Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2018/2019

COURSE NAME	:	FINITE ELEMENT METHOD
COURSE CODE	:	BDA 31003
PROGRAMME CODE	:	BDD
EXAMINATION DATE	:	DECEMBER 2018 / JANUARY 2019
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWERS **FOUR (4)** QUESTIONS **ONLY**

THIS QUESTION PAPER CONSISTS OF **EIGHT (8)** PAGES

Q1 (a) Based on structure geometry, degree of freedom, constraint and/or loading, evaluate and justify the best element to be used in modelling each problem shown in **Figure Q1(a)** to **Figure Q1(d)** respectively.

(20 marks)

(b) Justify why Model B is better than Model A to study the problem shown in **Figure Q1(e)**.

(5 marks)

Q2 A wall of a heat exchanger tube from an incinerator plant consists of two different materials is shown in **Figure Q2**. The first layer is composed of 10 cm of insulating brick with a thermal conductivity of 0.15 W/m°C. The second layer is made from 12 cm of wool felt with a thermal conductivity of 0.6 W/m°C. The hot air coming from the combustion chamber which generates 1000 W/m^3 is passing inside the heat exchanger tube. The outside wall temperature of the heat exchanger is 25 °C and the outside air is at a temperature of -5 °C with a convection coefficient of 30 W/m^2 °C.

(a) Evaluate the temperature distribution across the heat exchanger tube wall and determine the total heat loss/gain through the wall if the area of the wall is approximately 200 m^2.

(20 Marks)

(b) Draw a temperature versus nodes graph to show the temperature distribution across the tube.

(5 Marks)

Q3 A fixed-end steel shaft ABCD is subjected to torques as shown in **Figure Q3**. The torques have magnitude of 3000 Nm, 2000 Nm and 800 Nm. The length of each segment is 0.5 m and the diameters of the segments are 80 mm, 60 mm and 40 mm. The shaft shear modulus of elasticity, G is 80 GPa.

(a) Illustrate the finite element model of this rotational system. Please label the nodes, elements, constraint and loads clearly.

(5 marks)

(b) Construct the finite element table to calculate the stiffness of each element.

(3 marks)

(c) Verify that the angle of twist at point B and D on the element are as follow:

$\theta_B \approx 0.0090$ rad $\qquad$ $\theta_D \approx 0.0427$ rad

(15 marks)

(d) If the segments have uniform diameter, compare the resulting angle of twist at D with the value in Q3(c).

(2 marks)

Q4 A bar of trapezoid cross section, having thermal conductivity of 180 W/m°C for triangular element and 160 W/m°C for rectangular element, is subjected to the boundary conditions shown in **Figure Q4**. The left side of the bar is insulated and other edges are exposed with different characteristics. The expose temperatures and the convection coefficients for all free edges are shown in **Figure Q4**. By following the node and element definitions as seen in **Figure Q4**, and letting node 1 as origin (0,0),

(a) Develop tables for useful information on elements.

(3 marks)

(b) Verify that the global load matrix for these two elements are as below:

$$[K]^{(G)} = \begin{bmatrix} 162.78 & -162.71 & 0.0333 & 0 & 0 \\ -162.71 & 320.45 & -64.4 & -39.36 & -53.97 \\ 0.0333 & -64.4 & 157.89 & -53.97 & -39.32 \\ 0 & -39.36 & -53.97 & 108.08 & -14.53 \\ 0 & -53.97 & -39.32 & -14.53 & 108.15 \end{bmatrix} \begin{bmatrix} T1 \\ T2 \\ T3 \\ T4 \\ T5 \end{bmatrix} = \begin{Bmatrix} 2 \\ 0 \\ 5.375 \\ 3.281 \\ 6.656 \end{Bmatrix}$$

(20 Marks)

(c) Explain how to determine the temperature vector of the bar. (No calculation required)

(2 marks)

Q5 (a) For a SOLID element states the degree of freedom exist in each nodes.

(3 marks)

(b) **Figure Q5(a)** shows a simply supported beam with a force, P acting at the center. With an aid of a sketch, suggest the best element arrangement to predict stress at the middle of the beam. Justify your suggestion by aid of a sketch.

(5 marks)

(c) A steel plate with 2mm thickness as shown in **Figure Q5(b)** is support at nodes 1 and 5 and under normal distributed loading at its end as shown in nodes 1, 2 and 3. The plate modulus elasticity is 200 GPa and Poisson's ratio 0.3 is also maintained and stable in its x-y surface but allowing node displacement in z-axis.

