UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: July 2016

Module Number: ME5301 **Module Name: Computer Aided Design**

[Three Hours]

[Answer **all questions**, each question carries **12** marks]

Q1. a) What is the relationship between Computer Aided Design (CAD) and Computer Aided Manufacturing (CAM)?

[1.0 Mark]

b) What are the types of Geometric Models ? Briefly explain each of them.

[3.0 Marks]

c) List down five major feature types used in the Feature Based Design?

[1.0 Mark]

d) Derive the transformation matrix for rotation of a point in the xy plane around z-axis and translation of a point in the xy plane.

[3.0 Marks]

e) Consider the triangle which is having the vertices of $(\sqrt{2},\sqrt{2})$, $(2\sqrt{2},\sqrt{2})$, $(3\sqrt{2},4\sqrt{2})$. Find the new coordinates when it is subjected to the following transformations.

- Triangle is given a translation of "rx =$\sqrt{2}$" along the X axis and "ry =$\sqrt{2}$" along the Y axis.
- Then it is given a rotation of 45^0 parallel to the Z axis through the vertex$(2\sqrt{2},2\sqrt{2})$.

[4.0 Marks]

Q2. a) Explain the two methods for constructing a single curve.

[4.0 Marks]

b) State the method/methods of construction (mentioned in Q2.a) of the following curves,

(i) Parametric cubic curve
(ii) Bezier curve
(iii) B-Spline curve

[4.0 Marks]

c) (i) Prove that a Bezier curve with 4 control points can be described by p = UMP
Where U = $[\,u^3 \;\; u^2 \;\; u \;\; 1]$

P = $[P_0\ P_1\ P_2\ P_3]$ and

$$M = \begin{bmatrix} -1 & 3 & -3 & 1 \\ 3 & -6 & 3 & 0 \\ -3 & 3 & 0 & 0 \\ 1 & 0 & 0 & 0 \end{bmatrix}$$

(ii) Using the above relationship p = UMP, construct the Bezier curve whose control points are described by (0,0), (60,100), (100,160) and (160,0).
(Use the graph sheet to plot the curve.)

[4.0 Marks]

Q3. a) Figure 3 (a) shows the control points for a Bezier curve. Sketch the curve. Draw the line tangent to the curve at the point u = 0.5. [3.0 Marks]

b) Figure 3 (b) shows the control points for a B-spline curve of order three (degree two). Sketch the curve. [3.0 Marks]

c) Find the algebraic coefficients of a PC curve having the following properties

a) It lies in the XY plane

b) When u=0 x=0 and y=0 and $\frac{dy}{dx} = \infty$

c) When u=0.25 x = 1 y = 2 and $\frac{dy}{dx} = 1$

d) When u=1 x=4 and y=4

[6.0 Marks]

Q4. a) Show that the element stiffness matrix (in global co-ordinates) of a spring element located at an angle θ to the horizontal is $k\begin{bmatrix} C^2 & CS & -C^2 & -CS \\ CS & S^2 & -CS & -S^2 \\ -C^2 & -CS & C^2 & CS \\ -CS & -S^2 & CS & S^2 \end{bmatrix}$.

[4.0 Marks]

b) Calculate nodal displacements and element stresses for the members of the truss shown in Figure Q4. Cross sectional area of each member = 500mm^2, E=200GPa and P=25kN

[8.0 Marks]

Q5. a) Describe the steps involved in Finite Element Method (FEM) in stress analysis.

b) With the usual notation, show that the stiffness matrix of a Constant Strain Triangular (CST) element is given by,

$$k = \int_v B^T DBdV$$

[3.0 Marks]

c) The CST element of thickness *t mm*, shown in Figure Q5, is under the plane stress condition. It has a Young's modulus of *E GPa* , specific weight γ *kN/m*^{3} and zero Poisson's ratio. Considering plane stress conditions, find the;

I. Element stiffness matrix for this element.

II. Equivalent load vector

The following are given.

The elasticity matrix for plane stress condition, $[D] = \frac{E}{1-\upsilon^2}\begin{bmatrix} 1 & \upsilon & 0 \\ \upsilon & 1 & 0 \\ 0 & 0 & \frac{1-\upsilon}{2} \end{bmatrix}$

Constant values $a_1 = x_2y_3 - x_3y_2$, $a_2 = x_3y_1 - x_1y_3$, $a_3 = x_1y_2 - x_2y_1$, $b_1 = y_2 - y_3$, $b_2 = y_3 - y_1$, $b_3 = y_1 - y_2$, $c_1 = x_3 - x_2$, $c_2 = x_1 - x_3$, $c_3 = x_2 - x_1$ with usual notation.

