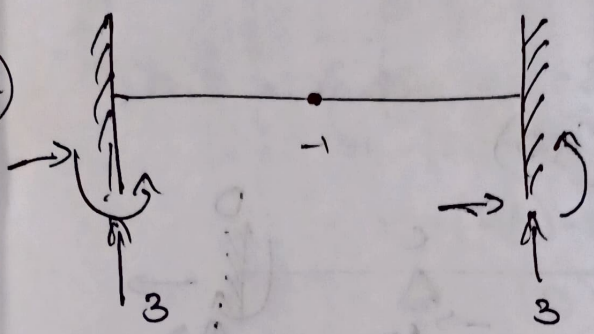
Assignment-1

1. Find the degree of static indeterminacy (DoSI)

a)



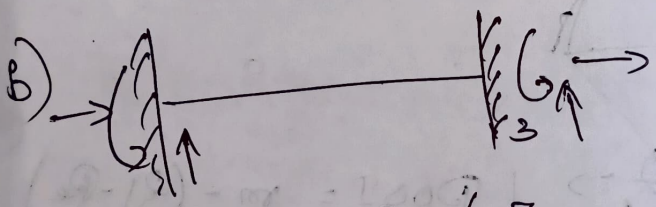
DoSI = No. of unknowns - equm eqn

= 6 - 3

= 3 - 1 → there is hinge in the beam memb.

= 2 (ID)

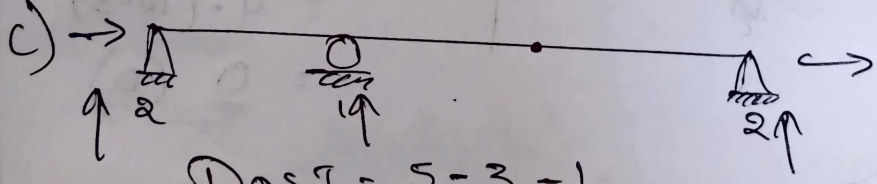
b)



DoSI = 6 - 3

= 3 (ID)

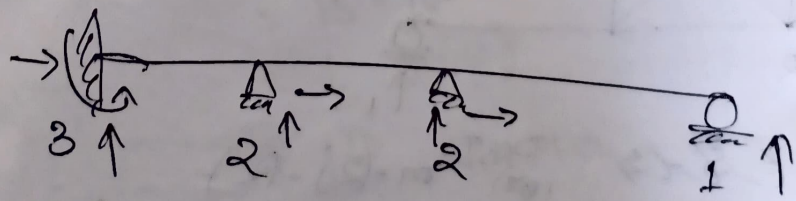
c)



DoSI = 5 - 3 - 1

= 1 (ID)

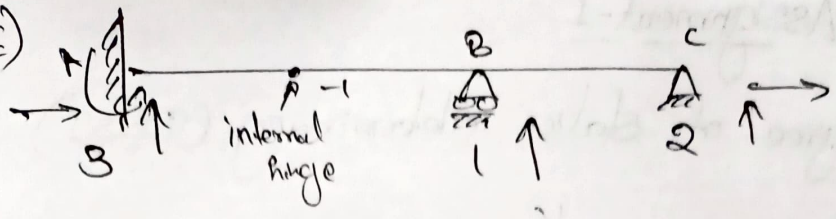
D)



DoSI = 8 - 3

= 5 (ID)

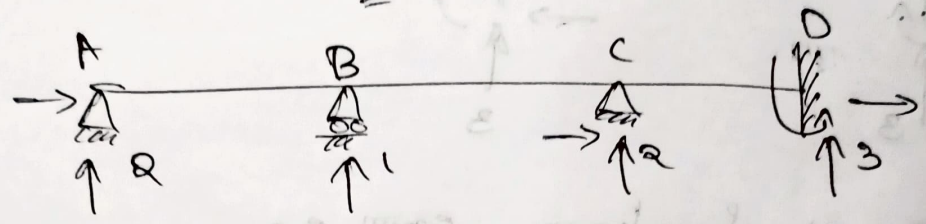
E)



DOSI = 6 - 3 - 1

= 2 (ID)

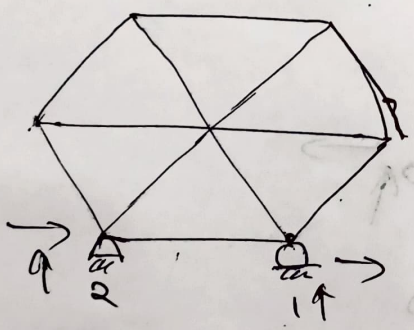
F)



DOSI = 8 - 3

= 5 (ID)

G)



