TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Engineering and Technology
DEPARTMENT OF BUILDING AND CIVIL ENGINEERING
UNIVERSITY EXAMINATION FOR:

BACHELOR OF TECHNOLOGY IN CIVIL ENGINEERING
TCV 4311 : ANALYSIS OF STRUCTURES III
SPECIAL/SUPPLEMENTARY EXAMINATION
SERIES: JULY 2025
TIME: 2 HOURS

Instructions to Candidates

You should have the following for this examination
-Answer Booklet, examination pass and student ID
This paper consists of five questions.
Attempt question ONE (Compulsory) and any other TWO questions.
Do not write on the question paper.

QUESTION ONE (COMPULSORY) 20 marks

a) Discuss the general methodology followed in analysis of structures using the Matrix Stiffness Method

(5 Marks)

b) Consider a spring system shown in **Figure Q1b** below. The applied force at node 3 is 1500N while the applied forces at nodes 2 and 4 are zero. Calculate the nodal displacements and element internal forces, given that;

k_1 =20N/mm, k_2 = 50N/mm, k_3 = 40 N/mm, F_{3x} = 1500 N

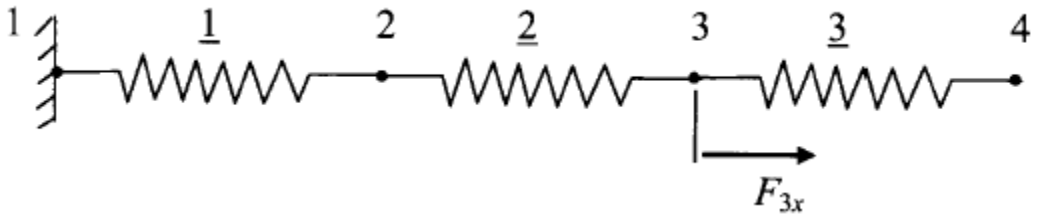

Figure Q1b: Three Spring System

(15 Marks)

QUESTION TWO (20 Marks)

Obtain the nodal displacements, reaction forces and element internal forces of the two-bar truss structure loaded as shown in **Figure Q2** below. For each element, A = 1.5 in^2 and E = 20×10^6 psi

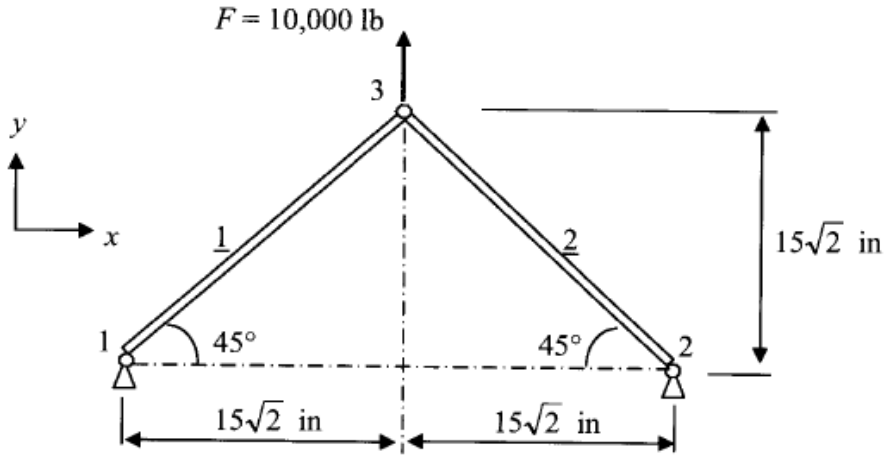

Figure Q2: Two bar truss structure

(20 Marks)

QUESTION THREE (20 Marks)

Figure Q3 shows a combined bar-beam structure. Element 1 is a beam and element 2 is a bar. Obtain the nodal displacements, reaction forces and element internal forces of the structure. Given that; E = 210 Gpa, Bar: A = 1E-3 m^2, Beam: A = 2E-3 m^2, I = 5E-5 m^4

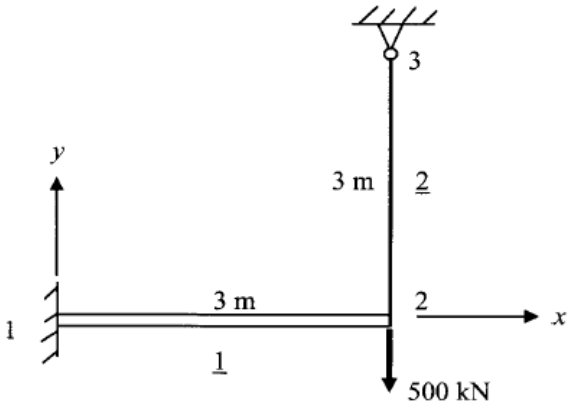

Figure Q3: A combined bar-beam structure

(20 Marks)

QUESTION FOUR (20 Marks)

a) Derive the Element stiffness equation for a bar element.