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

(2 marks)

(ii) From an experimental measurement of the plate under the loading condition using strain gauges, it is found that nodes 1, 2, and 5 are displaced as as shown in **Table Q5**. Evaluate the stress σ_{xx}, σ_{yy} and σ_{xy} of the element.

Table Q5: Displacement of nodes

Node	u_x	u_y
1	1.65 μm	0 μm
2	-10 μm	-10 μm
5	-3.86 μm	0 μm

(15 marks)

-END OF QUESTIONS–

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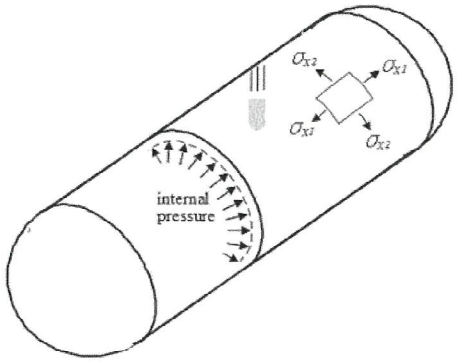
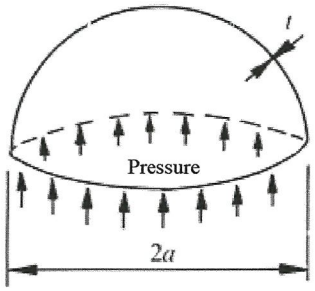


(a)



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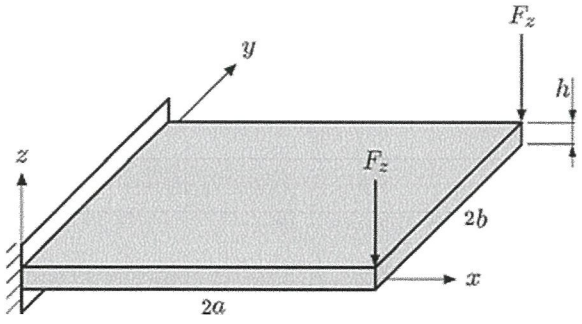
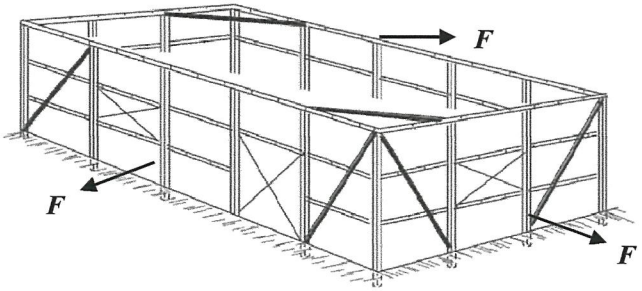


(c)



(d)

Figure Q1(a)-(d)

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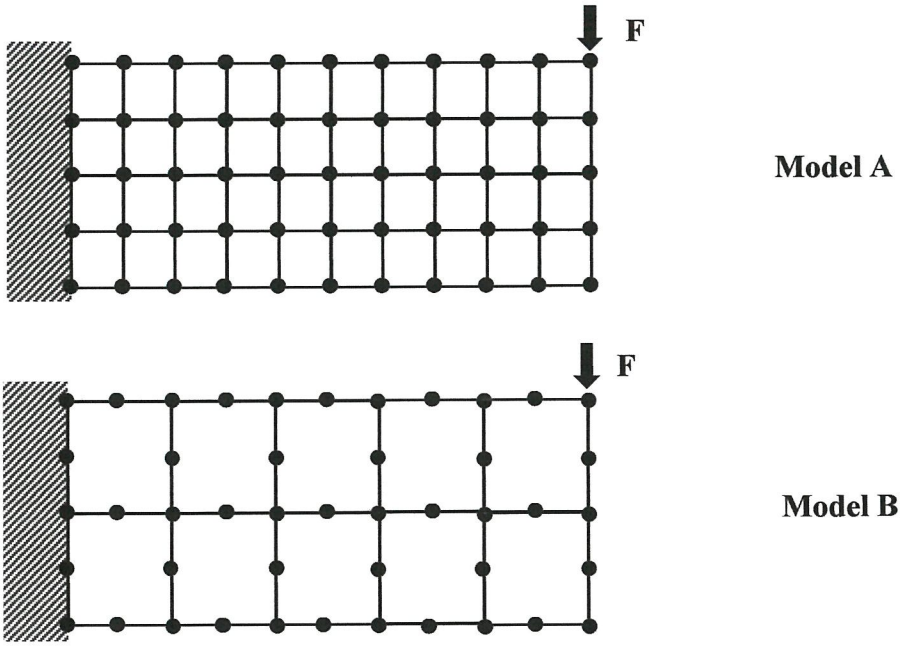