~~DOSI = 3 ∈ 3~~

~~= 0~~

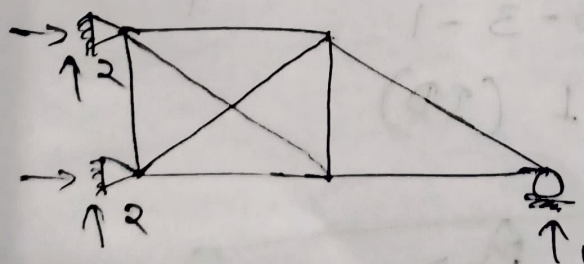
DOSI = m - (2j - Re)

= 9 - (2(6) - 3)

= 9 - (12 - 3)

= 0 (D)

H)



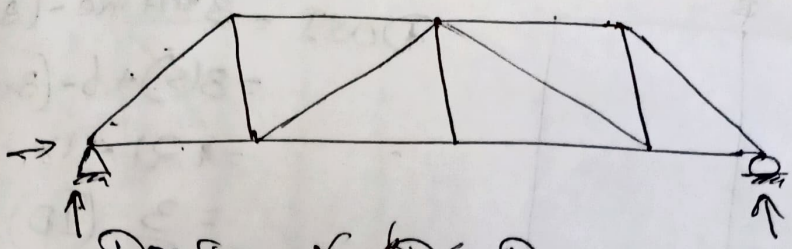
~~DOSI ∈ 5 - 3~~

~~= 2~~

DOSI = m - (2j - Re)

= 8 - (2×5 - 3)

= 3 (ID)

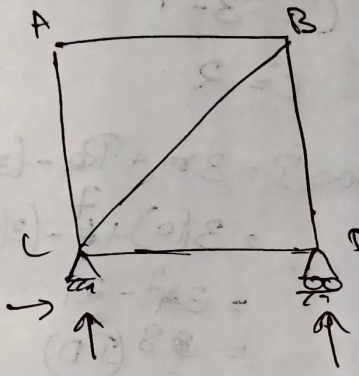


DOSI = ~~m-(2j-Re)~~

$= m-(2j-Re)$

$= 13-(2(8)-3)$

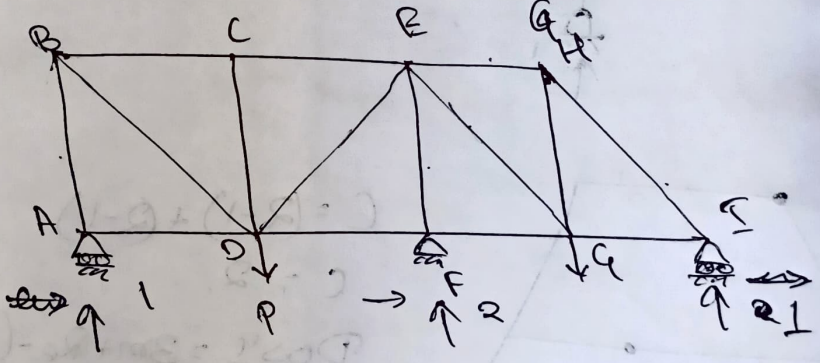
$= 0$ (D)



$DOSI = 5m-(2j-Re)$

$= 5-(2\times4)-3)$

$= 0$ (D)

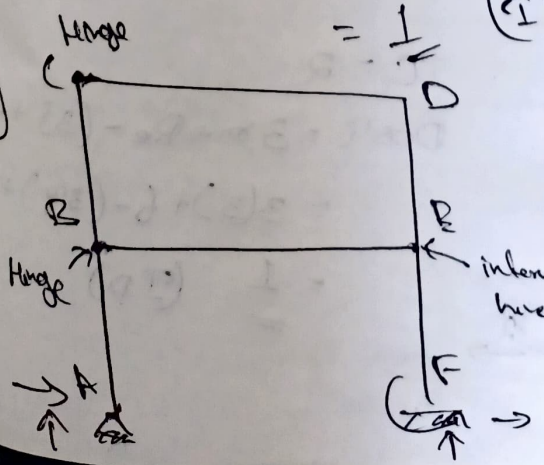


$DOSI = m-(2j-Re)$

$= 15-(2(9)-4)$

$= 15-14$

$= 1$ (1D)



$DOSI = 3m+Re-(3j+c)$

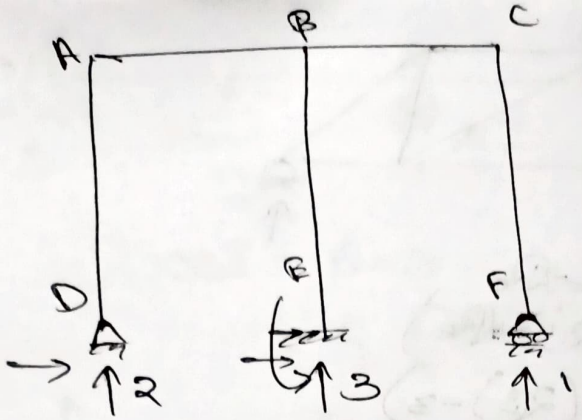
$C = (3-1)+(2-1)+(3-1)$

$C = 5$

$DOSI = 3\times6+5-(3\times6+5)$

$= 0$ (D)

