FUNDAMENTALS OF STRENGTH OF MATERIALS
(CIVL 2101)

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

(ii) 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) $b^2d/6$.

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

(iv) An I-section is subjected to a shear force F. The maximum shear stress will occur at
(a) top of the section
(b) neutral axis of the section
(c) junction of web and flange
(d) bottom of the section.

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

(vi) Wherever there is a jump in a bending moment diagram of a beam, it signifies that, there is an
(a) mass is zero
(b) beam cross section is circular
(c) applied point load at that point
(d) applied moment at that point.

(vii) Point of contraflexure is that point where
(a) shear force is negative
(b) bending moment is negative
(c) shear force changes sign
(d) bending moment changes sign.

(viii) Hook's law holds good up to
(a) Elastic limit
(b) Proportional limit
(c) Breaking point
(d) Plastic limit.

(ix) If the Young's modulus of elasticity of a material is twice it's modulus of rigidity, then the Poisson's ratio of the material is
(a) -1 (b) 0.5 (c) -0.5 (d) zero.

(x) The radius of Mohr's circle for two equal but unlike principal stresses of magnitude 'σ'
(a) σ (b) σ/2 (c) σ/4 (d) zero.

Fill in the blanks with the correct word

(xi) Width of beam 200mm and depth 300mm, then moment of inertia of the rectangular section is _____ mm^4.

(xii) Area under the stress-strain diagram up to proportional limit is known as _____.

(xiii) Euler's buckling load for column of length 'l', fixed at one end and hinged at the other end will be given by: _____.

(xiv) Slenderness ratio of a 5m long column hinged at both ends and having a circular cross-section with diameter 160 mm is _____.

(xv) Maximum shear stress in an element occurs at _____ degrees with the _____ plane.

Group - B

2. (a) Determine the magnitude of force 'P', required for a 100 kg mass in the position as shown (Fig.1) below via strings of negligible mass.

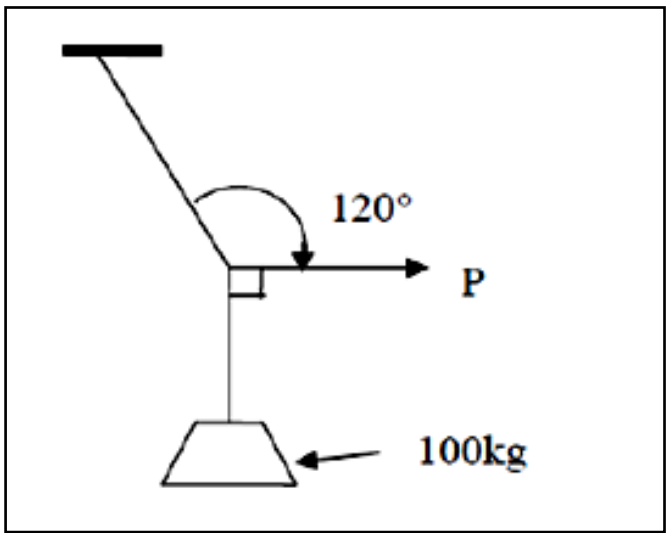

Fig.1

[(CO3)(Evaluate/HOCQ)]

(b) A bar of uniform diameter 25 mm is subjected to load as shown in the Fig.2. Determine the total elongation of the bar. Take E = 210 GPa.

