UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: March 2026

Module Number: ME5302 Module Name: Computer Aided Design (C-23)

[Three Hours]

[Answer all questions]

[Each question carries **twelve** marks]

Q1. CAD/CAM software is the digital backbone of modern manufacturing.

a) Briefly explain the importance of CAD/CAM software or tools, with reference to **two (02)** current challenges in modern manufacturing.

[2.0 Marks]

b) Suppose you are planning to start a new product design firm that will provide design solutions for large-scale manufacturing industries such as automotive or machinery manufacturing.
What factors should you consider when selecting and purchasing a CAD software system for your firm? Explain **four (04)** factors.

[4.0 Marks]

c) The primary objective of a database is to collect, organize, and maintain data in a central storage system.

(i) What are the advantages of having a centralized database in a CAD/CAM environment? Briefly explain **three (03)** advantages.

[3.0 Marks]

(ii) Compare relational, hierarchical and network database systems in terms of their database structure and limitations.

[3.0 Marks]

Q2. In computer graphics, transformations are implemented as matrix manipulations on the homogeneous coordinates of points.

a) If the homogeneous coordinates of a point P are given as (3, 9, 6, 3), find the scale factor and the Cartesian coordinates of the point.

[2.0 Marks]

b) A given point is located at $(\sqrt{2}, \sqrt{2})$ in the XY plane. It is first rotated by 45° about the Z axis and then given a translation of 1 unit along the X axis and 1 unit along the Y axis. Obtain the final position of the point.

[3.0 Marks]

c) Following the correct transformation sequence, show that the transformation matrix for scaling with respect to a selected fixed point (Xp, Yp, Zp) is given by,

$$\begin{bmatrix} S_x & 0 & 0 & X_p(1-S_x) \\ 0 & S_y & 0 & Y_p(1-S_y) \\ 0 & 0 & S_z & Z_p(1-S_z) \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

Here, Sx, Sy and Sz are the scaling factors along X, Y and Z axes, respectively.

[3.0 Marks]

d) Obtain the coordinates of **Point A** given in **Figure Q2(d)** according to the model coordinate system.

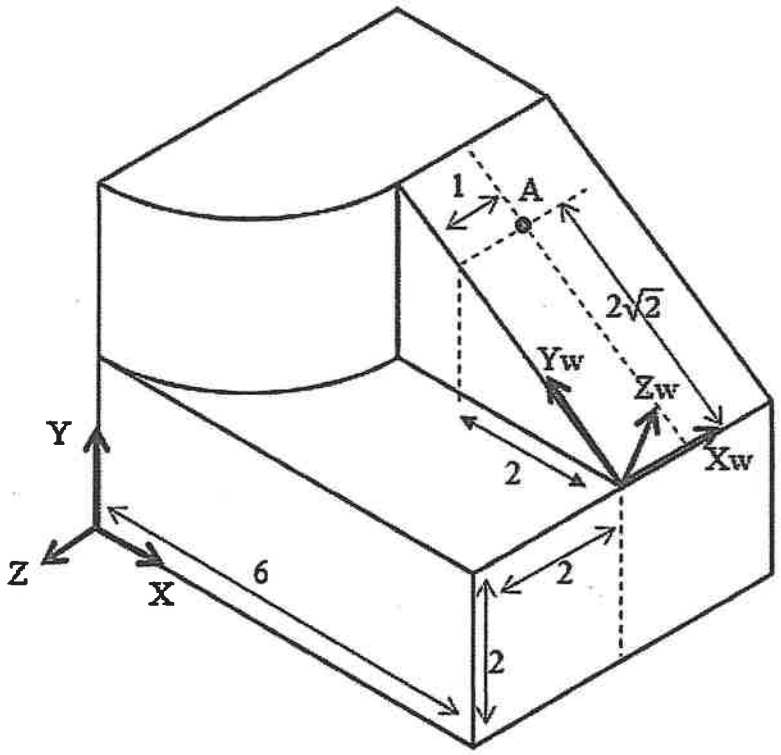

Figure Q2(d)

[4.0 Marks]

Q3. In computer graphics, we often need to draw different types of objects onto the screen. Objects are not always flat, and curves are often required to represent object shapes.

a) What is meant by second-order parametric continuity of a composite curve? Briefly explain.

[2.0 Marks]

b) Plot the **parametric space** of a curve on a plane parallel to XY plane and briefly explain the plots.

[3.0 Marks]

c) Consider a Bezier Curve with three control points p_0, p_1 and p_2.

