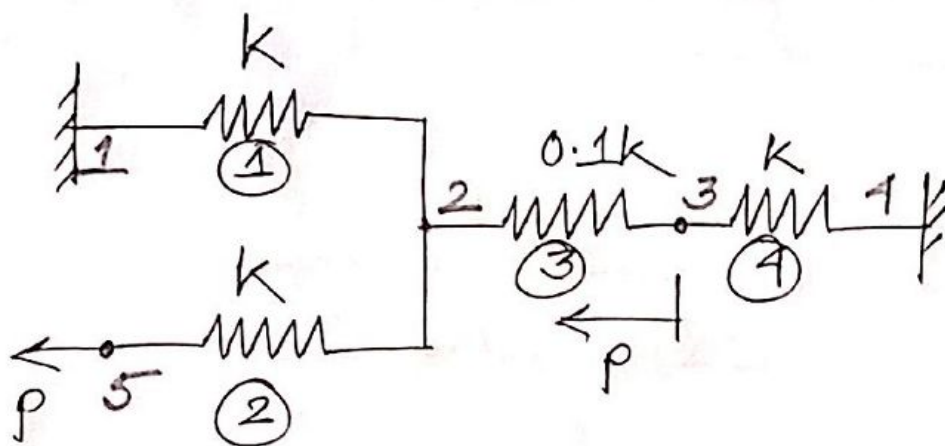


Set A



If $P = 100 \text{ kg}$ & $k = 10 \text{ kg/cm}$ find the element with maximum deformation.

Solution:

Element connectivity matrix

<u>Element</u>	<u>Node i</u>	<u>Node j</u>
1	1	2
2	5	2
3	2	3
4	3	4

$$K_1 = \begin{bmatrix} 10 & -10 \\ -10 & 10 \end{bmatrix}$$

$$K_2 = \begin{bmatrix} 10 & -10 \\ -10 & 10 \end{bmatrix}$$

$$K_3 = \begin{bmatrix} 1 & -1 \\ -1 & 1 \end{bmatrix}$$

$$K_4 = \begin{bmatrix} 10 & -10 \\ -10 & 10 \end{bmatrix}$$

The stiffness matrix

$$\begin{bmatrix} 10 & -10 & & & \\ -10 & 10+10 & -1 & & -10 \\ & -1 & 1+10 & -10 & \\ & & -10 & 10 & \\ & -10 & & & 10 \end{bmatrix}$$

The stiffness equation

$$\begin{bmatrix} 10 & -10 & 0 & 0 & 0 \\ -10 & 21 & -1 & 0 & -10 \\ 0 & -1 & 11 & -10 & 0 \\ 0 & 0 & -10 & 10 & 0 \\ 0 & -10 & 0 & 0 & 10 \end{bmatrix} \begin{Bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \\ u_5 \end{Bmatrix} = \begin{Bmatrix} F_1 \\ F_2 \\ F_3 \\ F_4 \\ F_5 \end{Bmatrix}$$

Applying boundary conditions

$$\begin{bmatrix} 10 & -10 & 0 & 0 & 0 \\ -10 & 21 & -1 & 0 & -10 \\ 0 & -1 & 11 & -10 & 0 \\ 0 & 0 & -10 & 10 & 0 \\ 0 & -10 & 0 & 0 & 10 \end{bmatrix} \begin{Bmatrix} 0 \\ u_2 \\ u_3 \\ 0 \\ u_5 \end{Bmatrix} = \begin{Bmatrix} F_1 \\ 0 \\ -100 \\ 0 \\ -100 \end{Bmatrix}$$

The reduced FE becomes,

$$\begin{aligned}(21)u_2 + (-1)u_3 + (-10)u_5 &= 0 \\ (-1)u_2 + (11)u_3 + (0)u_5 &= -100 \\ (-10)u_2 + (0)u_3 + (10)u_5 &= -100\end{aligned}$$

Now,

$$\begin{aligned}u_2 &= -10 \text{ m} \\ u_3 &= -10 \text{ m} \\ u_5 &= -20 \text{ m}\end{aligned}$$

$$\begin{aligned}\text{Displacement in element 1} &= u_2 - u_4 \\ &= -10 - 0 \\ &= -10 \text{ m}\end{aligned}$$

$$\begin{aligned}\text{Displacement in element 2} &= u_2 - u_5 \\ &= -10 - (-20) \\ &= 10 \text{ m}\end{aligned}$$

$$\begin{aligned}\text{Displacement in element 3} &= u_3 - u_2 \\ &= -10 - (-10) \\ &= 0 \text{ m}\end{aligned}$$

$$\begin{aligned}\text{Displacement in element 4} &= u_4 - u_3 \\ &= 0 - (-10) \\ &= 10 \text{ m}\end{aligned}$$

So, elements 1, 2 & 4 gets displaced an equal amount:

$$\begin{aligned}
 001 &= 2^{11}(01) + 2^{10}(1-) + 2^{09}(1-) \\
 011 &= 2^{11}(0) + 2^{10}(11) + 2^{09}(1-) \\
 101 &= 2^{11}(011) + 2^{10}(0) + 2^{09}(01-)
 \end{aligned}$$

$$\begin{aligned}
 100 &= 2^{11} + 2^{10} + 2^{09} \\
 010 &= 2^{11} \\
 110 &= 2^{11} + 2^{10}
 \end{aligned}$$

Displacement in lowest bit is 1

$$\begin{aligned}
 011 &= 2^{11} + 2^{10} + 2^{09} \\
 (011) \cdot 01 &= 2^{11} + 2^{10} + 2^{09} \\
 (101) \cdot 01 &= 2^{11} + 2^{10} + 2^{09}
 \end{aligned}$$

$$\begin{aligned}
 101 &= 2^{11} + 2^{10} + 2^{09} \\
 (01-) \cdot 01 &= 2^{11} + 2^{10} + 2^{09} \\
 110 &= 2^{11} + 2^{10}
 \end{aligned}$$

$$\begin{aligned}
 110 &= 2^{11} + 2^{10} \\
 (01-) \cdot 0 &= 0
 \end{aligned}$$