ADVANCED STRUCTURAL ANALYSIS
(CIVL 3244)

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) Flexibility method is a
(a) Force method (b) Displacement method
(c) Energy method (d) Numerical method.

(ii) Stress invariant l_z is given as
(a) $\sigma_x\sigma_y + \sigma_y\sigma_z + \sigma_z\sigma_x$ (b) $\sigma_x + \sigma_y + \sigma_y$
(c) $\tau_{xy}^2 + \tau_{yz}^2 + \tau_{zx}^2$ (d) $\sigma_x\sigma_y + \sigma_y\sigma_z + \sigma_z\sigma_x - \tau_{xy}^2 - \tau_{yz}^2 - \tau_{zx}^2$

(iii) The direction cosine of octahedral plane to the three axes of reference are
(a) $\pm 1/\sqrt{2},\ \pm 1/\sqrt{2}, \pm 1/\sqrt{2}$ (b) $\pm 1/\sqrt{3}, \pm 1/\sqrt{3}, \pm 1/\sqrt{3}$
(c) $\pm \sqrt{3}/2,\ \pm \sqrt{3}/2, \pm 1/\sqrt{2}$ (d) $\pm 1/\sqrt{2}, \pm 1/\sqrt{3}, \pm \sqrt{3}/2$

(iv) Size of the stiffness matrix for a structure having 3 DOF is
(a) 6×6 (b) 3×3 (c) 9×9 (d) 2×2.

(v) The rotational stiffness of a beam when far end is hinged, is
(a) 3EI/L (b) 2EI/L (c) 4EI/L (d) 5EI/L.

(vi) Anticlastic shell has
(a) positive Gaussian curvature (b) negative Gaussian curvature
(c) zero Gaussian curvature (d) all of these.

(vii) The Navier's solution of bending of simply supported plate is based on
(a) double trigonometric series (b) single trigonometric series
(c) single Fourier series (d) double Fourier series.

(viii) A cylindrical shell is
(a) rotational shell (b) singly ruled surface
(c) doubly ruled surface (d) non-developable surface.

(ix) The finite difference representation of the first derivative is given by

(a) $\frac{1}{2h}(w_{i+1} - w_{i-1})$ (b) $\frac{1}{2h}(w_{i-1} - w_{i+1})$

(c) $\frac{1}{h}(w_{i+1} - w_{i-1})$ (d) $\frac{1}{h}(w_{i+1} + w_{i-1})$

(x) Civil engineering shell are considered as shallow if ratio of maximum rise to least plan dimension

(a) is less than 1/5 (b) is less than 1/10

(c) is more than 1/5 (d) is more than 1/10.

Fill in the blanks with the correct word

(xi) The differential equation of isotropic plate subjected to external load of intensity q is _____ order differential equation.

(xii) A shell with doubly curved surface is known as _____.

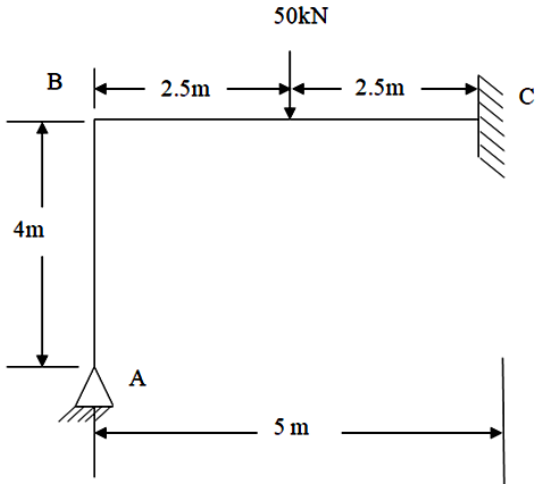
(xiii) In case of cylindrical shell the radius of curvature along beam direction is _____.

(xiv) Boundary conditions are known in _____ value problem.

(xv) A plane that is equally inclined to the three axes is called an _____ plane.