You may use the following functions if necessary.

$$\bar{p}(u) = \sum_{i=0}^{n} \bar{p}_i B_{i,n}(u)$$

$$B_{i,n}(u) = \frac{n!}{i!\,(n-i)!} u^i (1-u)^{n-i}$$

(i) Obtain the Bezier curve equation.

[2.0 Marks]

(ii) Show that the **tangent vector** at point p_0 and p_2 is given by $k(p_1-p_0)$ and $k(p_2-p_1)$ respectively.

[2.0 Marks]

(iii) Plot blending functions of the curve on the same graph.

[3.0 Marks]

Q4. The **Finite Element Method (FEM)** is a numerical method used to predict how structures behave under loads by dividing complex geometry into smaller, manageable pieces called **elements**.

a) State **two (02)** advantages and **two (02)** limitations of FEM.

[2.0 Marks]

b) Derive the element stiffness matrix and equations for a linear spring subjected to tensile forces, as shown in **Figure Q4(b).**

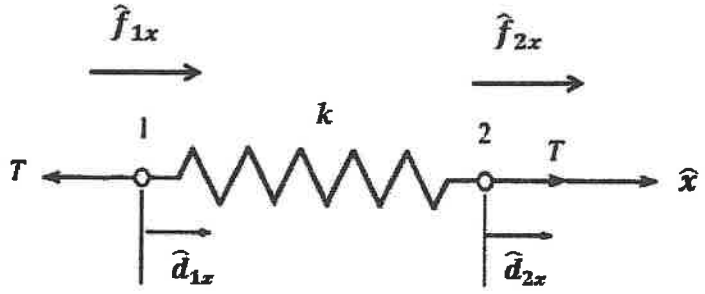

Figure Q4(b)

[3.0 Marks]

c) The spring assembly is given in **Figure Q4(c).** Node 1 is fixed, while node 5 is given a constant, known displacement δ=15.0 mm. The spring constants are k1 = k4 =150 kN/m, k2 =200 kN/m and k3 =175 kN/m.

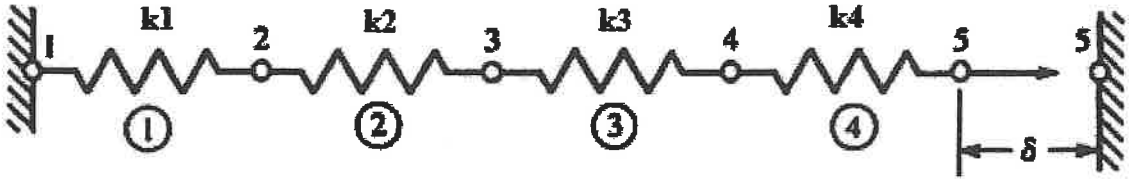

Figure Q4(c)

(i) Obtain the global stiffness matrix using the direct stiffness method.

[2.0 Marks]

(ii) Calculate the displacements of nodes 2, 3, and 4.

[2.0 Marks]

(iii) Calculate the global nodal forces and the local element forces.

[3.0 Marks]

Q5. The selection of the appropriate element type is a crucial step in **Finite Element Analysis (FEA)** that directly impacts the accuracy, computational speed, and reliability of the simulation results.

a) Which element shapes yield the best results in FEA? Explain in terms of their aspect ratio.

[2.0 Marks]

b) Briefly explain the conditions under which a structure can be considered **symmetric**, and describe how these symmetric conditions are modeled in the FEM.

[3.0 Marks]

c) **Figure Q5(c)** shows a **re-entrant corner (B)** of a model. Briefly explain the problem associated with **re-entrant corners in linear elastic models** in FEM. Suggest **two (02)** possible solutions to solve that problem.

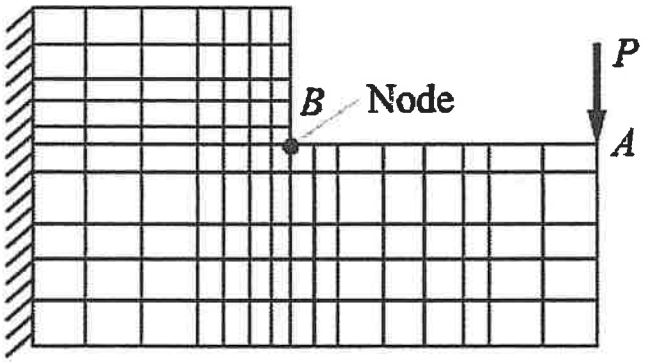

Figure Q5(c)

[3.0 Marks]

d) For a bar element having constant cross-sectional area A, modulus of elasticity E, and initial length L, show that the stiffness matrix is given by,

$$k = \frac{AE}{L}\begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$$

[4.0 Marks]