UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 7 Examination in Engineering: August 2015

Module Number: CE7323 **Module Name**: Computer Analysis of Structures

[Three Hours]

Answer all questions (Each question carries 12 marks)

All standard notations denote their regular meanings

Q1. Analyse the truss structure shown in Fig Q1 using flexibility matrix method. Assume for all members $AE = 2\times10^3$ kN.

a) Construct the flexibility matrix for structure. [7 Marks]

b) Find the displacement at point B. [3 Marks]

c) Determine the member force in all members. [2 Marks]

Q2. Two beams were subjected to a point loading at point B as shown in Fig Q2. Take the lengths of the beam elements $AB=BC=DB$ =10m and the parameter $EI=10\times10^6$ Nm^2 for both beams. Using stiffness matrix method of analysis,

a) Construct the global stiffness matrix of the system. [4 Marks]

b) Determine the deformation at the point B. [5 Marks]

c) Determine the reaction and the bending moment at the support '*D*' for beam DB. [1 Mark]

d) Explain briefly, for automatic computation, why stiffness matrix method is more suitable than flexibility matrix method. [2 Marks]

Ignore the axial effect and use the stiffness matrix for a beam element as,

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

Q3. Pin-jointed 2D truss is pinned support at Nodes A and C and roller support at Node B as shown in Fig Q3. The Young's modulus E = 200 GPa and cross-section area A = 5×10^{-4} m^2 for both elements AB and BC. The truss system is subjected to a force 1000 kN at Node B, as shown in Fig Q3.

a) Find the element stiffness matrix of the 2 elements with respect to a selected global coordinate system.

[4 Marks]

b) Determine the global stiffness matrix of the system.

[2 Marks]

c) Define the boundary condition and loading condition for each node.

[2 Marks]

d) Determine the displacements at Node B.

[2 Marks]

e) Determine support reaction at each node.

[2 Marks]

(Use the stiffness matrix for a 2D-bar element as shown below.)

$$\left[k^e\right] = \frac{EA}{L}\begin{bmatrix} c^2 & cs & -c^2 & -cs \\ cs & s^2 & -cs & -s^2 \\ -c^2 & -cs & c^2 & cs \\ -cs & -s^2 & cs & s^2 \end{bmatrix}$$

where $c = Cos\Theta$, $s = Sin\Theta$ and Θ is the anticlockwise angle at node measured from the global X-axis to the local x-axis of the bar element.

Q4. A beam subjected to different loading is shown in Fig Q4 and is supposed to be analyzed using the finite element technique with three elements. Assume $EI = 20 \times 10^6$ Nm^2, where E is Young's Modulus and I is the second moment of area of the beam.

a) Construct the global stiffness matrix of the system. [3 Marks]

b) Find the equivalent nodal forces and moments at the four nodes of the beam.

[2 Marks]

c) Determine the Nodal deformations and reactions. [6 Marks]

d) Propose the possible methods to increase the accuracy of the answer in the analysis. [1 Mark]

Ignore the axial effect and use the stiffness matrix for a beam element as shown at the end of Q2.

Q5. A triangular panel is made of isotropic materials with thickness of 10 mm (shown in Fig Q5). Young Modulus (E) and Poisson's ratio (v) of the material are 70 GPa and 0.3, respectively. The edge AB is fixed.

a) Formulate strain-displacement matrix [B]. [6 Marks]

b) Construct the stiffness matrix for a plate element. [4 Marks]

c) Determine the nodal deformations at C. [2 Marks]

Use the stiffness matrix for a 2D-plate element as shown below.

$$\left[K^{n}\right]=\int^{v}[B]^{T}[D][B]d(vol)$$

where

$$[D]=\frac{E}{1-\nu^{2}}\begin{bmatrix}1 & \nu & 0\\ \nu & 1 & 0\\ 0 & 0 & \frac{1-\nu}{2}\end{bmatrix}$$

and take displacements in the element in x and y direction as $u(x,y)=a_1+a_2x+a_3y$ and $v(x,y)=a_4+a_5x+a_6y$.

