OCD83

UNIVERSITY OF BOLTON

OFF CAMPUS DIVISION

MALAYSIA - KTG

BENG (HONS) MECHANICAL ENGINEERING

SEMESTER ONE EXAMINATION 2019/2020

FINITE ELEMENT AND DIFFERENCE SOLUTION

MODULE NO. AME6006

Date: 15th January 2020 **Time: 3 Hours**

INSTRUCTIONS TO CANDIDATES:

There are FOUR questions on this paper.

Answer ALL questions.

All questions carry equal marks.

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Q1 **Figure Q1** shows a plane truss consisting of three members. Pin joints 1 are fixed and joints 2 are roller to rigid body surface and we also have an inclined roller at joints 3. A point force of 1000kN is applied to joint 2 as shown. All members have an cross sectional area of either $A_{1,2}$ $(6.0 \times 10^{-4} m^2)$, and A_3 $(6\sqrt{2} \times 10^{-4} m^2)$. The length of member 1 is 1m. Young Modulus for all members is 210GPa.

a) Write down the element stiffness matrix for each member, and then assembly the overall stiffness matrix for the whole structure, clearly showing all its coefficients.

(13 marks)

b) Calculate displacement and reaction forces
The element stiffness matrix can be written as follows:

(12 marks)

$$k = \frac{AE}{L}\begin{bmatrix} C^2 & CS & -C^2 & -CS \\ CS & S^2 & -CS & -S^2 \\ -C^2 & -CS & C^2 & CS \\ -CS & -S^2 & CS & S^2 \end{bmatrix}$$

Total 25 Marks

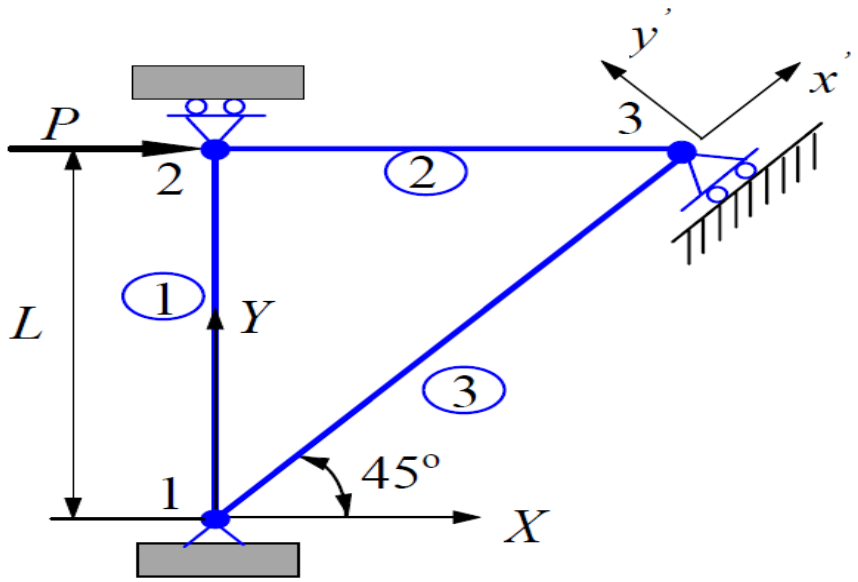

Figure Q1

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Q2 The coordinates of a three node plane stress triangle element of uniform thickness t are (x_1, y_1), (x_2, y_2) and (x_3, y_3) as shown in **Figure Q2**. Young Modulus *E* = 200 GPa for all members and n = 0.27, *sy* = 250 MPa (ductile material). Where:

$$d = \begin{Bmatrix} 0 \\ 0 \\ 2 \\ 0 \\ 1 \\ -1 \end{Bmatrix}$$

Find:

a) Planar strain at center (5 marks)

b) Planar stress at center (5 marks)

c) Principle stresses at center (5 marks)

d) Von Mises stress at center (5 marks)

e) Factor of safety, if the stress from d) represents the most extreme situation (5 marks)