Figure Q1(e)

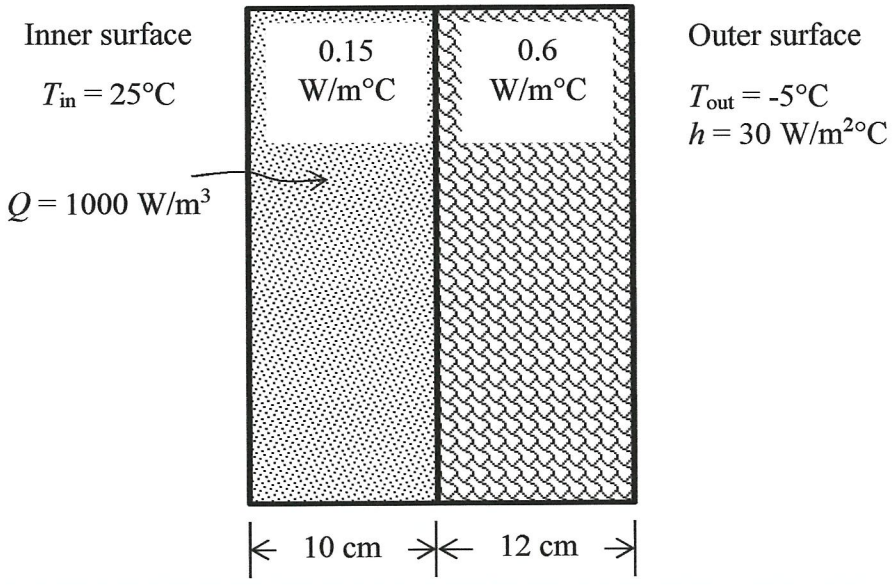

Figure Q2

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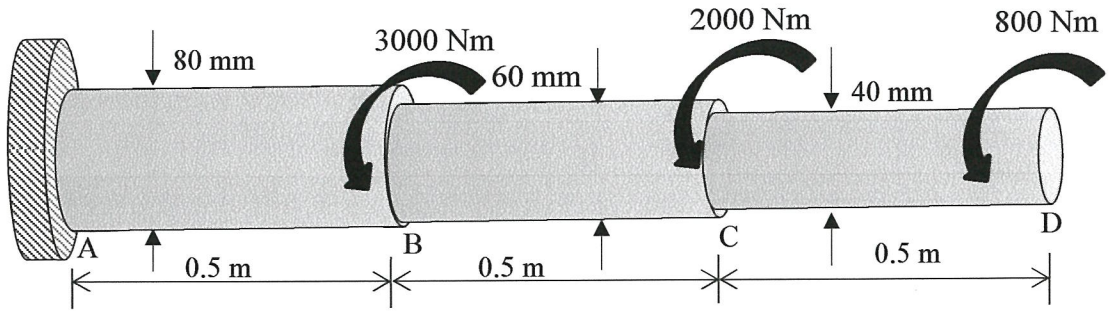