(5 Marks)

b) Consider a bar structure shown in Figure **Q4b** below. The applied forces at nodes 2 and 3 are 10000 lb at each node. Calculate the nodal displacements, reaction forces and element internal forces, given that A = 2.5 in^2 and E = 20×10^6 psi for all members.

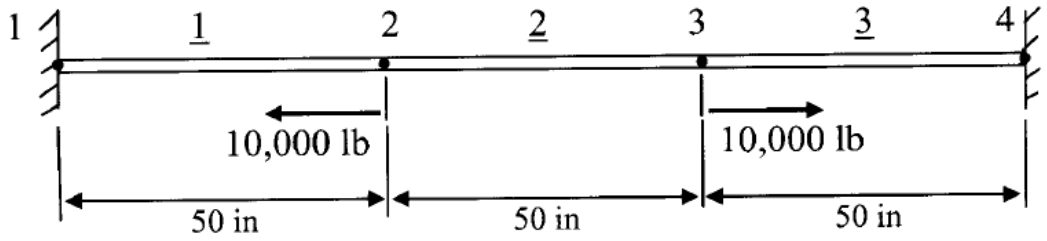

Figure Q4b: Three element bar structure

(15 Marks)

QUESTION FIVE (20 Marks)

Obtain the nodal displacements and reaction forces of the two-member frame structure loaded as shown in figure Q5. Find also the internal forces of element 1. For each member, E = $20*10^6$ psi, I = 250 in^4, and A = 25 in^2

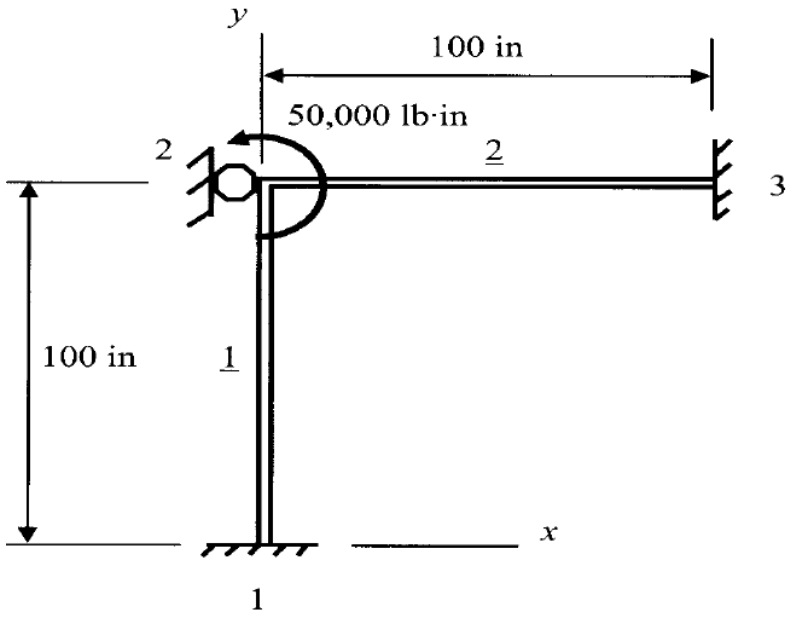

Figure Q5: Two-member frame structure

Given that Element Stiffness matrix [k] for a frame in global coordinates is;

$$[k] = (E/L)$$

$$\times \begin{bmatrix} AC^2 + \frac{12I}{L^2}S^2 & \left(A - \frac{12I}{L^2}\right)CS & \frac{-6I}{L}S & -\left(AC^2 + \frac{12I}{L^2}S^2\right) & -\left(A - \frac{12I}{L^2}\right)CS & \frac{-6I}{L}S \\ & AS^2 + \frac{12I}{L^2}C^2 & \frac{6I}{L}C & -\left(A - \frac{12I}{L^2}\right)CS & -\left(AS^2 + \frac{12I}{L^2}C^2\right) & \frac{6I}{L}C \\ & & 4I & \frac{6I}{L}S & \frac{-6I}{L}C & 2I \\ & & & AC^2 + \frac{12I}{L^2}S^2 & \left(A - \frac{12I}{L^2}\right)CS & \frac{6I}{L}S \\ & & \textit{Symmetry} & & AS^2 + \frac{12I}{L^2}C^2 & \frac{-6I}{L}C \\ & & & & & 4I \end{bmatrix}$$