UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: September 2019

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

[Three Hours]

[Answer all questions. All questions carry equal marks]

Q1. a) Write the three basic approaches to solve a finite element problem. Describe them briefly.

[3.0 Marks]

b) Figure Q1 shows a thin plate which is subjected to a tensile stress as illustrated. Draw a neat sketch of suitable finite element mesh pattern by considering the symmetry of the model and specify the boundary conditions in the sketch. Show the transition zone in between fine mesh and coarse mesh clearly.

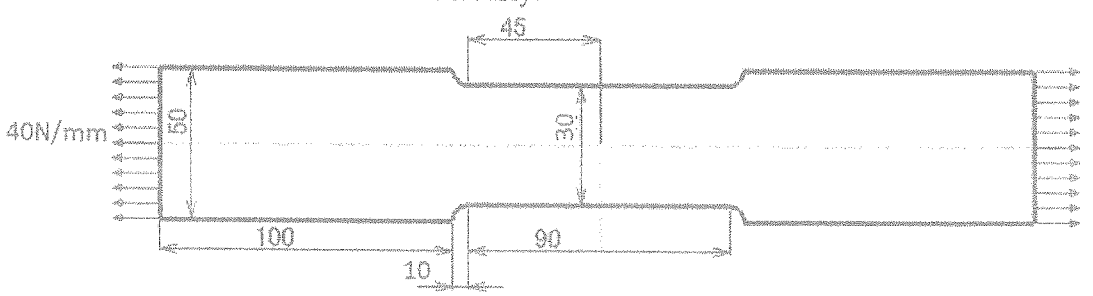

Figure Q1-b
All dimensions are in millimeters.

[5.0 Marks]

c) The spring assemblage with arbitrarily numbered nodes is given in Figure Q1-c. A force of 5000 lb is applied at node 4 in the x direction. The spring constants are given in the figure. Nodes 1 and 2 are fixed. Obtain the general equation for total potential energy of the spring assemblage and find its minimum value. Thus obtain,

(i) the global stiffness matrix,
(ii) the displacements of nodes 3 and 4,
(iii) the reaction forces at nodes 1 and 2,

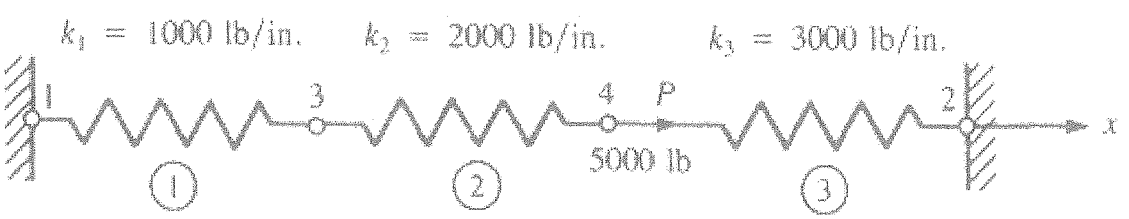

Figure Q1-c

[4.0 Marks]

Q2. a) Classify the CAD models by considering the geometric construction of CAD models. Briefly describe the classified groups.

[3.0 Marks]

b) Figure Q2-b illustrates an object with two surfaces. If the CAD system use,

(i) Relational database, categorize all the relationships and specify all the relationships as data by using the data storing format. (Define any entity if necessary)

[3.0 Marks]

(ii) Hierarchical database, present all the data using the data storing format. (Defined any entity if necessary)

[3.0 Marks]

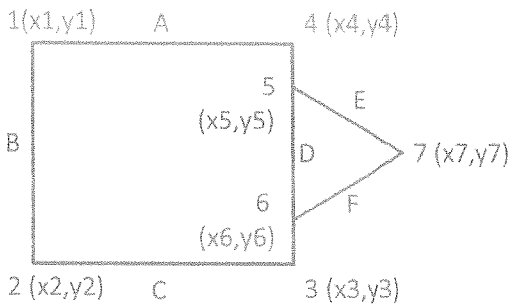

Figure Q2-b

c) Derive the Bresenhamp's algorithm for a line where the gradient of the line m is $0<m<1$, and the current point is (x_i, y_i). Specify the initial decision parameter.

[3.0 Marks]

Q3 a) Discuss the similarities and dissimilarities of Bezier curves and B-spline curves?

[2.0 Marks]

b) (i) Derive the basis matrix (**M**) for cubic Bezier curve. Also give the corresponding blending functions.

(ii) What are the conditions for smoothly joining the two Bezier curve segments?