M)



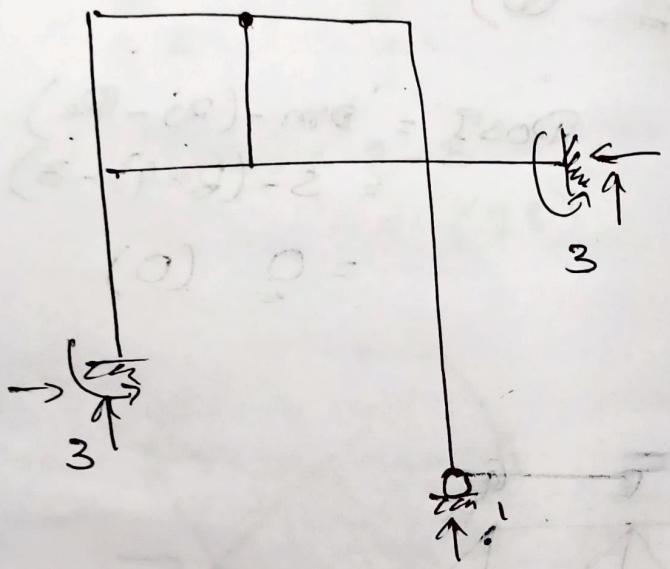
DOSI = $3m + Re - (3j + c)$

$= 3(6) + 6 - (3 \times 6 + 6)$

$= 21 - 18$

$= 3$ (ID)

N)



$C = 3 - 1$

$C = 2$

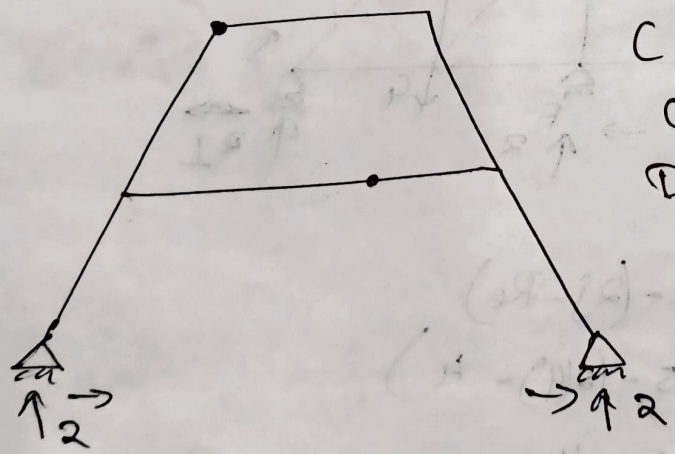
DOSI = $3m + Re - (3j + c)$

$= 3(10) + 7 - (3(9) + 2)$

$= 37 - 29$

$= 8$ (ID)

O)



$C = (2 - 1) + (2 - 1)$

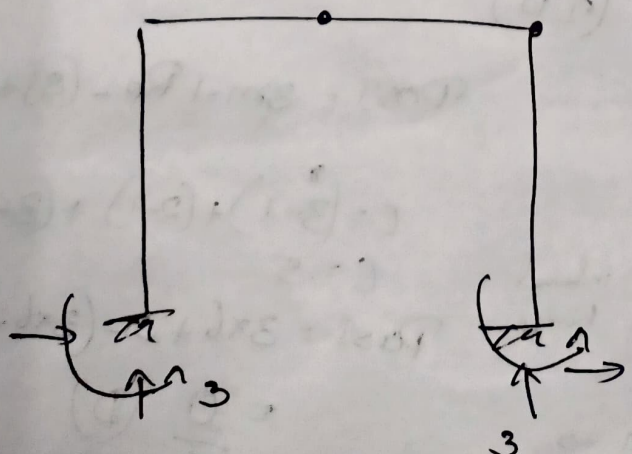
$C = 2.$

DOSI = $3m + Re - (3j + c)$

$= 3(6) + 4 - (3(6) + 2)$

$= 2$ (ID)

P)

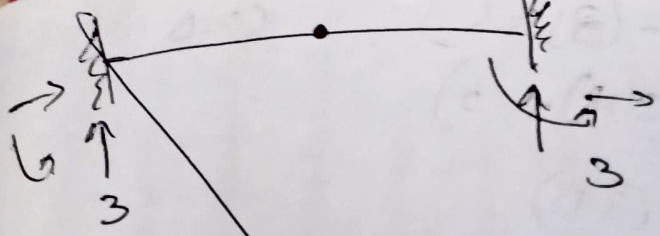


$C = 2$

DOSI = $3m + Re - (3j + c)$

$= 3(3) + 6 - (3(4) + 2)$

$= 1$ (ID)