Group - B

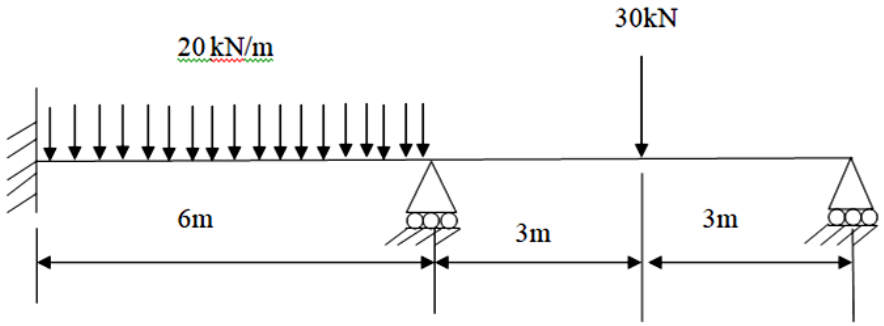
2. Analyze the frame shown in Fig. using stiffness method. EI is same for all members.



[(CO1,CO2)(Analyze/IOCQ)]

12

3. Analyse the continuous beam shown in fig. by Flexibility method. Consider EI is same for both members.



[(CO1,CO2)(Analyze/IOCQ)]

12

Group - C

4. (a) Show the schematic representation of derivatives up to fourth order using central difference technique. *[(CO2,CO4)(Remember/LOCQ)]*

   (b) Solve for central maximum deflection of a simply supported beam of span $'l'$ under uniform load $'q'$ using finite difference technique with four equal parts. *[(CO2,CO3,CO4)(Apply/IOCQ)]*

2 + 10 = 12

5. (a) Estimate the critical buckling load for a column with both ends simply supported using finite difference method. *[(CO2,CO3,CO4)(Analyze/IOCQ)]*

   (b) Solve the following set of simultaneous equation to find the unknown stress $\sigma_1, \sigma_2, \tau_{12}$ using the relaxation technique.

   $8\sigma_1 + 2\sigma_2 - \tau_{12} = 3; 2\sigma_1 - 10\sigma_2 + 3\tau_{12} = 5; \sigma_1 + 5\sigma_2 + 7\tau_{12} = 6$

[(CO2,CO4)(Apply/LOCQ)]

6 + 6 = 12

Group - D

6. (a) Derive the expression for deflection and bending moments of a simply supported rectangular plate subjected to sinusoidal load $q = q_0 sin\frac{\pi x}{a} sin\frac{\pi y}{b}$. Also calculate the maximum deflection and bending moments. *[(CO2,CO3,CO4)(Evaluate/HOCQ)]*

   (b) Write the assumptions of classical plate theory. *[(CO2,CO4)(Remember/LOCQ)]*

10 + 2 = 12

7. Tabulate the stresses $N_\theta, N_x, N_{x\theta}$ for $x = -\frac{l}{2}, 0$ and $\theta = 0, -\varphi$ for snow load of cylindrical shell of span 8.0m, height of crown 1.5m and 75mm thick. The length of the shell along the beam direction is 10 m. *[(CO2,CO3,CO4)(Evaluate/HOCQ)]*

12

Group - E

8. A rectangular block of material is subjected to a tensile stress of 10,000 N/mm^2 on a plane and a tensile stress of 4000 N/mm^2 at right angles to the former together with a shear stress of 6000N/mm^2 on the same planes.
   Find (i) The direction of principal planes.
   (ii) Magnitude of maximum shear stress and the corresponding plane.
   (iii) Normal stress on the planes of maximum shear stress
   (iv) Stresses on a plane inclined at 30^0 to the plane carrying the stress of 10000 N/mm^2. *[(CO5,CO6)(evaluate/HOCQ)]*

12

9. Write short note on the following:
   (i) Plane stress and plain strain problem
   (ii) Spherical and deviator stress

(iii) Stress invariants
(iv) Octahedral stress. *[(CO4)(Understand/LOCQ)]*

(4 × 3) = 12

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	22.92	41.67	35.41

Course Outcome (CO):

After the completion of the course students will be able to

1. Apply stiffness and flexibility method using system approach.
2. Develop skill in understanding the behavior of plates and analytical techniques to solve the two dimensional structural engineering problems.
3. Construct the mathematical models of structural systems.
4. Understand the application of differential equations for the response of 2 D problem.
5. Define 3D state of stress and strains, equilibrium and compatibility.
6. Derive the governing equations and their solutions for application to problems in plane stress state, plane strain state, torsion, bending.

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