TECHNICAL UNIVERSITY OF MOMBASA

UNIVERSITY EXAMINATIONS 2016/2017
FOURTH YEAR FIRST SEMESTER EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN CIVIL ENGINEERING

ECE 2408: THEORY OF STRUCTURES V

DATE: DECEMBER 2016 **TIME: 2 Hours**

INSTRUCTIONS: Attempt ALL questions. Use clear sketches to illustrate your answers. All questions carry equal marks.

Q.1. Determine the nodal displacements and member internal forces for the basic truss system loaded as shown in Figure Q.1. For each member, $A = 1000mm^2 \ and \ E = 200 \ kN/mm^2$

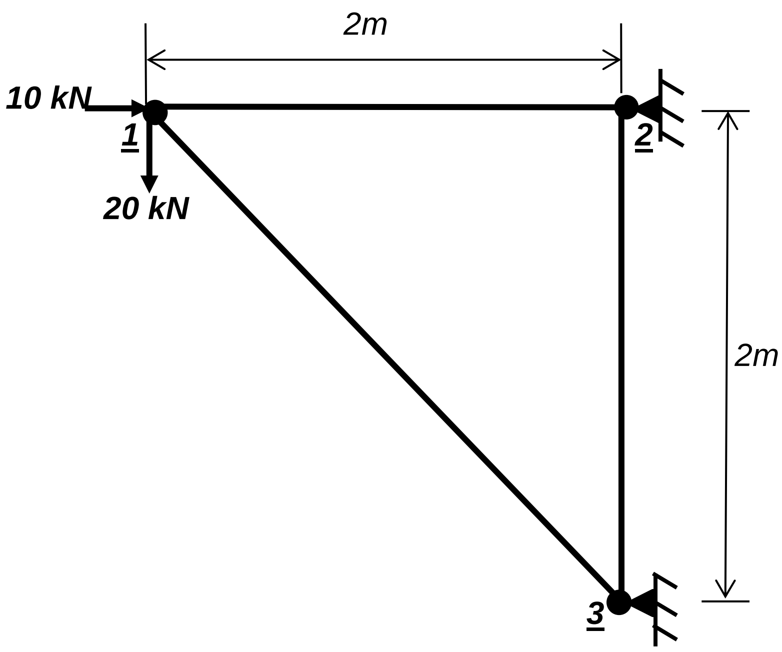

Figure Q.1

***Hint:* For each element i – j:**

$\{f\} = [k]\{d\}$ ***in global coordinates, where***

$$\begin{Bmatrix} f_{ix} \\ f_{iy} \\ f_{jx} \\ f_{jy} \end{Bmatrix} = [k] \begin{Bmatrix} d_{iy} \\ d_{ix} \\ d_{jx} \\ d_{jy} \end{Bmatrix};$$

$$[k] = [T]^T[\hat{k}][T];$$

$$[T] = \begin{bmatrix} C & S & 0 & 0 \\ -S & C & 0 & 0 \\ 0 & 0 & C & S \\ 0 & 0 & -S & C \end{bmatrix};$$

in local member coordinates

$$[\hat{k}] = \frac{AE}{l}\begin{bmatrix} 1 & 0 & -1 & 0 \\ 0 & 0 & 0 & 0 \\ -1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

Q.2. Obtain the displacements and internal member forces for the rigidly basic jointed frame loaded as shown in Figure Q.2. For all members, $A = 500\ mm^2,\ I = 1E6\ mm^4\ and\ E = 100\ \ kN/mm^2$.