$C = (2-1) = 1$

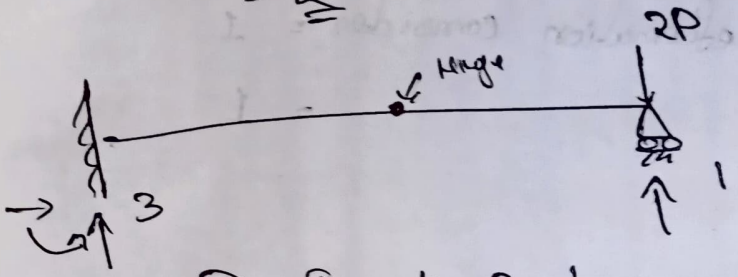
$DoSI = 3m + Re - (3j + C)$

$= 3(1) + 6 - (3(2) + 1)$

$= 9 - 7$

$= 2$

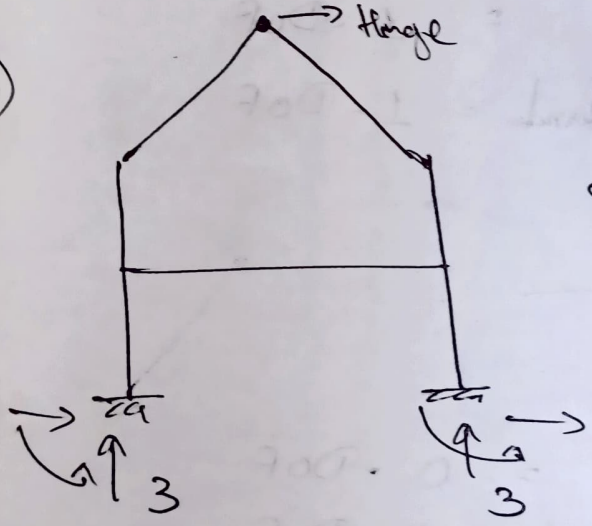
P)



$DoSI = 4 - 3 - 1$

$= 0$ (D)

Q)



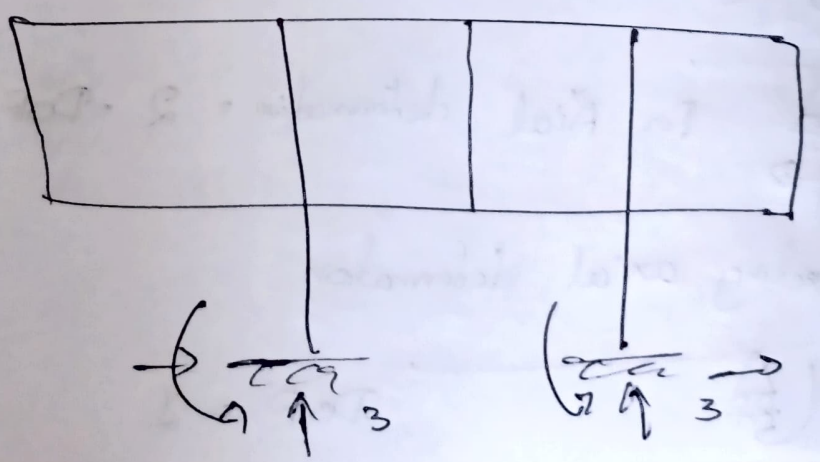
$C = 2 - 1 = 1$

$DoSI = 3m + Re - (3j + C)$

$= 3(7) + 6 - (3(7) + 1)$

$= 5$ (ID)

S)



DoI = 3m + Re − (3j + c) c = 0

= 3(15) + 6 − (3(12) + 0)

= 15 (1D)

Q2) Show the degree of freedom

a)

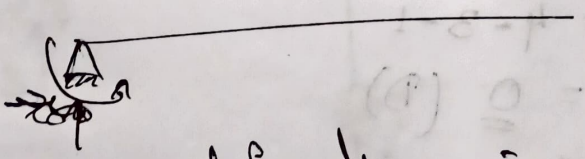
a) 

DoF

axial deformation consider = 1

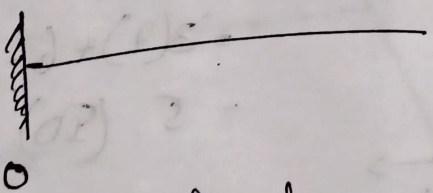
= 1

neglecting "

b) 

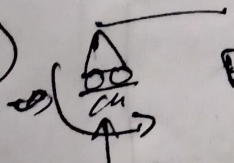
axial deformation = 1 - DoF

neglecting axial deformation = 1 - DoF

c) 

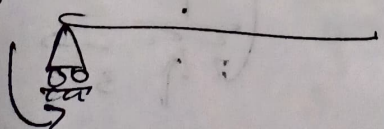
axial deformation = 0 - DoF

neglecting axial deformation = 0 - DoF

D) 

For Axial deformation = 2 - DoF

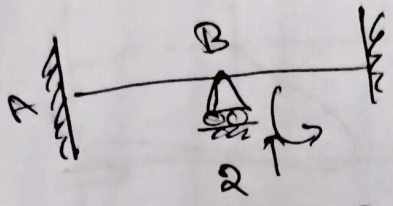
Neglecting axial deformation



DoF = 1

Find the Degree of kinematic indeterminacy.

