UTHM
Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2019/2020

COURSE NAME	:	FINITE ELEMENT METHOD
COURSE CODE	:	BDA 31003/BDA 40303
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	DECEMBER 2019/ JANUARY2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER **FOUR (4)** QUESTIONS **ONLY**

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

Q1 Three bars ABCD each made of different materials are connected together and subjected to a force of 70 kN at point 2, 80 kN at point 3 and fixed at its both ends as shown in **Figure Q1.** The material properties and diameter of each bar are given in **Table 1.** The structure is subjected to an increase in temperature $\Delta T = 80°C$.

Table Q1: Material Properties for the bars

	Bronze	Aluminum	Steel
E	83 GPa	70 GPa	200 GPa
α	$18.9\times10^{-6}/\ °C$	$23\times10^{-6}/\ °C$	$11.7\times10^{-6}/\ °C$
A	2400 mm^2	1200 mm^2	600 mm^2

(a) Explain how many degrees of freedoms per node, nodes in the structure and what is the order of the global stiffness matrix of the structure (for example: 5x5)

(5 Marks)

(b) Label the coordinate for each node and load clearly

(2 Marks)

(c) Construct the finite element table to calculate the stiffness of each element and then evaluate the global stiffness matrix

(10 Marks)

(d) By considering all the boundary conditions (constraints), solve for displacement matrix.

(8 Marks)

Q2 You are a practical student in piping company at RAPID, Pengerang. Your supervisor give you a task to investigate two types of parallel piping networks as illustrated in **Figure Q2.** The networks will be used to flow an oil with dynamic viscosity of $\mu = 0.6$ Ns/m^2 and density of $\rho = 880$ kg/m^3. The pressure at the inlet point (node 1) is 59500 Pa and the pressure at outlet point (node 4) is -6000 Pa. The dimension of the pipe for each network is given in **Table Q2.**

Table Q2: Dimensions of pipe for each network

Network	Dimension of elements, E (m)							
	1		2		3		4	
A	L = 8	D = 0.3	L = 6	D = 0.3	L = 10	D = 0.4	L = 8	D = 0.3
B	L = 9	D = 0.4	L = 7	D = 0.4	L = 11	D = 0.5	L = 9	D = 0.4

The fluids flow is assumed laminar and the viscosity is constant inside the channel.

(a) Determine the pressure at each node for piping network A and network B

(16 marks)

(b) Then, by using answer in (a), find the flowrate of each network. Which of the piping network (A or B) will flow the oil with better flowrate. Give your reason

(9 marks)

Q3 **Figure Q3** shows heat is entering into a large plate at the rate of q_o =300 W/m³ . The plate thickness is 25 mm. The outside surface of the plate is maintained at the temperature of 10°C. Thermal conductivity k = 1.0W/m.°C.

(a) Determine the temperature distribution using only two elements

(17 marks)

(b) Examine the heat loss, Q of the plate.

(8 marks)

Q4 A two dimensional structure as shown in **Figure Q4** is isolated in two edges; edge 1-5 and edge 2-3. The edge 3-4-5 is exposed to the air with temperature of T_f= 20 °C and the convection coefficient h = 20 W/m²°C. The bottom edge is maintained at temperature T = 80 °C. The conduction coefficient of the material is uniform, k = 80W/m°C.

(a) Identify the coordinates for each node for every elements

(6 marks)

(b) Calculate the conductance matrix and the thermal load vector of each element

(12 marks)

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

(2 marks)

(d) Determine the temperature distribution at each node by using Direct Elimination Method

(5 marks)

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 and the measurement is recorded 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

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

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

(a) What the *plane* case of the plate?

(2 marks)

(b) Draw nodes, elements and constrains of the plate

(6 marks)

(c) 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 QUESTION–

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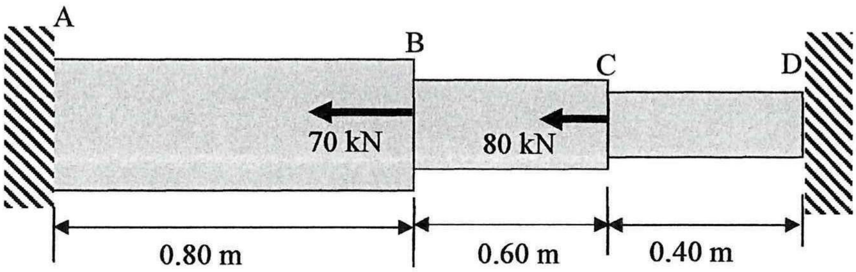

Figure Q1

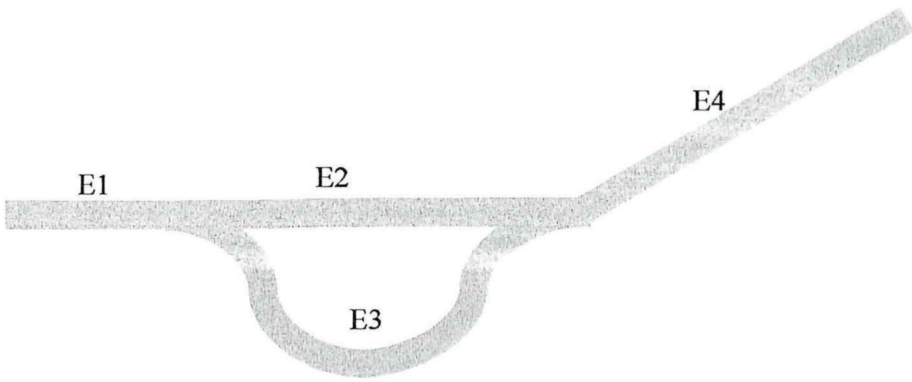

Figure Q2

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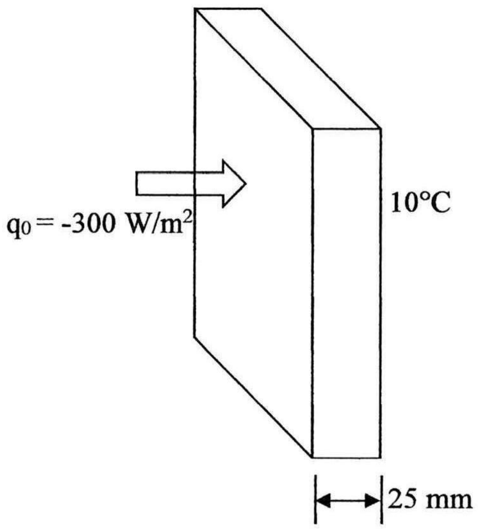

Figure Q3

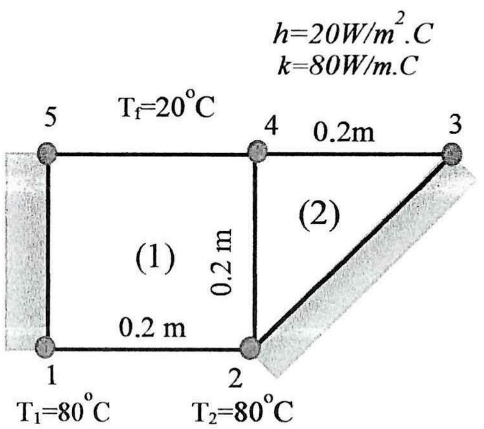

Figure Q4

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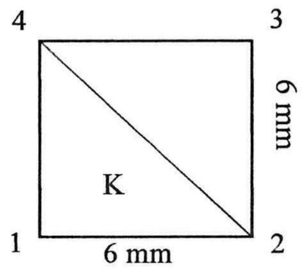

Figure Q5