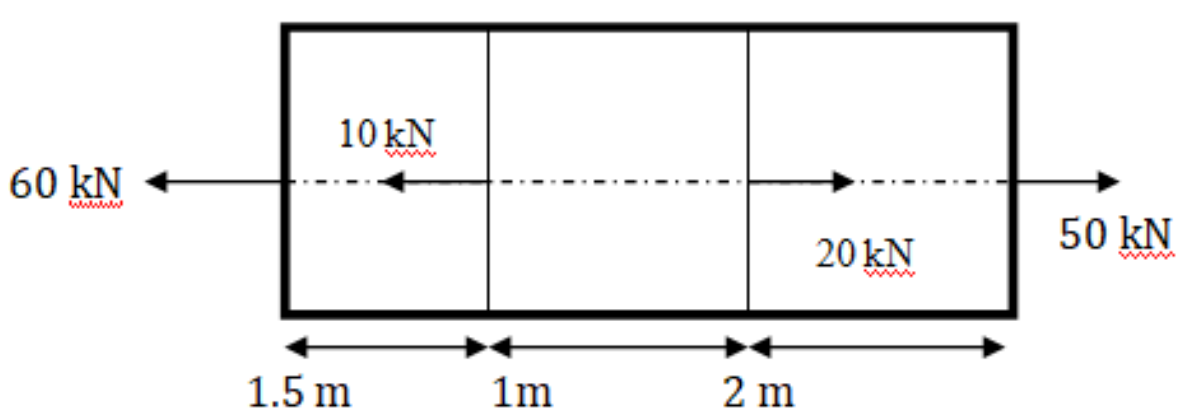

Fig.2

[(CO3)(Evaluate/HOCQ)]

(c) Develop the relationship between elastic constants E, G, K and Poisson's ratio μ is E = 2G (1+μ) = 3K (1-2μ).

[(CO2)(Apply/IOCQ)]

3 + 6 + 3 = 12

3. (a) Determine the position of centroid of the section as shown in Fig.3 about X-X axis. All dimensions are in mm.

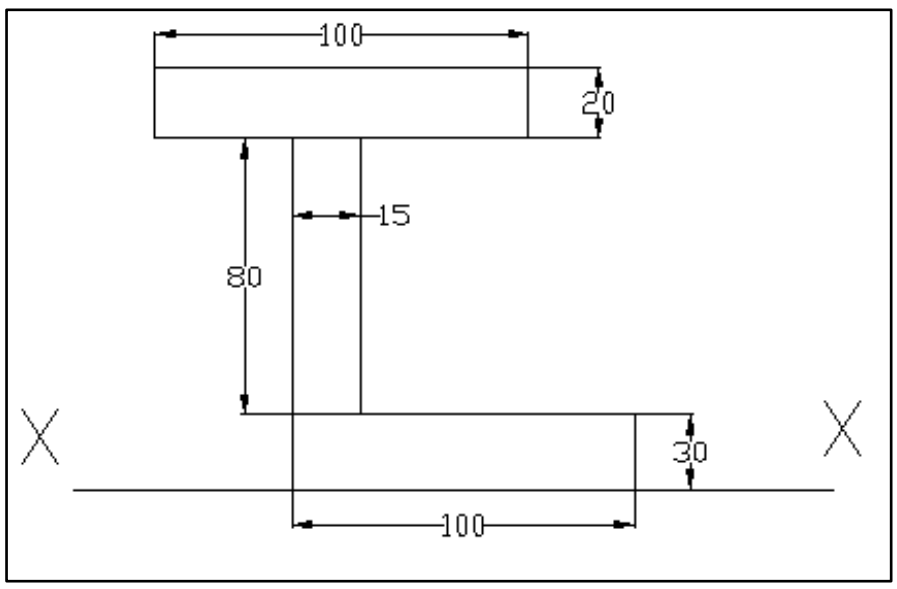

Fig.3

[(CO1)(Evaluate/HOCQ)]

(b) Illustrate the concept of centre of gravity, centre of mass and centroid.

[(CO1)(Understand/LOCQ)]

10 + 2 = 12

Group - C

4. (a) Develop the shear force and bending moment diagrams of the following beam (ref. Fig.4).

