Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
(ONLINE)
SEMESTER II
SESSION 2019/2020

COURSE NAME	:	FINITE ELEMENT METHOD
COURSE CODE	:	BDA 31003
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	JULY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS **ONLY** **OPEN BOOK EXAMINATION**

THIS QUESTION PAPER CONSISTS OF **SEVEN (7)** PAGES

Q1) **FIGURE Q1** shows a system of truss with three (3) elements. Node 1, 2 and 4 is pin connected, whilst node 3 is given force of 50 kN and 100 kN as shown. Given area, $A = 50 \times 10^{-4}$ m^2 and Young Modulus, $E = 2 \times 10^{11}$ N/m^2 for all elements.

(a) Determine the displacement components at node 3, by using Direct Elimination Method.

(15 marks)

(b) Compare the stress value for each element.

(6 marks)

(c) Justify your answer in (b), in relation to support reaction and/or any solid engineering basis.

(4 marks)

Q2 Liquid with dynamic viscosity of $= 0.5$ N• s/m^2 and density of $\rho = 1000$ kg/m^3 flows through the piping network with L = 100m shown in the accompanying **FIGURE Q2**. Determine the pressure distribution in the system if the flow rate at node 1 is 25 x 10^{-4}m^3/s. For the given conditions, the flow is laminar throughout the system. We assumed that the pressure at node 1 is 40kPa and at node 4 is -4kPa.

(a) Construct a table to discretize the given piping network of **FIGURE Q2** into 4 elements and 4 nodes, as numbered.

(4 marks)

(b) Determine the elemental flow resistance $[R]^{(e)}$ for each element.

(8 marks)

(c) Assemble the global matrices for resistance matrix $[R]^{(G)}$, pressure force matrix $\{F_P\}^{(G)}$ and the unknown nodal pressure matrix $\{P\}^{(G)}$.

(5 marks)

(d) Estimate the nodal pressure distribution, P at each node of the network according to the global finite element equations:

$$[R]^{(G)}\{P\}^{(G)} = \{F_P\}^{(G)}$$

(3 marks)

(e) By roughly estimated pressure of part (d) above, determine the flow rate Q in each node using Penalty Method.

(5 marks)

Q3 A wall shown in **FIGURE Q3** of 0.5m thickness having thermal conductivity of 6 W/m K. The wall is to be isolated with a material of thickness 0.1 m having an average thermal conductivity of 0.3 W/m K. The inner surface temperature is 1200 °C and the outside of the isolation is exposed to atmospheric air at 20 °C with heat transfer coefficient of 40 W/m^2 K. (Assuming the area A is one unit area)

(a) Calculate the stiffness matrix and the thermal load vector of each element

(10 marks)

(b) Distinguish the global system matrix equation [Kc] {T} = {F} before and after considering all constraints.

(9 marks)

(c) Differentiate between the nodes temperature.

(6 marks)

Q4 For the two-dimensional body shown in **FIGURE Q4 (a),** the temperature of the top side of the body is maintained at 100 °C, while the other edge of the body is insulated. A uniform heat source of Q = 1000 W/m^3 acts over the whole plate. Considering only the left half of the body, the finite element model with the element and nodes numbers is shown in **FIGURE Q4 (b)**. The vertical plane of symmetry passing through the body 2 m from both left and right edges can be considered to be an insulated boundary.
By assuming a constant thickness of 1 m, and the coefficient of thermal conductivity K_{xx} = K_{yy} = 25 W/(m°C),

(a) Develop the local conductance matrix and its associated thermal load vector for every 4 element (do not need to assemble the local matrix)

(24 marks)

(b) Distinguish which element has undergone convection effect and state its equation for conduction matrix due to the convection upon that edge.

(1 mark)

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Q5 A two-dimensional plate structure **FIGURE Q5** is made of triangular elements. The plate thickness is 1mm and is made of aluminum alloy with Young's modulus E = 69 GPa and Poisson's ration v = 0.3. After the structure has been constrained, element K experience displacement measurement as records in **Table Q5**:

Table Q5: Recorded displacement measurement

Node	u (mm)	v (mm)
1	0	0
2	0.2	0.2
4	0.1	0.1

Based on the experimental displacement data shown in **Table Q5**,

Hints: You have to decide whether the problem is plane stress or plane strain. You also have to.

(i) Based on the plate condition, name the *plane* case of the plate?

(2 marks)

(ii) Draw nodes, elements and constrains of the plate.

(6 marks)

(iii) Calculate the strain displacement matrix [B] and the stiffness matrix [k] of the element and finally based on the experimental displacement data shown in **Table Q5**, find the elemental stress of element K.

(17 marks)

-END OF QUESTIONS–

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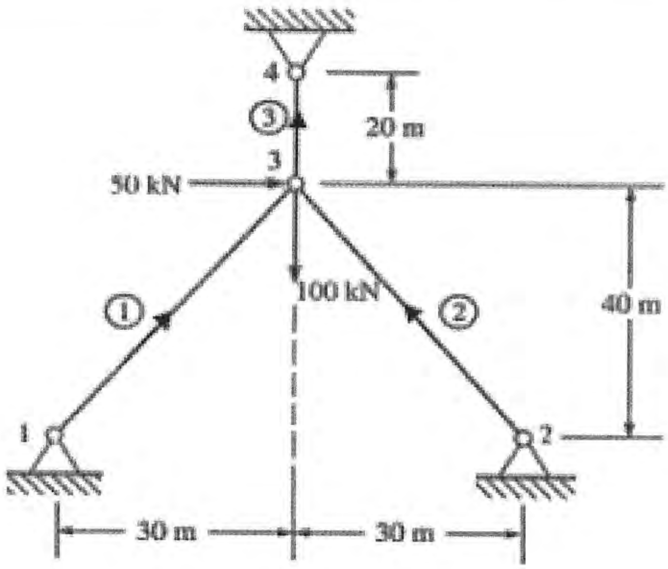