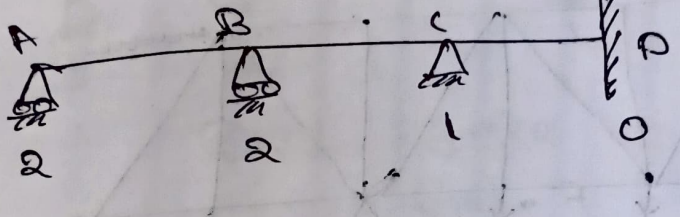
a)



DoKI = ΣDOF

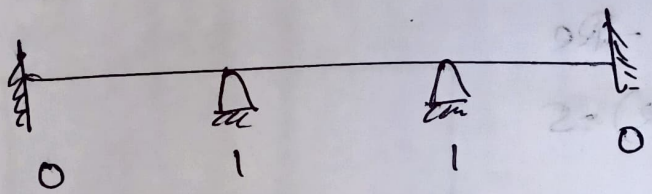
= 2

b)



DoKI = 5

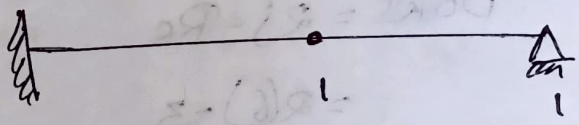
c)



DoKI = 1+1

= 2

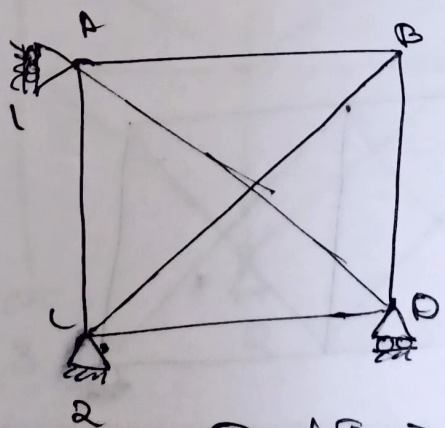
d)



DoKI = 1+1

= 2

e)

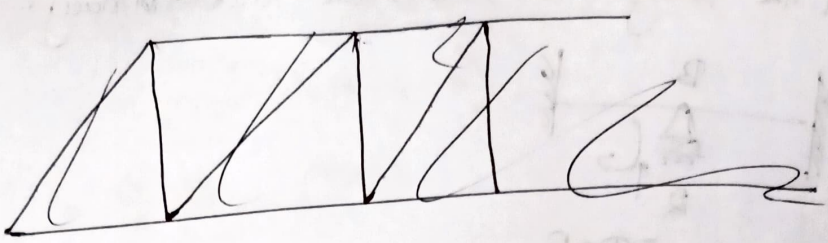


DoKI = 2j - Re

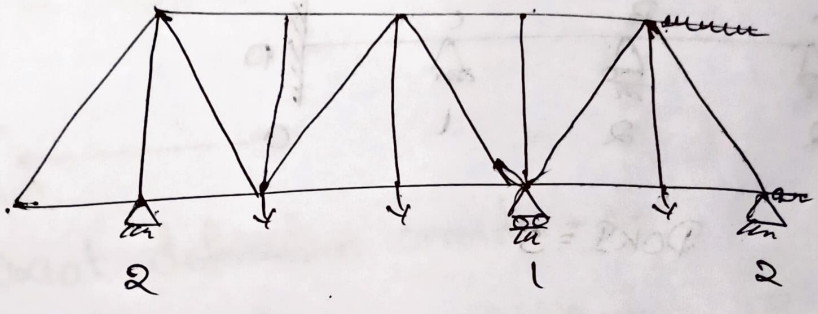
= 2(4) - 4

= 4

E)

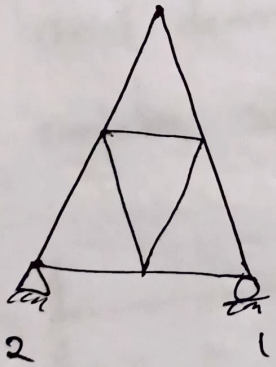


F)



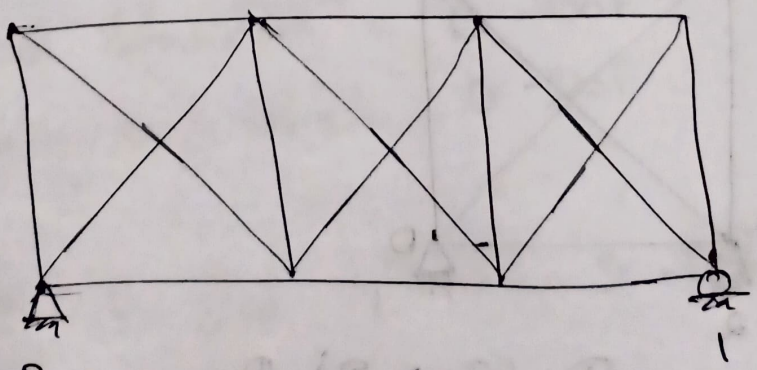
$$DoKS = 2j - Re$$
$$= 2(12) - 5$$
$$= 19$$

