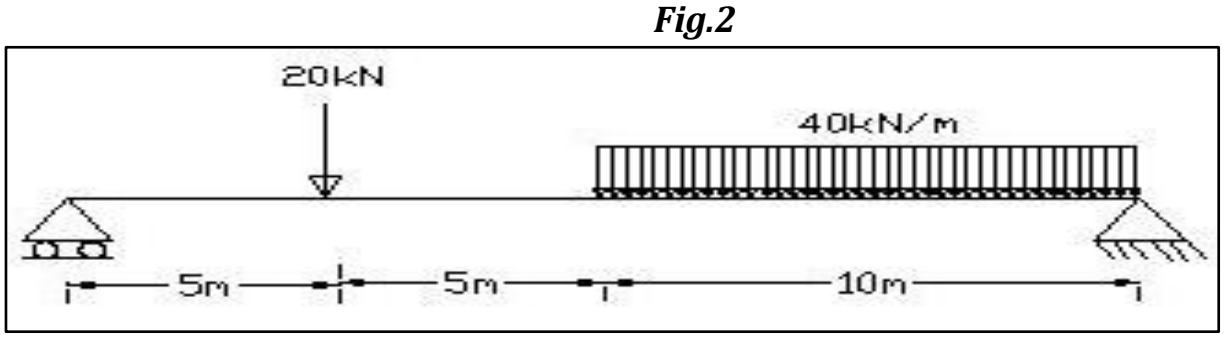

Fig. 3

[(CO4)(Apply/IOCQ)]
6 + 6 = 12

5. (a) Explain the terms Hoop and meridonial stresses. [(CO3)(Understand/LOCQ)]

(b) A cylindrical steel pressure vessel 400 mm. in diameter with a wall thickness of 20 mm. is subjected to an internal pressure of 4.5 MPa.

(i) Calculate the hoop stress and meridonial stress in the steel.

(ii) To what value may the internal pressure be increased if the stress in the steel is limited to 120 MPa. [(CO3) (Evaluation/HOCQ)]

(c) At a point inside a loaded material, σx = +100 MPa, σy = - 40 MPa, τxy = 30MPa. Identify the orientation of principal plane, calculate magnitude of principal stress and maximum shear stress using Mohr's Circle method. [(CO3)(Apply/IOCQ)]

2 + 5 + 5 = 12

Group - D

6. (a) Show that the following relation holds true. Symbols have their usual meanings.

$$\frac{M}{I} = \frac{\sigma}{y} = \frac{E}{R}$$

[(CO3) (Remember/LOCQ)]

(b) Determine the expression for shear stress distribution across the cross section of a beam. Using the expression, draw the shear stress distribution across the transverse section of the beams. The shape of the transverse sections is rectangular. Assume the dimensions of the beam as suitable. [(CO3) (Evaluate/HOCQ)]

6 + 6 = 12

7. (a) Determine the forces in the various members of the truss shown in Fig.4.