Figure Q1

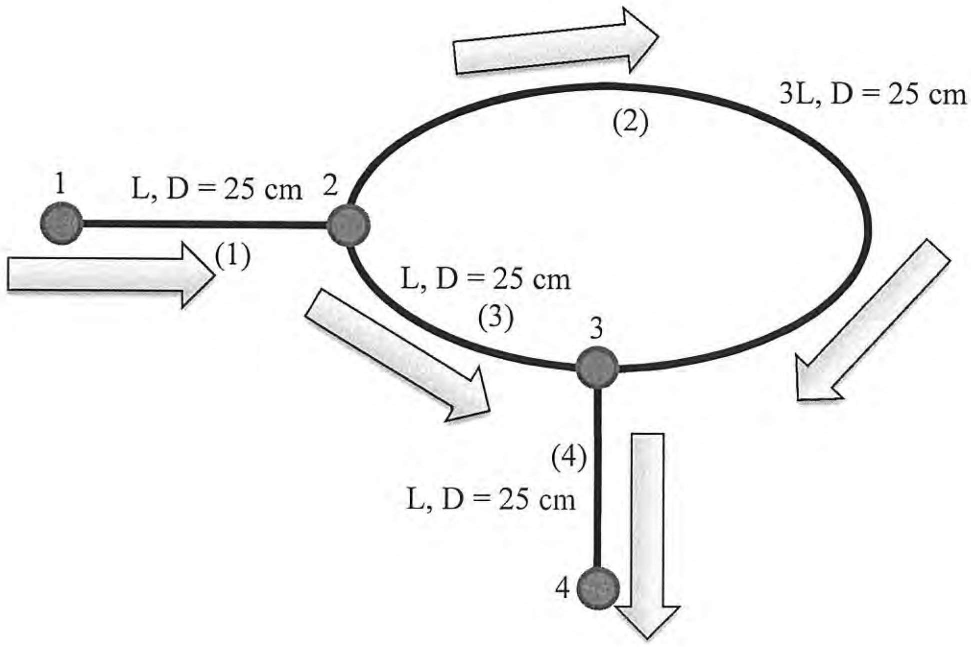

Figure Q2

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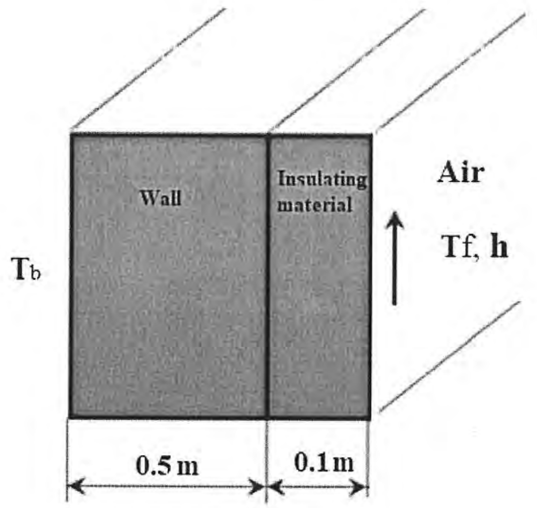

Figure Q3

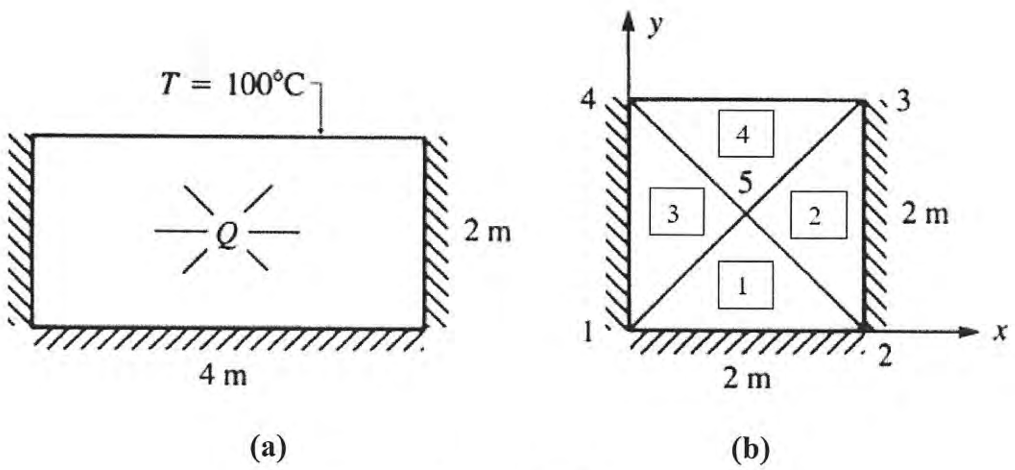

Figure Q4

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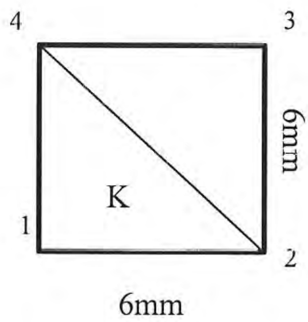

Figure Q5