G)

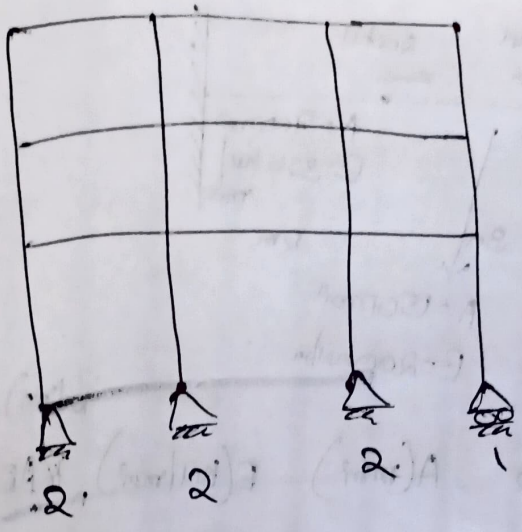


$$DoKS = 2j - Re$$
$$= 2(6) - 3$$
$$= 9$$

H)



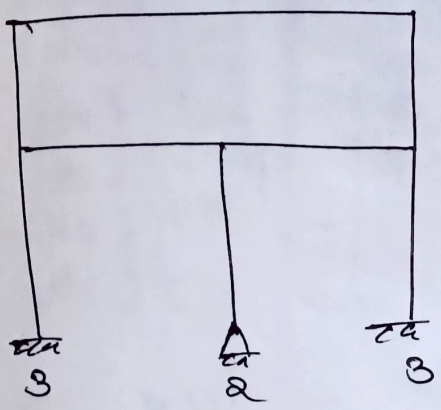
$$DoKS = 2j - Re$$
$$= 2(8) - 3$$
$$= 13$$



DOKI = 2j - Re
= 2(16) - 7
= 25

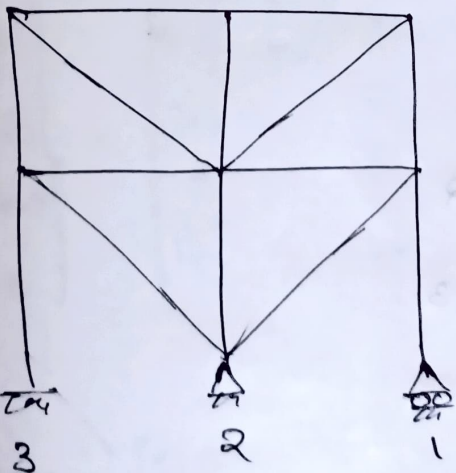
DOKI = 3j - Re
= 3(16) - 7
= 41

j)



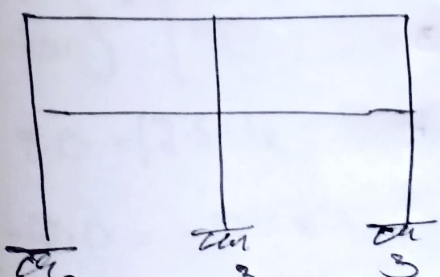
DOKI = 3j - Re
= 3(8) - 8
= 16

k)



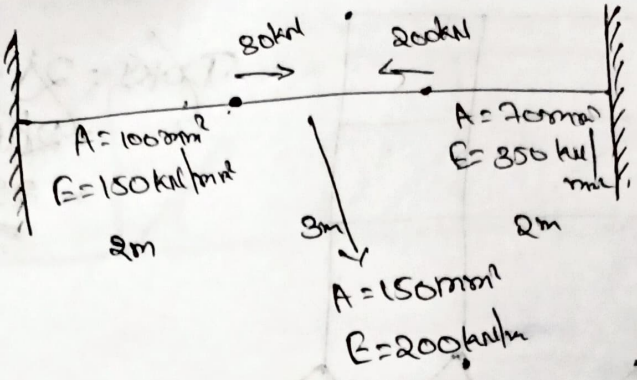
DOKI = 3j - Re
= 3(9) - 6
= 21

l)



DOKI = 3j - Re
= 3(9) - 9
= 18

4)



Member	i^{th} node	j^{th} node	A(mm^2)	E(kN/mm^2)	L(mm)	$k = \frac{AE}{L}$
1	1	2	100	150	2000	7.5 kN/mm
2	2	3	150	200	3000	10 kN/mm
3	3	4	70	350	2000	12.25