[7.0 Marks]

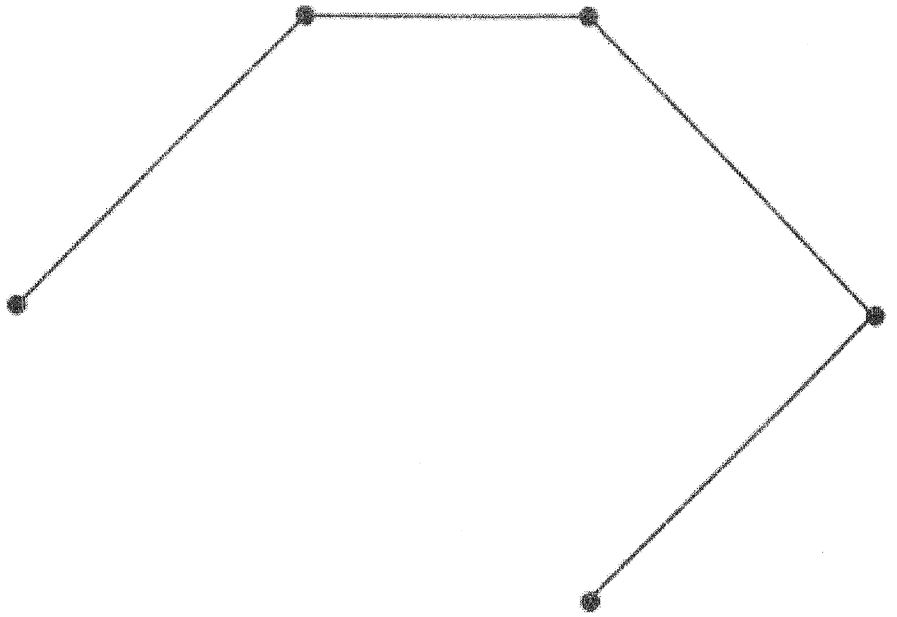

Figure 3 (a) (attach this to your answer booklet)

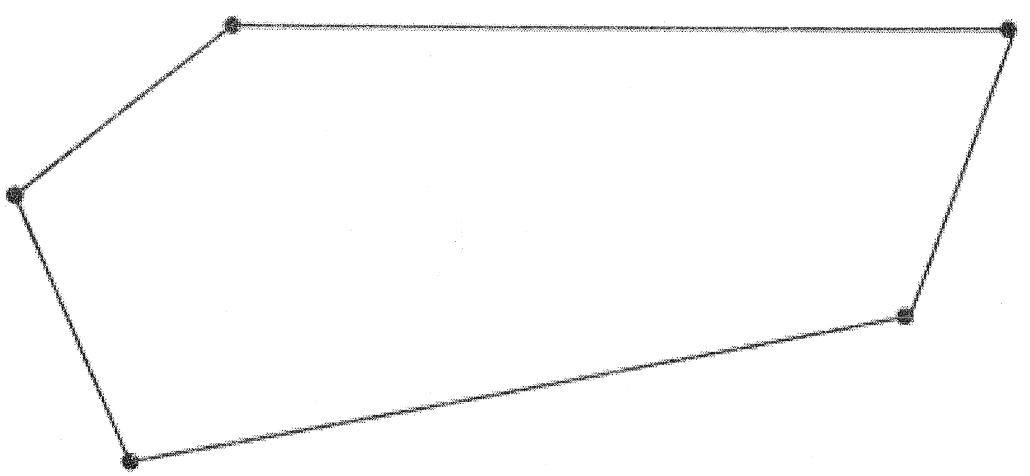

Figure 3 (b) (attach this to your answer booklet)

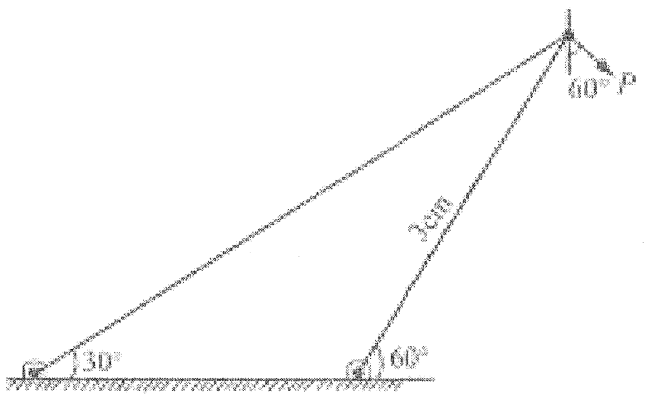

Figure Q4

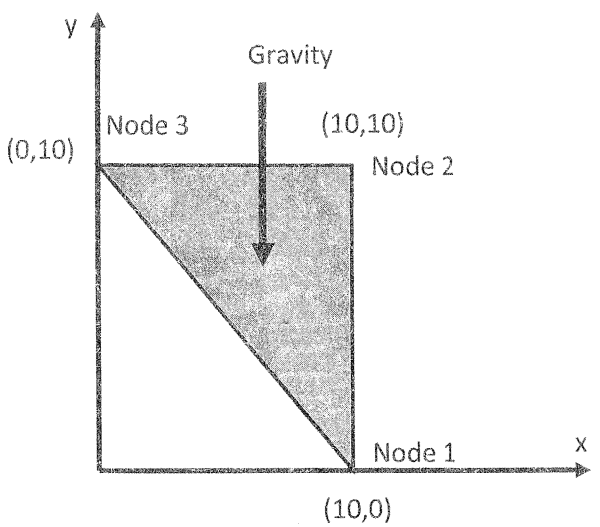

Figure Q5