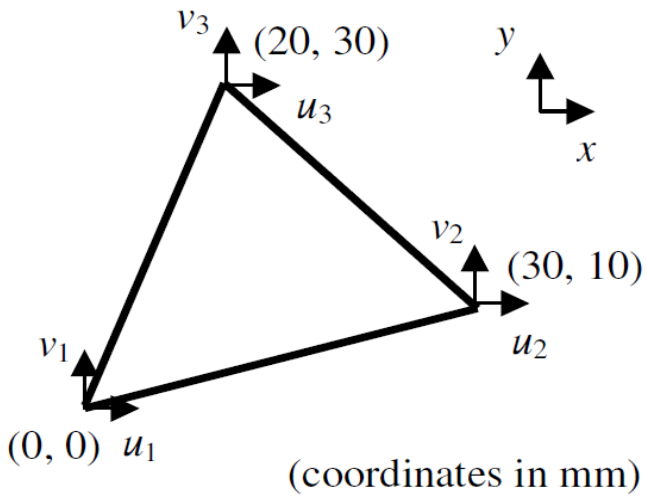

Figure Q2

Total 25 Marks

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Q3 A Kirchhoff plate, loaded by point force F acting at the center point, is simply supported on two edges and free on the other two edges as shown in the **Figure Q3**. Use the approximation $w = uZ_0(\frac{x}{L})(\frac{y}{L})$

Determine the displacement at the center point. Problem parameters $E, \mu,$ and t are constants.

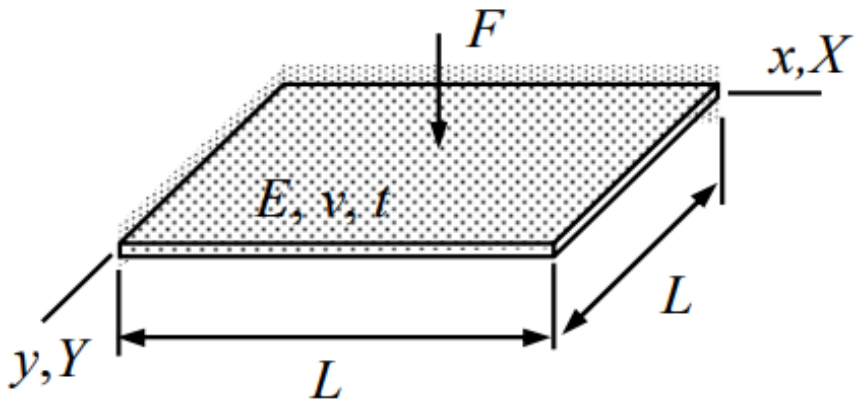

Figure Q3

(25 marks)

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Q4 The **Figure Q4** shows the beam structure and use two beam elements of equal length. Point force of magnitude F is acting on node 2. Young's modulus of the material E and the second moment of cross-section I are constants.

Determine displacement u_{Z2} and rotation θ_{Y2} at node 2 of the beam structure as shown in Figure Q4.

(25 Marks)

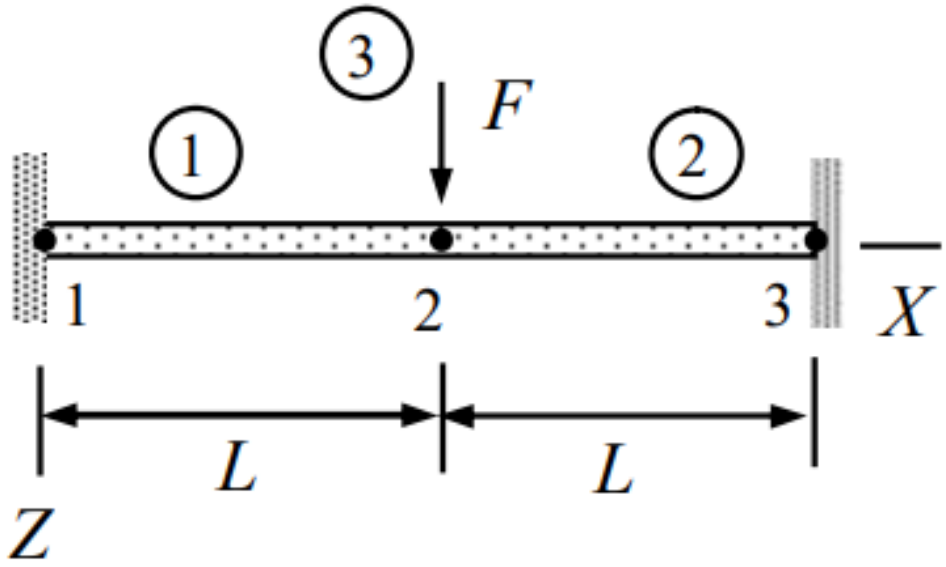

Figure Q4

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