[4.0 Marks]

c) Determine a good set of control points for 5 point Bezier Representation of the curve as shown in the Figure Q3. P_0, P_1, P_2, P_3 and P_4 are the five control points that make the control polygon. The control polygon lines, P_0P_1 and P_3P_4 are parallel to the y axis. The length $\frac{1}{2} \times P_0P_1 = P_3P_4 = y$

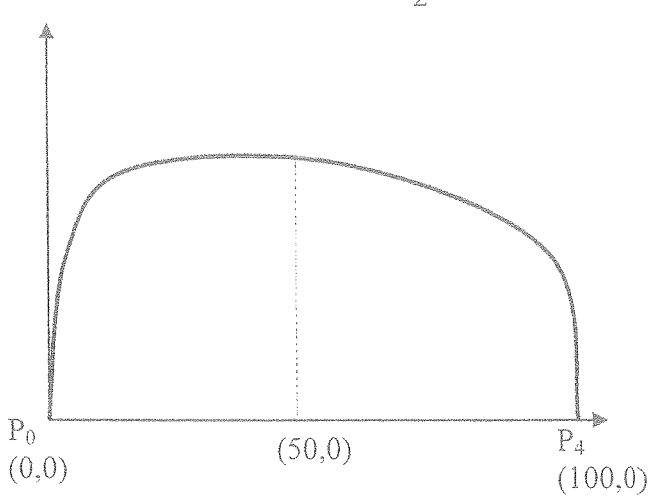

Figure Q3

[6.0 Marks]

Q4 a) Develop a PC curve for two end points P(0) and P(1), a midpoint P(0.5), as well as the tangent at the midpoint P'(0.5).

$$\text{Take} \begin{bmatrix} 0 & 0 & 0 & 1 \\ 0.125 & 0.25 & 0.5 & 1 \\ 0.75 & 1 & 1 & 0 \\ 1 & 1 & 1 & 1 \end{bmatrix}^{-1} = \begin{bmatrix} -4 & 0 & -4 & 4 \\ 8 & -4 & 6 & -4 \\ -5 & 4 & -2 & 0 \\ 1 & 0 & 0 & 1 \end{bmatrix}$$

[6.0 Marks]

b) Parametric cubic curve passes through the points (0,0), (2,4), (4,3), (5, -2) which are parametrized at u = 0, ¼, ¾, and 1, respectively. Determine the geometric coefficient matrix and the slope of the curve when u = 0.5.

[6.0 Marks]

Q5 a) Derive homogeneous rotational transformation matrices for the rotation about X, Y and Z axes. Provide a clear figure of Cartesian coordinate system for each transformation. Use θ as rotation angle.

[3.0 Marks]

b) Derive a general homogeneous transformation matrix for scaling with respect to a selected fixed position (Xp, Yp, Zp). Use scale factors in X, Y and Z as Sx, Sy and Sz respectively. Provide all the steps clearly.

[4.0 Marks]

c) If you are asked to scale the object illustrated in figure Q5 by scale factor 2 in all axes with respect to a given point P (1,0,1), find the coordinates of the points A, B, C, D, and E of the figure after scaling up.

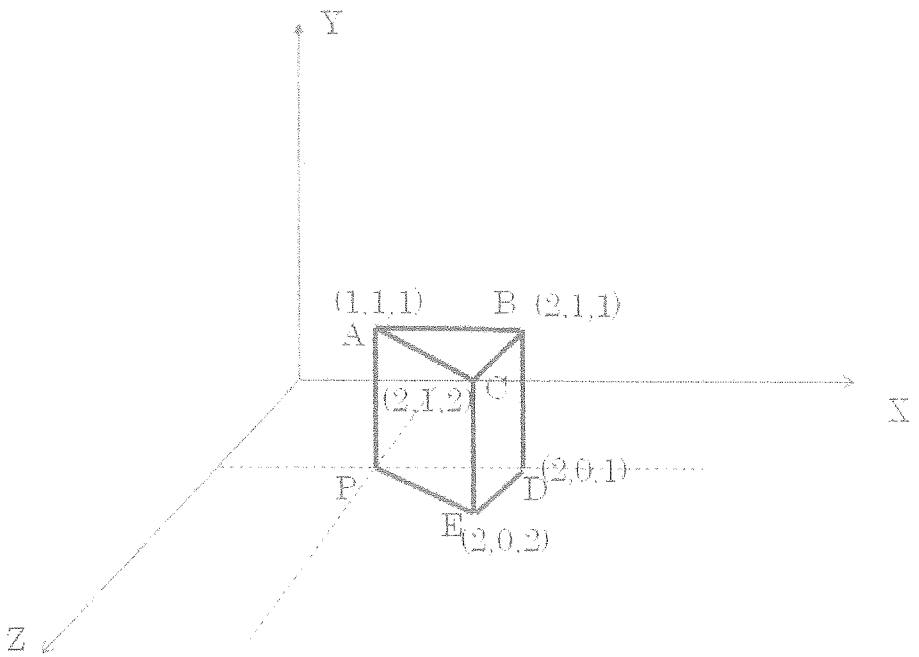

Figure Q5-2

[5.0 Marks]