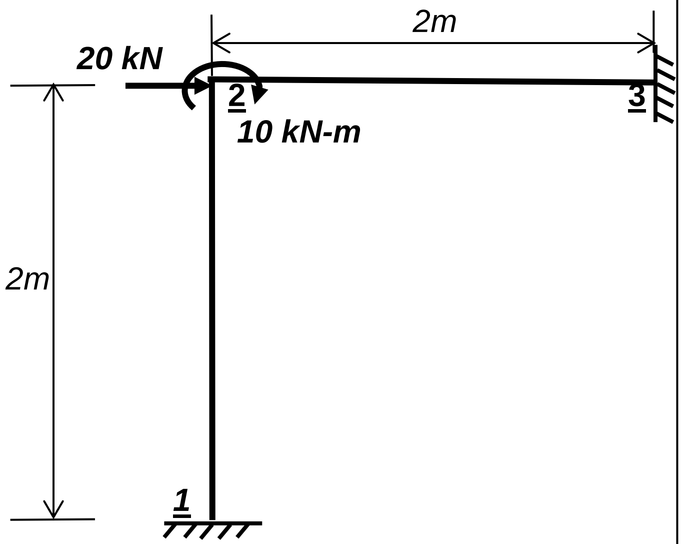

Figure Q.2

Hints

In local coordinates

$$[k] = \begin{bmatrix} \frac{AE}{l} & 0 & 0 & \frac{-AE}{l} & 0 & 0 \\ 0 & \frac{12EI}{l^3} & \frac{6EI}{l^2} & 0 & \frac{-12EI}{l^3} & \frac{6EI}{l^2} \\ 0 & \frac{6EI}{l^2} & \frac{4EI}{l} & 0 & \frac{-6EI}{l^2} & \frac{2EI}{l} \\ \frac{-AE}{l} & 0 & 0 & \frac{AE}{l} & 0 & 0 \\ 0 & \frac{-12EI}{l^3} & \frac{-6EI}{l^2} & 0 & \frac{12EI}{l^3} & \frac{-6EI}{l^2} \\ 0 & \frac{6EI}{l^2} & \frac{2EI}{l} & 0 & \frac{-6EI}{l^2} & \frac{4EI}{l} \end{bmatrix}$$

In global coordinates

$$[K] = [T]^T.[k].[T]$$

Q.3. Determine the slopes, shear forces and bending moments at the supports for the beam loaded as shown in Figure Q.3 using matrix methods of analysis. $E = 200\ kN/mm^2 and\ \ I\ = \ 2E6\ mm^4\ for\ all\ members$

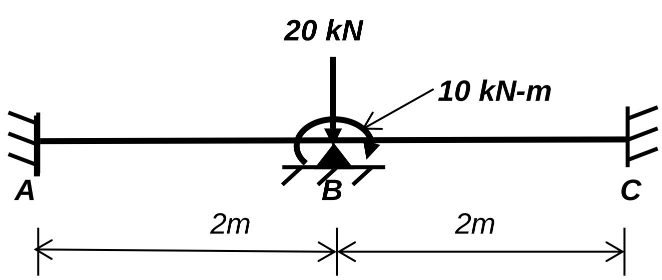

Figure Q.3

Hint:

$$[k] = EI\begin{bmatrix} \frac{12}{l^3} & \frac{6}{l^2} & \frac{-12}{l^3} & \frac{6}{l^2} \\ \frac{6}{l^2} & \frac{4}{l} & \frac{-6}{l^2} & \frac{2}{l} \\ \frac{-12}{l^3} & \frac{-6}{l^2} & \frac{12}{l^3} & \frac{-6}{l^2} \\ \frac{6}{l^2} & \frac{2}{l} & \frac{-6}{l^2} & \frac{4}{l} \end{bmatrix}$$

Q.4. The frame below is subjected to the external loads and supported as shown in the Figure Q.4.

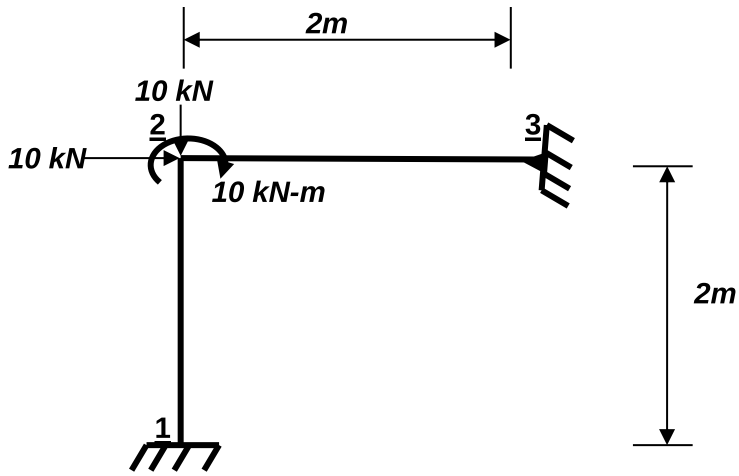

FIGURE Q.4

If the global element stiffness matrices are:-

$$[K_{12}] = \begin{bmatrix} 50 & 100 & -15 & -50 & -100 & -15 \\ 100 & 300 & 10 & -100 & -300 & 10 \\ -15 & 10 & 50 & 15 & -10 & 25 \\ -50 & -100 & 15 & 50 & 100 & 15 \\ -100 & -300 & -10 & 100 & 300 & -10 \\ -15 & 10 & 25 & 15 & -10 & 50 \end{bmatrix}, \quad [K_{23}] = \begin{bmatrix} 500 & 0 & 0 & -500 & 0 & 0 \\ 0 & 5 & 15 & 0 & -5 & 15 \\ 0 & 15 & 50 & 0 & -15 & 25 \\ -500 & 0 & 0 & 500 & 0 & 0 \\ 0 & -5 & -15 & 0 & 5 & -15 \\ 0 & 15 & 25 & 0 & -15 & 50 \end{bmatrix}$$

Assemble the stiffness matrix for the entire structure from the global element stiffness matrices given and hence compute the reactions of the supports of the frame.