UNIVERSITI
TEKNOLOGI
PETRONAS

FINAL EXAMINATION
JANUARY 2022 SEMESTER

COURSE	:	**VEB3022 - FINITE ELEMENT METHOD FOR CIVIL ENGINEERS**
DATE	:	**7 APRIL 2022 (THURSDAY)**
TIME	:	**9.00 AM - 12.00 NOON (3 HOURS)**

INSTRUCTIONS TO CANDIDATES

1. Answer **ALL** questions in the Answer Booklet.
2. Begin **EACH** answer on a new page in the Answer Booklet.
3. Indicate clearly answers that are cancelled, if any.
4. Where applicable, show clearly steps taken in arriving at the solutions and indicate **ALL** assumptions, if any.
5. **DO NOT** open this Question Booklet until instructed.

Note :

i. There are **FIVE (5)** pages in this Question Booklet including the cover page .

ii. **DOUBLE-SIDED** Question Booklet.

1. **FIGURE Q1** shows two linear springs 1 and 2 that are connected at node-2. The stiffness of spring-1 K_1 is 5 N/mm, and for spring-2 K_2 is 10 N/mm. The applied nodal force at node-2 is F_2 = 100 N and at node-3 is F_3 = 200 N.

Develop:

a. Element stiffness matrix of springs 1 and 2,

[8 marks]

b. Global stiffness matrix $[K_G]$ of the spring system.

[8 marks]

c. Estimate nodal displacement U_2 and U_3 and reactive force F_1.

[9 marks]

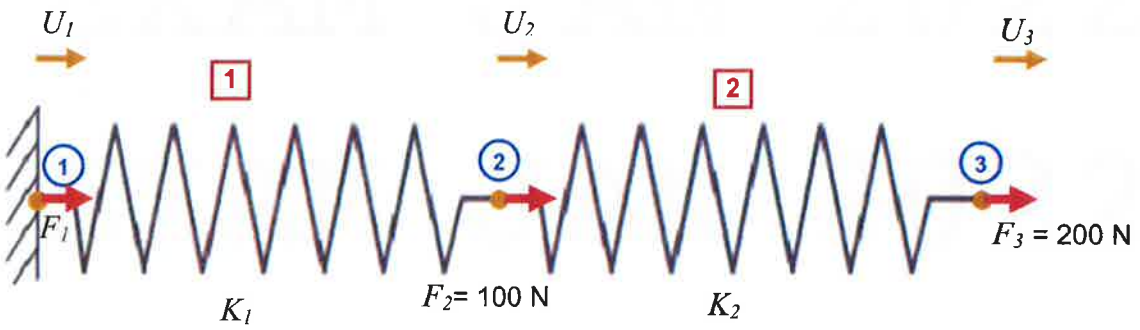

FIGURE Q1

2 **FIGURE Q2** shows two prismatic bar elements, 1 and 2, connected at node-2. Length of element 1, L_1 is 2000 mm, and the length of element 2. L_2 is 2500 mm. An axial force, F_2 of 500 N, is applied at node-2, node-1, and node-3 are rigidly attached to the fixed support. The EA is given as 7×10^7 N.

Develop:

a. Element stiffness matrix $[k_1]$, and $[k_2]$,

[8 marks]

b. Global stiffness matrix $[K]$ of the system,

[8 marks]

c. Estimate nodal displacement, U_2, and reactive forces, F_1 and F_3.

[9 marks]

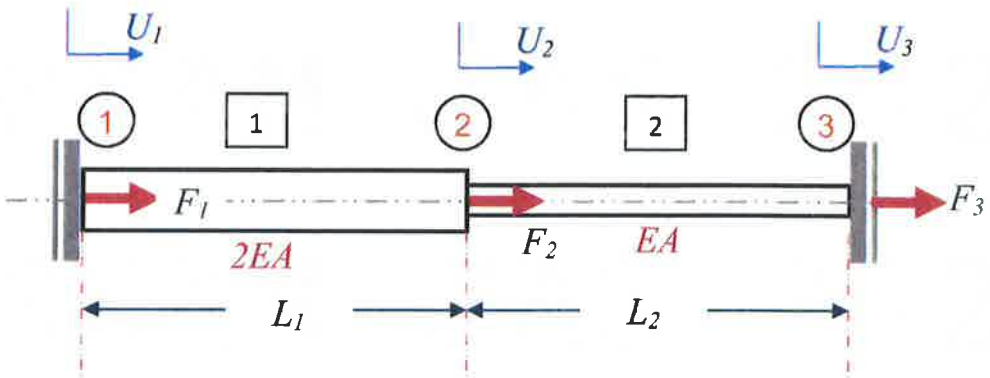

FIGURE Q2

3. **FIGURE Q3** shows a three-element truss structure. At node-3, it is subjected to a rightward horizontal force of 2000 N. The EA of all three elements is given as $6x10^7$ N.

a. Develop the element stiffness matrix in the local and global coordinate system.