Member-1

$$k = \begin{bmatrix} AE/L & -AE/L \\ -AE/L & AE/L \end{bmatrix}$$

$$= \begin{matrix} \\ 1 \\ 2 \end{matrix} \begin{matrix} \begin{matrix} 1 & \quad 2 \end{matrix} \\ \begin{bmatrix} 7.5 & -7.5 \\ -7.5 & 7.5 \end{bmatrix} \end{matrix}$$

Member-2

$$k = \begin{matrix} \\ 2 \\ 3 \end{matrix} \begin{matrix} \begin{matrix} 2 & \quad 3 \end{matrix} \\ \begin{bmatrix} 10 & -10 \\ -10 & 10 \end{bmatrix} \end{matrix}$$

Member-3

$$k = \begin{matrix} \\ 3 \\ 4 \end{matrix} \begin{matrix} \begin{matrix} 3 & \quad 4 \end{matrix} \\ \begin{bmatrix} 12.5 & -12.5 \\ -12.5 & 12.5 \end{bmatrix} \end{matrix}$$

Global stiffness matrix

$$K = \begin{bmatrix} 7.5 & -7.5 & 0 & 0 \\ -7.5 & 7.5+10 & -10 & 0 \\ 0 & -10 & 10+12.5 & -12.5 \\ 0 & 0 & -12.5 & 12.5 \end{bmatrix} \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \end{matrix}$$

$$K = \begin{bmatrix} 7.5 & -7.5 & 0 & 0 \\ -7.5 & 17.5 & -10 & 0 \\ 0 & -10 & 22.5 & -12.5 \\ 0 & 0 & -12.5 & 12.5 \end{bmatrix}$$

$$u = \begin{Bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \end{Bmatrix} \qquad P = \begin{Bmatrix} 0 \\ 80 \\ -200 \\ 0 \end{Bmatrix}$$

$$P = KU$$

$$\begin{Bmatrix} 0 \\ 80 \\ -200 \\ 0 \end{Bmatrix} = \begin{bmatrix} 7.5 & -7.5 & 0 & 0 \\ -7.5 & 17.5 & -10 & 0 \\ 0 & -10 & 22.5 & -12.5 \\ 0 & 0 & -12.5 & 12.5 \end{bmatrix} \begin{Bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \end{Bmatrix}$$

$u_1 \to 0$, $u_4 \to 0$

$$\begin{Bmatrix} 80 \\ -200 \end{Bmatrix} = \begin{bmatrix} 17.5 & -10 \\ -10 & 22.5 \end{bmatrix} \begin{Bmatrix} u_2 \\ u_3 \end{Bmatrix}$$

$$80 = 17.5u_2 - 10u_3$$

$$-200 = -10u_2 + 22.5u_3$$

$u_2 = 0.68$

$u_3 = -9.19$

Forces in Member :-

(1.)

$$\begin{Bmatrix} F_{x_1}^1 \\ F_{x_2}^1 \end{Bmatrix} = \begin{bmatrix} 7.5 & -7.5 \\ -7.5 & 7.5 \end{bmatrix} \begin{Bmatrix} u_1 \to 0 \\ u_2 \to 0.68 \end{Bmatrix}$$

$$\begin{Bmatrix} F_{x_1}^1 \\ F_{x_2}^{a'} \end{Bmatrix} = \begin{Bmatrix} 5.1 \\ -5.1 \end{Bmatrix} \text{ kN}$$

Member-2

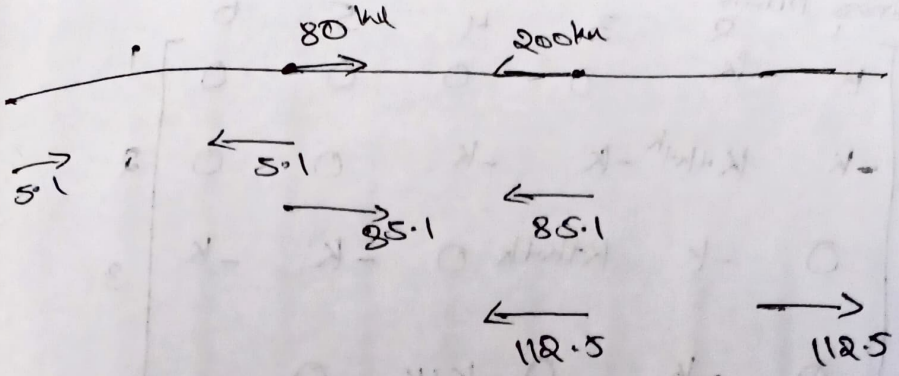
$$\begin{Bmatrix} F_{x_2}^2 \\ F_{x_3}^2 \end{Bmatrix} = \begin{bmatrix} 10 & -10 \\ -10 & 10 \end{bmatrix} \begin{Bmatrix} u_2 \to -0.68 \\ u_3 \to -9.19 \end{Bmatrix}$$