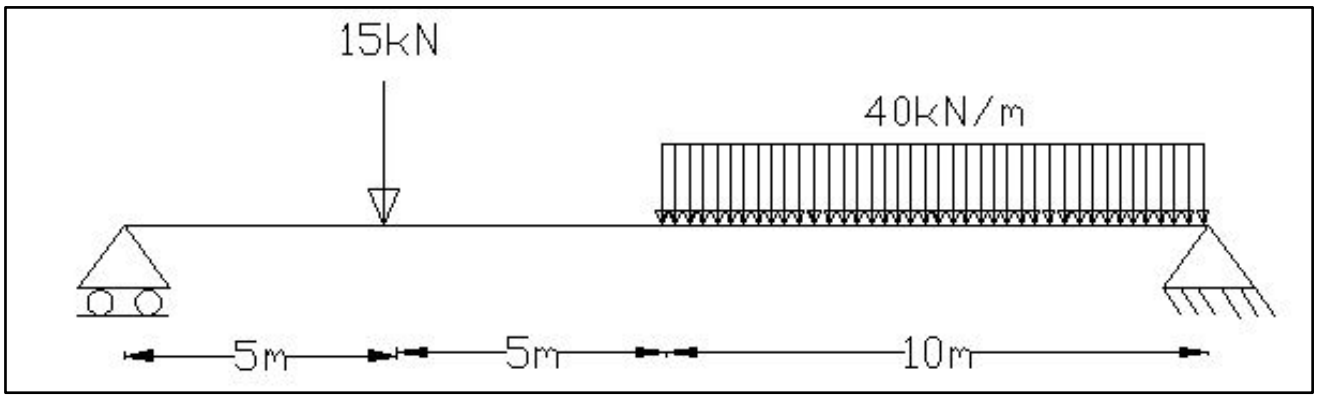

Fig.4

[(CO4)(Apply/IOCQ)]

(b) Develop the relation between applied load, shear force and bending moment.

[(CO4)(Apply/IOCQ)]

10 + 2 = 12

5. (a) At a point in the web of a simply supported girder (Fig.5), the horizontal bending tensile stress is 80 MPa and the shearing stress at the same point is 35 MPa. Determine the following:
(i) principal stress
(ii) maximum shear stress
(iii) tensile stress, which, when acting alone would produce the same maximum shear stress.

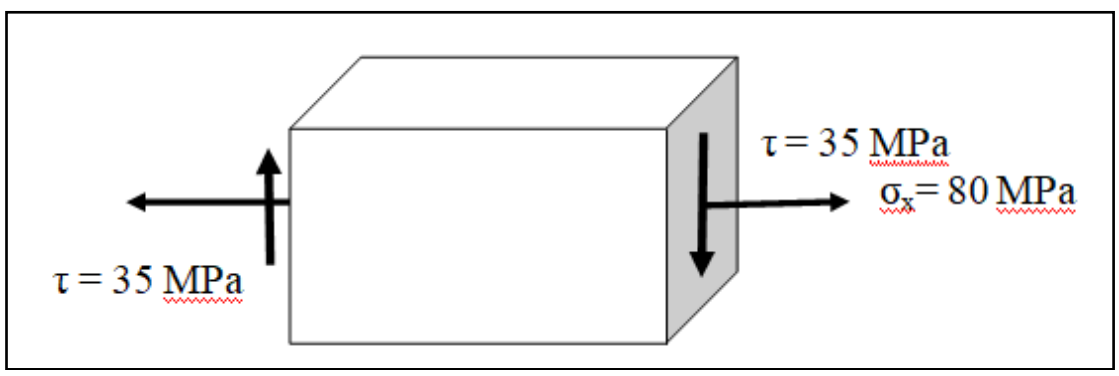

Fig.5

[(CO3)(Evaluate/HOCQ)]

(b) A hollow closed cylindrical shell made of 1 cm thick steel plate, 2 m long, has an internal diameter of 1000 mm. If it is subjected to an internal fluid pressure of 2 MPa, find the magnitude of hoop (circumferential) stress and meridonial (longitudinal stress). What are the value of change in diameter and length of shell? Also, determine the value of change in volume of shell.

[(CO3)(Evaluate/HOCQ)]

8 + 4 = 12

Group - D

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

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

[(CO4)(Understand/LOCQ)]

(b) Determine the maximum bending stress that will develop in the beam as shown in Fig.6. Beam has cross section of 200 mm width and 450 mm depth and Young's modulus 2×10^5 N/mm^2.

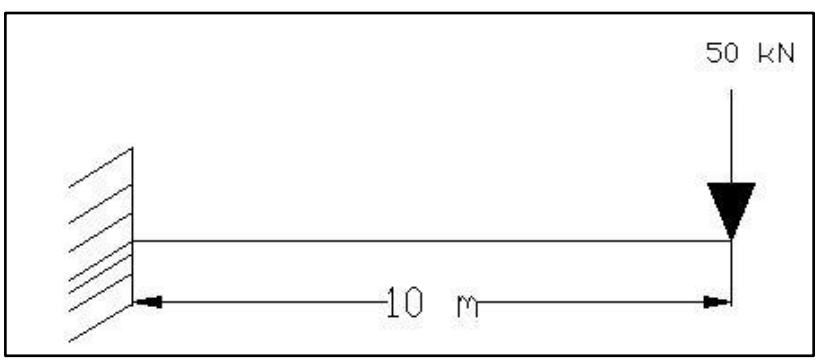

Fig.6

[(CO4)(Evaluate/HOCQ)]

(c) Explain the term shear centre.