[10 marks]

b. Construct the transformation matrix [C].

[6 marks]

c. Develop the global stiffness matrix [K_G] for the system.

[6 marks]

d. Assemble the system equilibrium equation in the matrix form.

[3 marks]

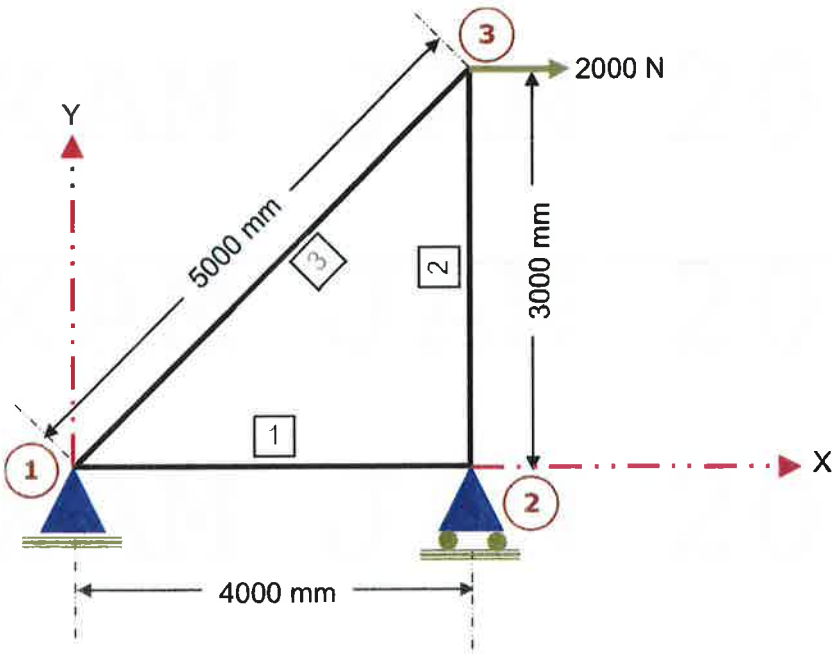

FIGURE Q2

4. **FIGURE Q4** shows a fixed end beam split into elements 1 and 2. The length of element-1 L_1 is 6 m, and the length of element-2, L_2 is 4 m, and the rigidity, EI is 12 kN-m^2. Node-2 is subjected to a vertically downward load P of 100 kN and an applied nodal moment M of 50 kN-m.

Develop:

a. Element stiffness matrix [k_1], and [k_2],

[8 marks]

b. Global stiffness matrix [K],

[8 marks]

c. Finite element equilibrium equation.

[3 marks]

d. Estimate downward deflection at node-2, v_2.

[6 marks]

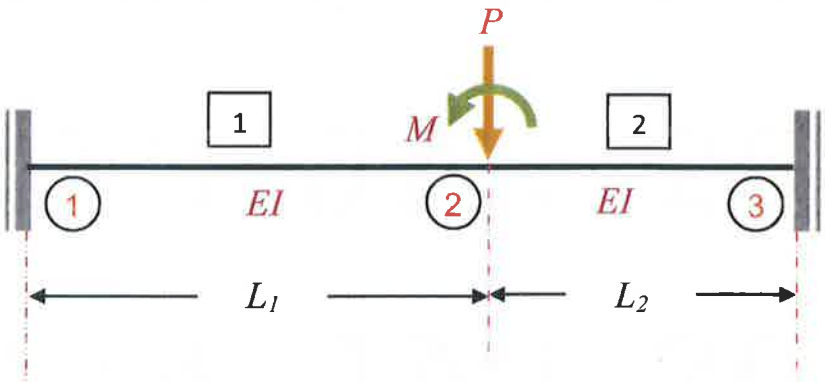

FIGURE Q4

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