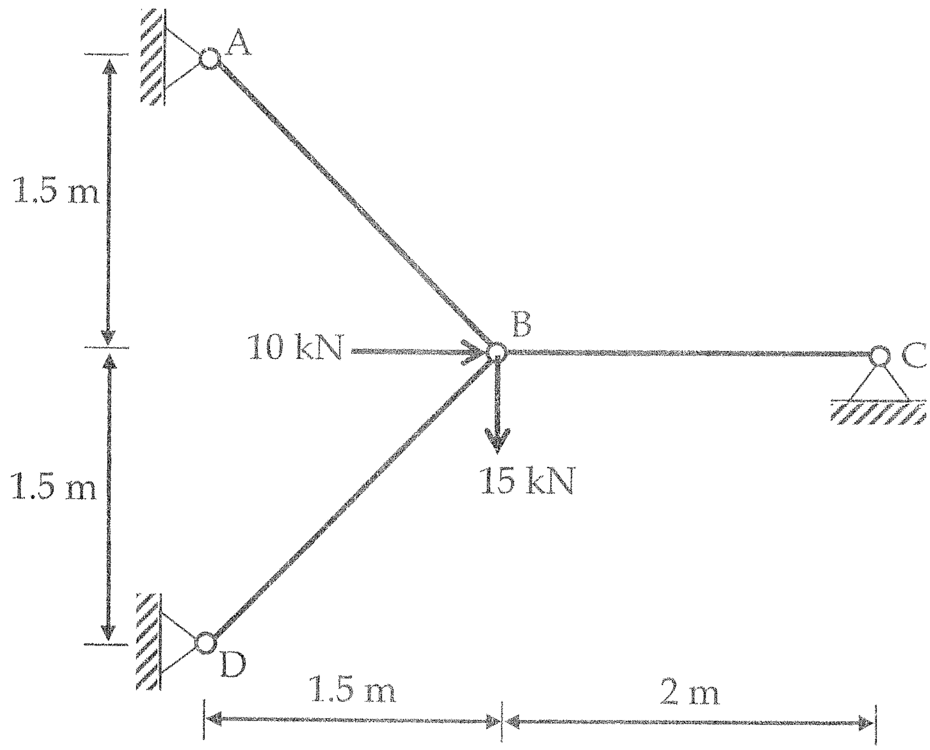


Fig. Q1

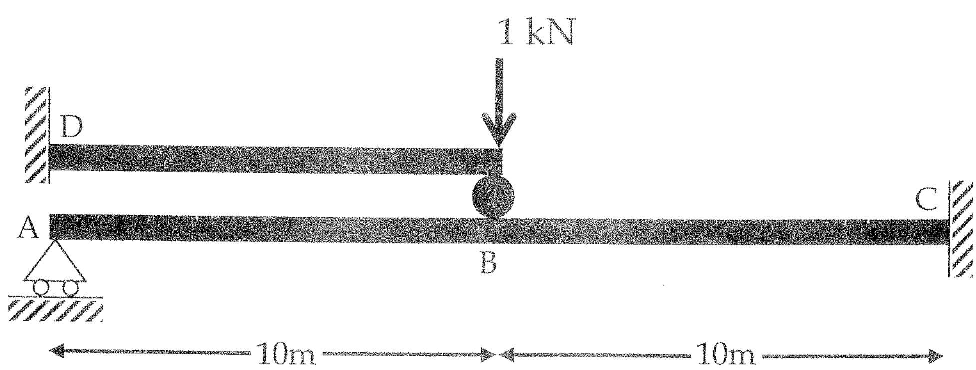


Fig. Q2

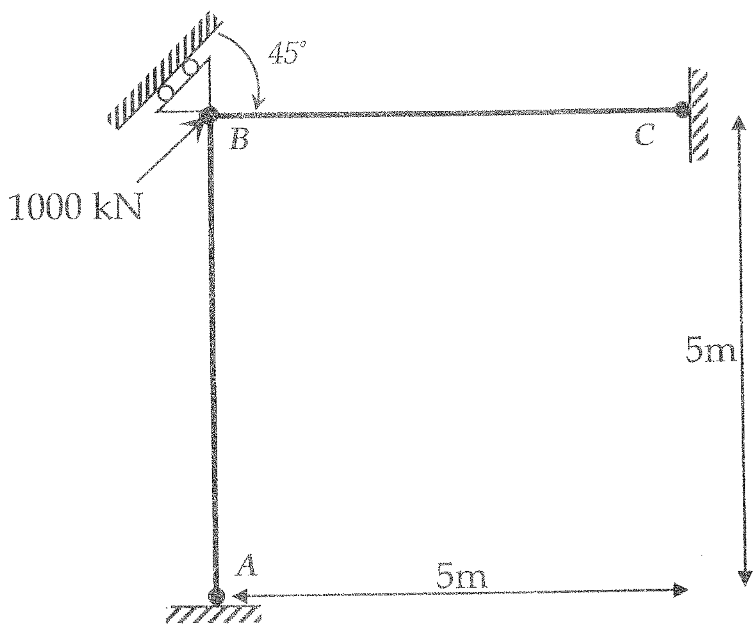