Figure Q3

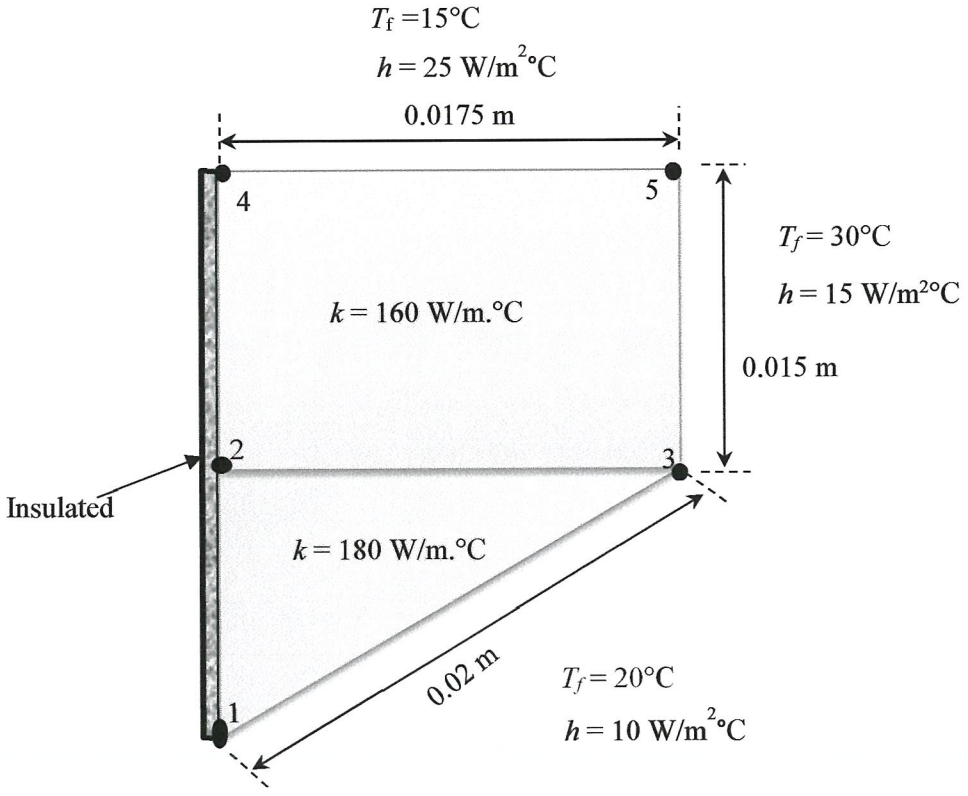

Figure Q4

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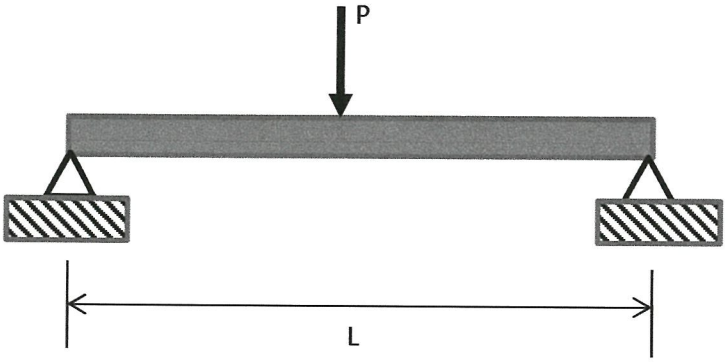
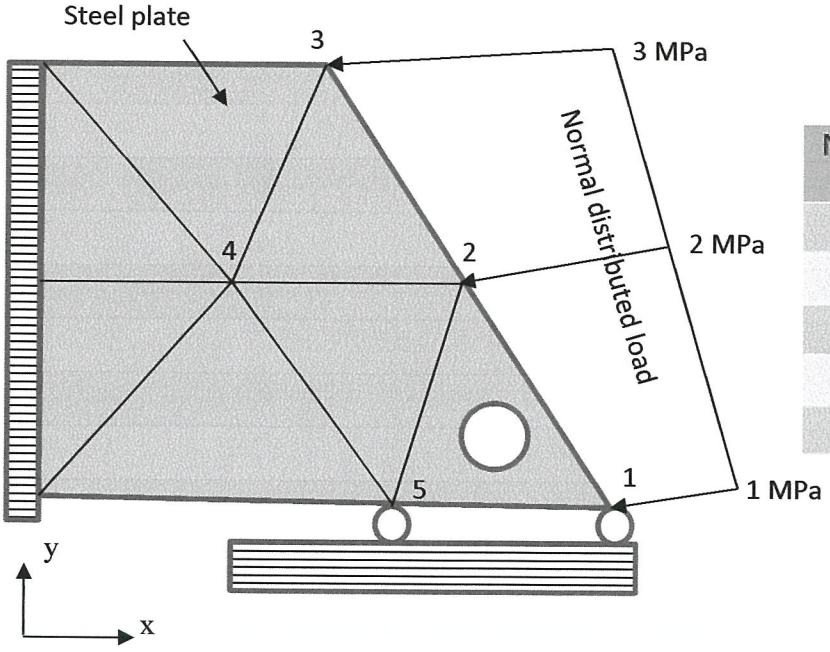


Figure Q5 (a)



Node	x (mm)	Y (mm)
1	100	0
2	85	20
3	70	40
4	60	20
5	75	0

Figure Q5 (b)