UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: August 2018

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

[Three Hours]

[Answer **all** questions. All questions carry equal marks]

Q1. a) Write the general steps to solve a finite element problem.

[4.0 Marks]

b) Use displacement method and derive element stiffness matrix for the element given in Figure Q1-1. Give all the steps clearly.

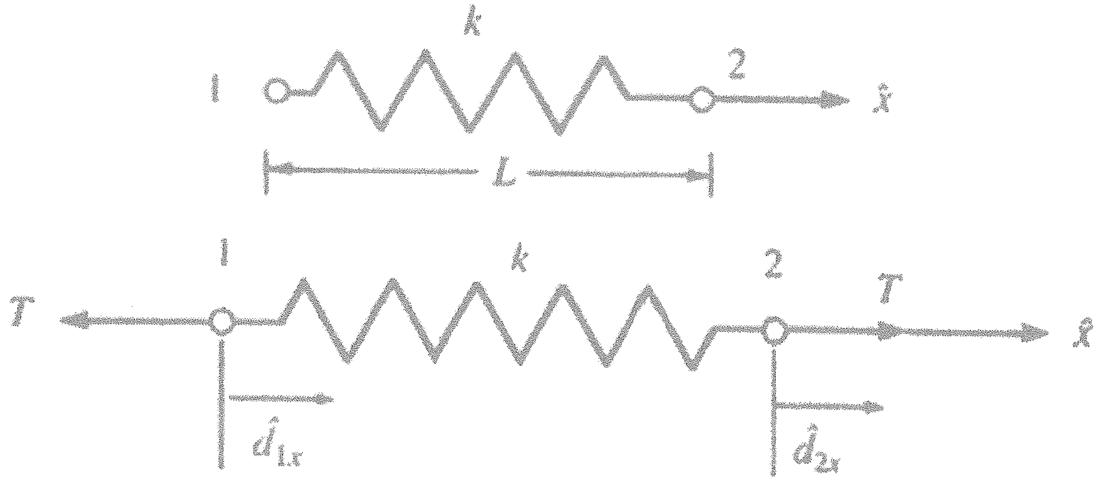

Figure Q1-1

[3.0 Marks]

c) For the system of linear elastic springs shown in Figure Q1-2, express the boundary conditions, the compatibility or continuity condition, and the nodal equilibrium conditions clearly. Then formulate the global stiffness matrix (**don't use direct stiffness method**) and equations for solution of the unknown global displacement and forces. Find the displacement at each node and global forces. The spring constants for the elements are k_1; k_2, and k_3; P is an applied force at node 2.

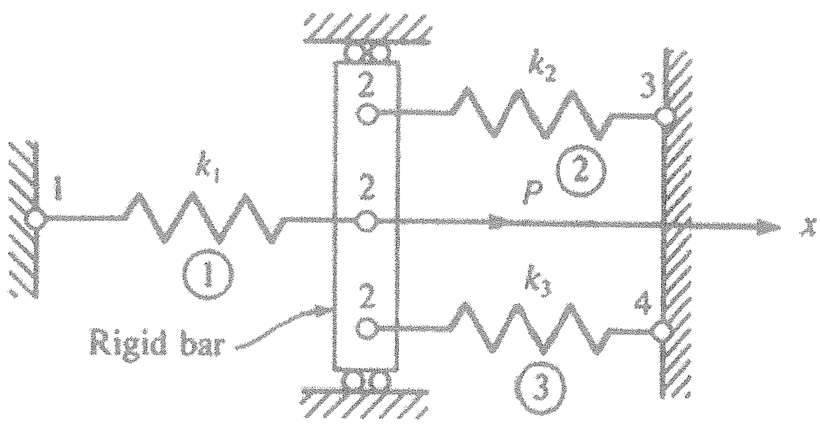

Figure Q1-2

[5.0 Marks]

Q2. a) List three types of coordinate systems which are needed in order to input, store and display model geometry and briefly describe them.

[3.0 Marks]

b) Name three important characteristics of CAD databases and explain them

[3.0 Marks]

c) There are four types of database models used in CAD databases. Describe all four models one by one, by emphasizing the advantages and disadvantages.

[4.0 Marks]

d) Derive parallel line algorithm and find the initial decision parameter. Suppose $\Delta x=13$ and the number of processors are 4, find the width of the partitions and starting x values for the partitions. Consider first starting point as x_0, y_0.

[2.0 Marks]

Q3 a)
i. Explain the basic idea of B-Spline curves.
ii. Give an example of a B-Spline curve.
iii. What is the main benefit of a B-Spline curve over a Bezier curve? Explain your answer.

[5.0 Marks]

b) Sketch a Bezier curve and its control polygon between the below points.

