**CAD & Finite Element Analysis (MCL311)**

**Major Exam: Sem II – 2021-2022**

Date: 12/04/2022 Total Marks: 100 Time: 2 hours

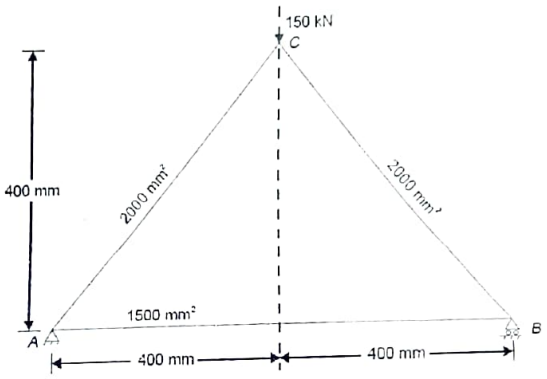
## PART-A

Total Marks: 60

1. Explain the following with suitable diagrams: (i) Isoparametric, (ii) Subparametric and, (iii) Superparametric elements. **[10]**

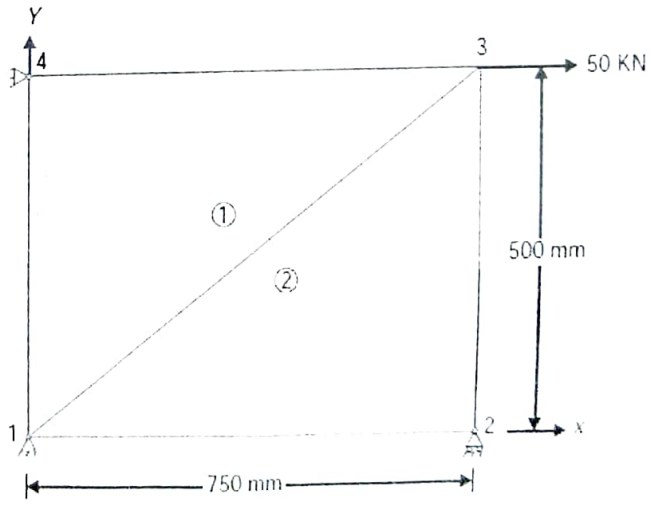
2. What is meant by mesh refinement? Why do we do mesh refinement? Describe different types of mesh refinement with suitable diagrams. **[10]**

3. For the three – bar truss shown in the adjacent figure, determine the nodal displacements and the stress in each member using FE method. Find the support reactions also. Take modulus of elasticity as 200 GPa. **[20]**




[Division of marks: element stiffness matrices for three members: 2×3=6; global stiffness matrix: 4; prescription of boundary condition & reduced global stiffness matrix: 2; nodal displacements: 3; stresses in each member: 3; support reactions: 2]

4. Find the nodal displacements and element stresses in the propped beam shown in Fig. 12.2. Idealize the beam into two CST elements as shown in the figure. Assume plane stress condition. Take $\mu$ = 0.25, E = $2\times10^5$ N/mm$^2$, Thickness = 15mm. **[20]**




[Division of marks: element stiffness matrices for two elements: 4×2=8; global stiffness matrix: 3; prescription of boundary condition & reduced global stiffness matrix: 3; nodal displacements: 3; stresses in each member: 3]

## PART-B

Total Marks: 40

**1.** Fill in the blanks (write what is to be filled in your answer sheet) [2]

a. $C^1$ level continuity in two curve segments ensures that the _ _ _ _ _ _ _ _ _are same and slopes are _ _ _ _ _ _ _ _

b. In oblique projection, view lines converge at _ _ _ _ _ _ _ _ _ _ _ distance from the object.

c. In perspective projection, view lines converge at _ _ _ _ _ _ _ _ _ _ _ distance from the object.

d. A bicubic/hermite surface patch requires at least _ _ _ _ _ _ _ _ _ independent scaler values for it to be defined uniquely.

e. _ _ _ _ _ _ _ parametric form of PC curves is preferred as compared to _ _ _ _ _ _ _ parametric form for designing in CAD.

**2.** Answer the following (write to the point)

a. Which form of mathematical equations are highly preferred to represent a geometric entity in computer aided modeling? Provide at least three distinct and clear arguments/reasons for the preference. [2]

b. Mention two key advantages of using homogeneous coordinate for geometric transformations. [1]

c. Mention two characteristic properties of B-spline curves which are uniquely different from Bezier curves and PC curves. [1]

d. In b-spline curves, for a given value of **k**, what happens when the number of control points are increased? Specifically, what is the effect on [2]

i. order of blending functions
ii. order of the curve
iii. number of curve segments
iv. influence of a control point on local control of curve/segments

**3.** Given three control points on the xy-plane (-1,0), (0,1) and (2,0) [8]

i. Write down the corresponding Bézier curve equation.
ii. Since there are three control points, there are three Bézier coefficients. Write down their equations and sketch their graphs (in one plot, in order to compare).
iii. Use your calculator to find enough number of points using the conventional parametric form and sketch the curve. (2 to 3 extra points other than the given points may be sufficient).

**4.** Given a point *P*(1,2,-5), translate it by $\mathbf{d} = 2\hat{\imath} + 3\hat{\jmath} - 4\hat{k}$ and then rotation by 30° about the Z-axis. What is the final point? If the point P was rotated first before translation will the new point be the same as before? [6]

**5.** Starting from the algebraic equation of PC curves $\boldsymbol{p}(u) = \boldsymbol{UA}$, derive the geometric form of PC curves $\boldsymbol{p}(u) = \boldsymbol{UMB}$, given the standard geometric input $[\boldsymbol{p_0}, \boldsymbol{p_1}, \boldsymbol{p_0^u}, \boldsymbol{p_1^u}]$. Show all the steps clearly. [8]

6. Shown in figure below, is a cubical object in three dimensional space, and an arbitrary plane which passes through the point $(x_o, y_o, z_o)$ and having direction cosines$(l, m, n)$. In a certain CAD modeling procedure, it is desired to obtain the reflection of cubical object about this arbitrary plane. For this purpose, it is required to find a transformation which can be implemented in computer to find the reflection of the object. Develop a transformation for reflection of a general point $(x, y, z)$ (on the cube) about the arbitrary plane. The transformation is to be achieved **only by using the standard transformation matrices** (translation, reflection matrix about principal orthogonal planes, and rotation matrix about principal axes) available in computer library. Show step by step procedure to find the overall transformation and determine all interim transformations in terms of given quantities. [10]