Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2023/2024

COURSE NAME	:	FINITE ELEMENT ANALYSIS
COURSE CODE	:	BFS 41003
PROGRAMME CODE	:	BFF
EXAMINATION DATE	:	JULY 2024
DURATION	:	3 HOURS
INSTRUCTIONS	:	1. ANSWER ALL QUESTIONS 2. THIS FINAL EXAMINATION IS CONDUCTED VIA ☐ Open book ☒ Closed book 3. STUDENTS ARE **PROHIBITED** TO CONSULT THEIR OWN MATERIAL OR ANY EXTERNAL RESOURCES DURING THE EXAMINATION CONDUCTED VIA CLOSED BOOK

THIS QUESTION PAPER CONSISTS OF **FIVE (5)** PAGES

Q1 A rectangular isoparametric element in two dimensions, featuring four nodes positioned at the corners is depicted in **Figure Q1.1**. Determine the following:

(a) Shape functions in the coordinate of (ξ- η).

(4 marks)

(b) Jacobi matrix [J]

(13 marks)

(c) Displacement matrix [B]

(8 marks)

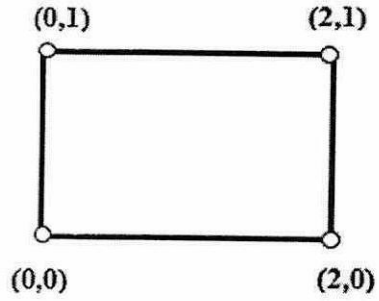

Figure Q1.1

Q2 **Figure Q2.1** displays a truss structure comprising three members and four nodes, supported by three pinned connections. Every node has two degrees of freedom. Node 3 experiences a vertical load of 20 kN applied to it. Take A= 300 mm^2 and E= 200 GPa. Determine the following using the direct stiffness matrix method:

(a) Global stiffness matrix.

(11 marks)

(b) Nodal displacements at node 3.

(4 marks)

(c) Reaction of supports.

(6 marks)

(d) Internal force in all members.

(4 marks)

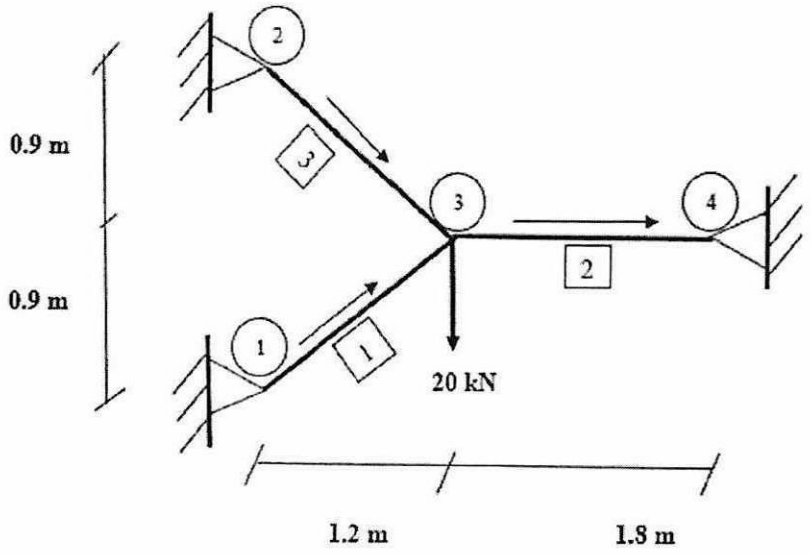

Figure Q2.1

Q3 A 1-D isoparametric bar element with 4 nodes, and a rectangular isoparametric element with 9 nodes, are shown in **Figure Q3.1** and **Figure Q3.2**, respectively. Derive the shape functions using zero method for both elements.

(25 marks)

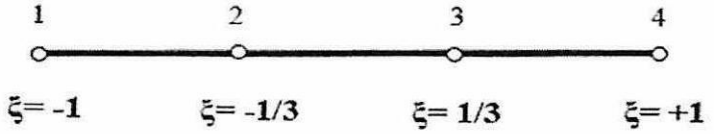

Figure Q3.1

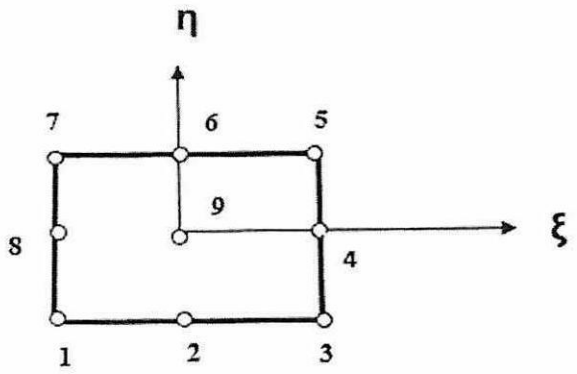

Figure Q3.2

Q4 **Figure Q4.1** shows a beam with a total length of 4m, subjected to a concentrated load at the end. This beam comprising two members and three nodes. Every node has two degrees of freedom. Node 3 experiences a vertical load of 5 kN applied to it. EI is constant. Using the direct stiffness matrix method, determine the following:

(a) Stiffness matrix of beam structure.

(12 marks)

(b) Displacements at (D1, D2, D3 and D4).

(8 marks)

(c) Reactions of supports.

(5 marks)

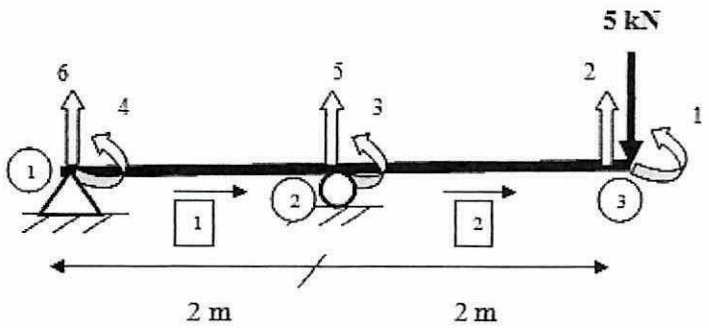

Figure Q4.1

- END OF QUESTIONS -

APPENDIX A

For truss structure:

$$K=\frac{AE}{L}\begin{bmatrix} \lambda_x^2 & \lambda_x\lambda_y & -\lambda_x^2 & -\lambda_x\lambda_y \\ \lambda_x\lambda_y & \lambda_y^2 & -\lambda_x\lambda_y & -\lambda_y^2 \\ -\lambda_x^2 & -\lambda_x\lambda_y & \lambda_x^2 & \lambda_x\lambda_y \\ -\lambda_x\lambda_y & -\lambda_y^2 & \lambda_x\lambda_y & \lambda_y^2 \end{bmatrix}$$

$$q=\frac{AE}{L}\begin{bmatrix} -\lambda_X & -\lambda_y & \lambda_X & \lambda_y \end{bmatrix}\begin{bmatrix} D_{Nx} \\ D_{Ny} \\ D_{Fx} \\ D_{Fy} \end{bmatrix}$$

For beam structure:

$$K=EI\begin{bmatrix} \frac{12}{L^3} & \frac{6}{L^2} & -\frac{12}{L^3} & \frac{6}{L^2} \\ \frac{6}{L^2} & \frac{4}{L} & -\frac{6}{L^2} & \frac{2}{L} \\ -\frac{12}{L^3} & -\frac{6}{L^2} & \frac{12}{L^3} & -\frac{6}{L^2} \\ \frac{6}{L^2} & \frac{2}{L} & -\frac{6}{L^2} & \frac{4}{L} \end{bmatrix}$$