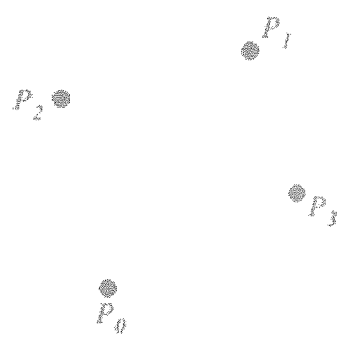

Figure Q3

[2.0 Marks]

c) The basis (blending) functions for a second order Bezier curve are given by:
$B_1(u) = u^2$ $\quad B_2(u) = 2u(1-u)$ $\quad B_3(u) = (1-u)^2$

Give the basis matrix (M) for a second order Bezier curve and write a general expression for the curve as a function of the basis matrix and the control points.

[5.0 Marks]

Q4 a) Find the algebraic coefficients of a PC curve having the following properties.
- It lies in the XY plane
- When u=0 x=0 and y=0 and
- When u=0.25 x = 1 y = 2 and
- When u=1 x=4 and y=4

[5.0 Mark]

b) A PC curve was derived in class for end point positions and tangent constraints, but these aren't the only geometric constraints that could be used. Develop a similar 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).

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

[7.0 Marks]

Q5 a) Homogeneous transformation matrix can be written in the form $[T] = \begin{bmatrix} T_1 & T_2 \\ T_3 & 1 \end{bmatrix}$. Describe T1, T2 and T3 by emphasizing operations and definitions which can be represent by these three matrixes.

[3.0 Marks]

b) Figure Q5-1 illustrates a model coordinate system defined by O and a working coordinate system defined by Ow. Pw is the center of the hole and the coordinates given are with respect to working coordinate system.

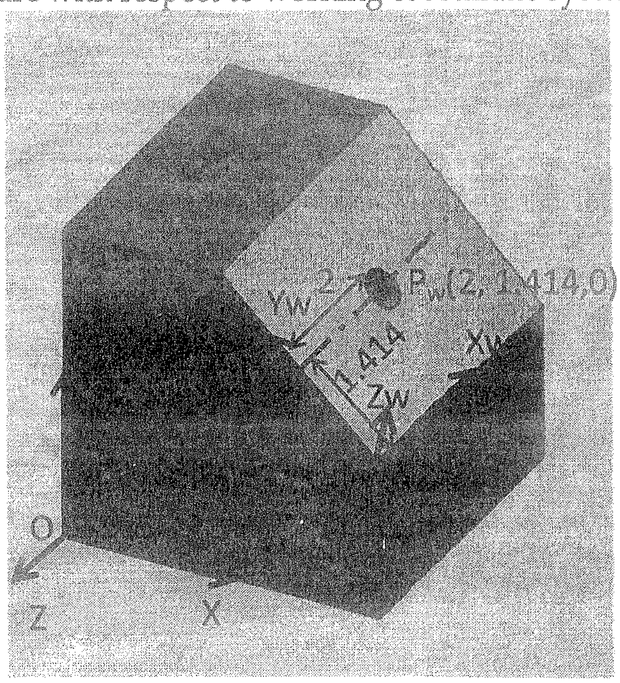

Figure Q5-1

i) Write the relevant homogeneous transformation matrices.
ii) Write the concatenated transformation matrix and simplify it.
iii) Calculate the coordinates of Pw with respect to model coordinate system. Show the method of calculation clearly.

[6.0 Marks]

c) Write the homogeneous transformation matrices for top view and right view projections and calculate the points on top view projection and right view projection. Object is given in figure Q5-2.

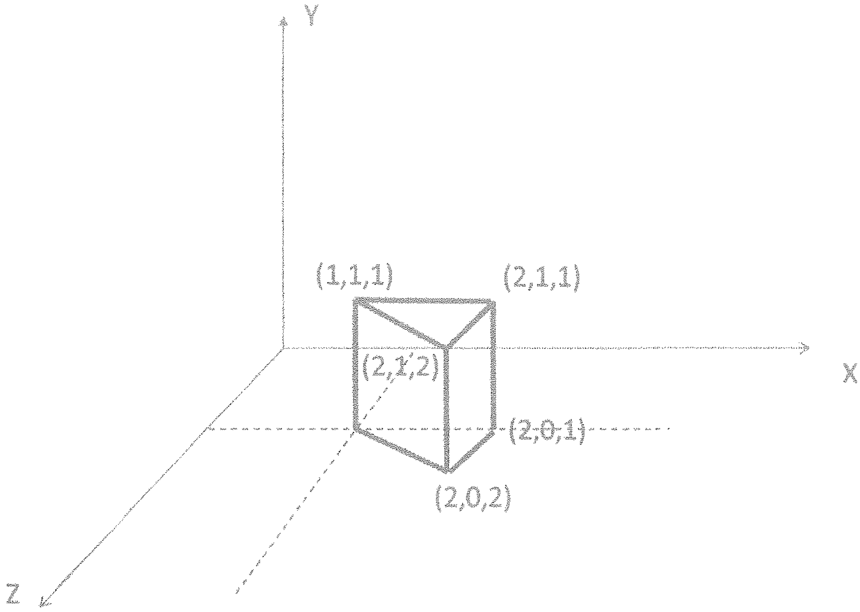

Figure Q5-2

[3.0 Marks]