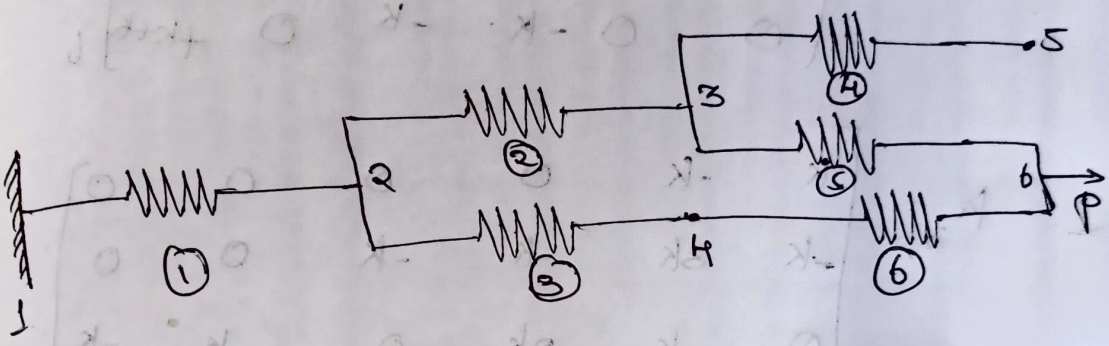
$$\begin{Bmatrix} F_{x_2}^2 \\ F_{x_3}^2 \end{Bmatrix} = \begin{Bmatrix} 85.1 \\ -85.1 \end{Bmatrix} \text{ kN}$$

Member-3

$$\begin{Bmatrix} F_{x_3}^3 \\ F_{x_4}^3 \end{Bmatrix} = \begin{bmatrix} 125 & -125 \\ -125 & 125 \end{bmatrix} \begin{Bmatrix} u_3 \to -9.19 \\ u_4 \to 0 \end{Bmatrix}$$

$$\begin{Bmatrix} F_{x_3}^3 \\ F_{x_4}^3 \end{Bmatrix} = \begin{Bmatrix} -1125 \\ 112.5 \end{Bmatrix} \text{ kN}$$





Member - 1

$$k = \begin{bmatrix} 1 & 2 \\ k & -k \\ -k & k \end{bmatrix} \begin{matrix} 1 \\ 2 \end{matrix}$$

Member - 2

$$k = \begin{bmatrix} 2 & 3 \\ k & -k \\ -k & k \end{bmatrix} \begin{matrix} 2 \\ 3 \end{matrix}$$

Member - 3

$$k = \begin{bmatrix} 2 & 4 \\ k & -k \\ -k & k \end{bmatrix} \begin{matrix} 2 \\ 4 \end{matrix}$$

Member - 4

$$k = \begin{bmatrix} 2 & 5 \\ k & -k \\ k & -k \end{bmatrix} \begin{matrix} 3 \\ 5 \end{matrix}$$

Member - 5

$$k = \begin{bmatrix} 3 & 6 \\ k & -k \\ k & -k \end{bmatrix} \begin{matrix} 3 \\ 6 \end{matrix}$$

Member - 6

$$k = \begin{bmatrix} 4 & 6 \\ k & -k \\ -k & k \end{bmatrix} \begin{matrix} 4 \\ 6 \end{matrix}$$

Global stiffness matrix

$$K = \begin{bmatrix} k & -k & 0 & 0 & 0 & 0 \\ -k & k+k+k & -k & -k & 0 & 0 \\ 0 & -k & k+k+k & 0 & -k & -k \\ 0 & -k & 0 & k+k & 0 & -k \\ 0 & 0 & -k & 0 & k & 0 \\ 0 & 0 & -k & -k & 0 & k+k \end{bmatrix}$$

$$K = \begin{bmatrix} k & -k & 0 & 0 & 0 & 0 \\ -k & 3k & -k & -k & 0 & 0 \\ 0 & -k & 3k & 0 & -k & -k \\ 0 & -k & 0 & 2k & 0 & -k \\ 0 & 0 & -k & 0 & k & 0 \\ 0 & 0 & -k & -k & 0 & 2k \end{bmatrix}$$

$$U = \begin{Bmatrix} u_1 \\ u_2 \\ u_3 \\ u_4 \\ u_5 \\ u_6 \end{Bmatrix} \qquad P = \begin{Bmatrix} R_0 \\ R_0 \\ 0 \\ 0 \\ 0 \\ P \end{Bmatrix}$$

$$F = K\Delta U$$

By applying the boundary condition at node 1

$$k = \begin{bmatrix} 3k & -k & -k & 0 & 0 \\ -k & 3k & 0 & -k & -k \\ -k & 0 & 2k & 0 & -k \\ 0 & -k & 0 & k & 0 \\ 0 & -k & -k & 0 & 2k \end{bmatrix}$$

$$[k] = k \begin{bmatrix} 3 & -1 & -1 & 0 & 0 \\ -1 & 3 & 0 & -1 & -1 \\ -1 & 0 & 2 & 0 & -1 \\ 0 & -1 & 0 & k & 0 \\ 0 & -1 & -1 & 0 & 2 \end{bmatrix}$$