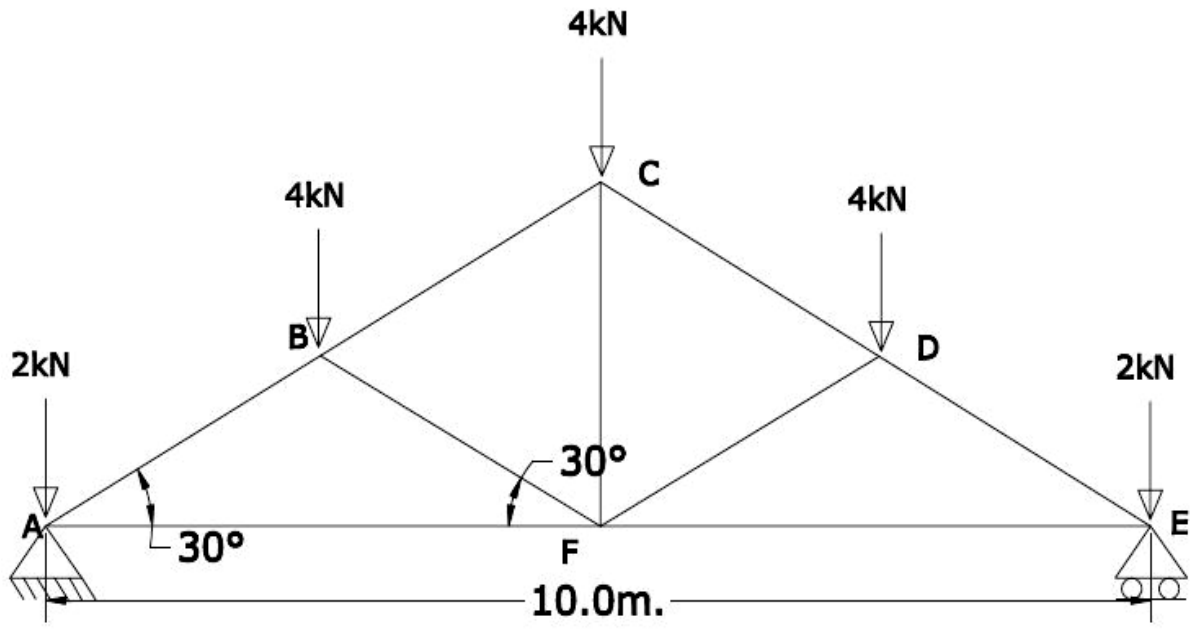

Fig. 4

[(CO3)(Analyse/IOCQ)]

(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 solid shaft to resist the same torque at the same maximum shear stress as for the hollow shaft. [(CO5) (Evaluation/HOCQ)]

6 + 6 = 12

Group – E

8. (a) Examine the critical load for a long column having both ends hinged using Euler's theory. The column has length '*L*', uniform cross-sectional area 'A' and rigidity '2EI'. [(CO6) (Analyse/IOCQ)]

(b) Determine the minimum thickness required for a steel pipe column of outer diameter 160 mm. and 7.2 m. length, to carry an axial load of 200 kN. Assume a factor of safety of 2.5. Take E = 200 kN/mm². Consider that the both ends of the column are hinged.

[(CO6) (Evaluation/HOCQ)]

6 + 6 = 12

9. A beam of span 30m carries a point load as shown in Fig.5. The moment of inertia (I) of the beam is assumed to be constant throughout. Evaluate slope and deflection at the free end and at the midpoint. Use conjugate beam method. Assume material to be uniform throughout.

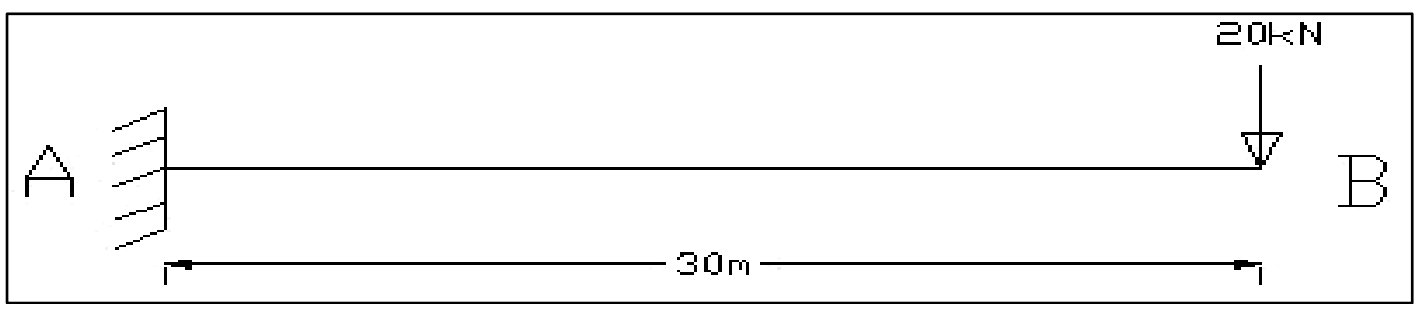

Fig. 5

[(CO4)(Evaluation/HOCQ)]

12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	12.5	30.21	57.29

Course Outcome (CO):

After the completion of the course students will be able to

1. Illustrate the equilibrium conditions and the concept of centre of gravity, moment of inertia of various sections.
2. Explain the elastic properties of ductile and brittle materials through stress-strain curves.
3. Determine various types of forces and stresses developed in structural elements.
4. Calculate the bending moment, shear force and deflection of beams along with developed strain energy under various loads and shear center and shear flow of prismatic sections.
5. Identify torsional moment and twist on a circular shaft.
6. Calculate the buckling load of columns using Euler's theory for different support conditions.

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