Fig. Q3

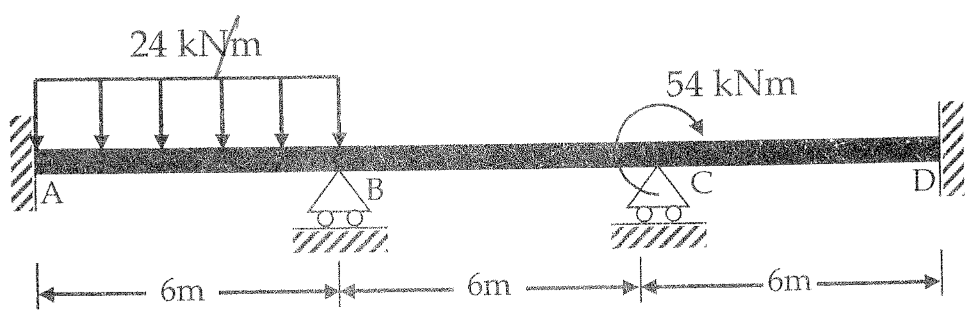
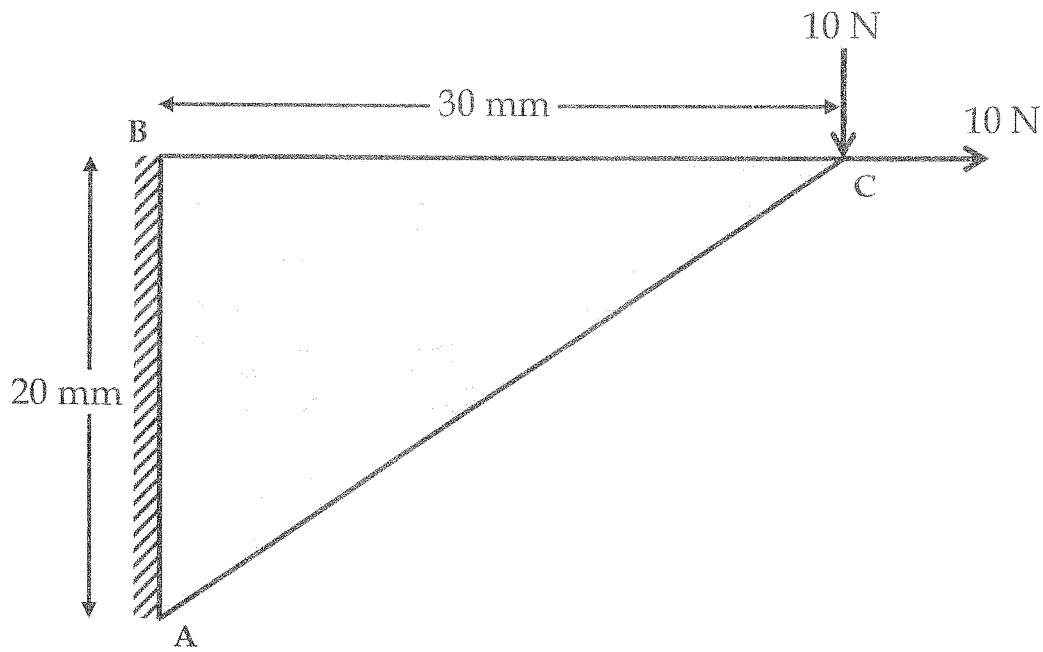


Fig. Q4


10 N
30 mm
B
10 N
C
20 mm
A