[(CO4)(Understand/LOCQ)]

6 + 4 + 2 = 12

7. (a) Evaluate the member forces in the truss as shown Fig.7 using Method of Joints.

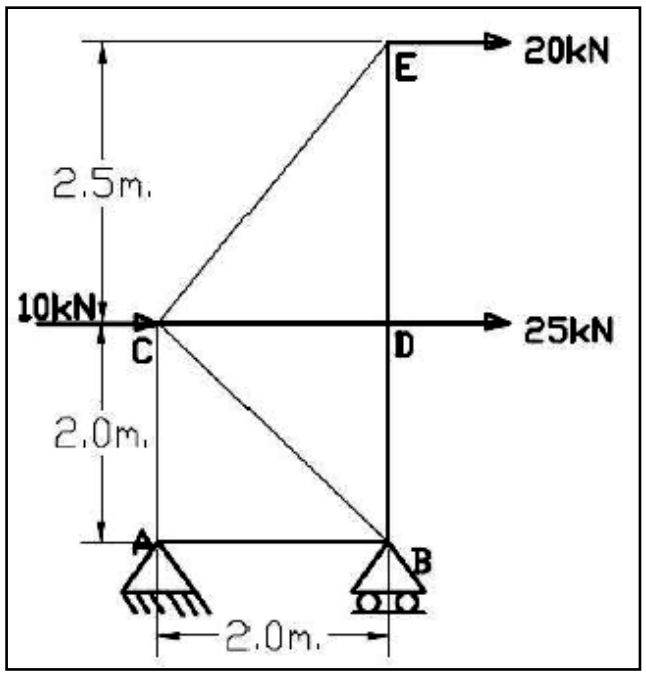

Fig.7

[(CO3)(Evaluate/HOCQ)]

(b) Determine the maximum stress and deformation of a shaft of 100 mm. external diameter, 10 mm wall thickness and 2.7 m length subjected to a torque of 30 kN-m. Assume G = 75 GPa for the material.

[(CO5)(Evaluate/HOCQ)]

7 + 5 = 12

Group - E

8. (a) Estimate the deflection of the beam as shown in Fig.8 at the free end. Flexural rigidity (*EI*) is constant throughout. Use conjugate beam method.

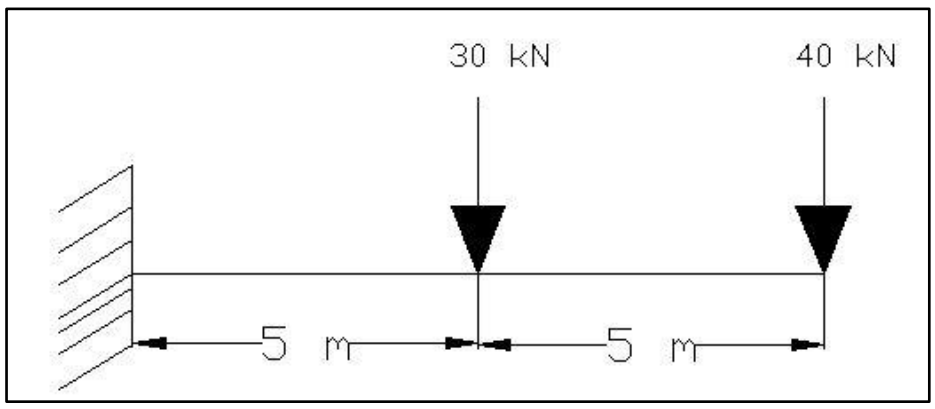

Fig.8

(CO4)(Evaluate/HOCQ)]

(b) Explain the term strain energy. *[(CO4)(Understand/LOCQ)]*

10 + 2 = 12

9. A 2 m long pin ended column of square cross-section is to be made of wood. Assuming, E = 12 GPa, allowable stress being limted to 12 MPa, determine the size of the column to support the following loads safely:
(i) 95 kN (ii) 200 kN.
Use Factor of safety as 3.0, and Euler's crippling load for buckling. *[(CO6)(Evaluate/HOCQ)]*

12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	12.5	15.63	71.87

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.*