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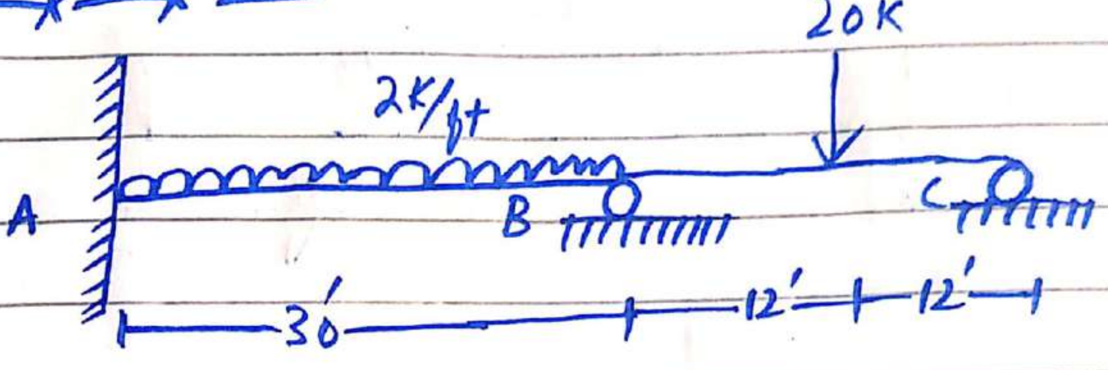
PAPER MID SUMMER= STRUCTURE ANALYSIS 2

Prob# 01

Given data:-



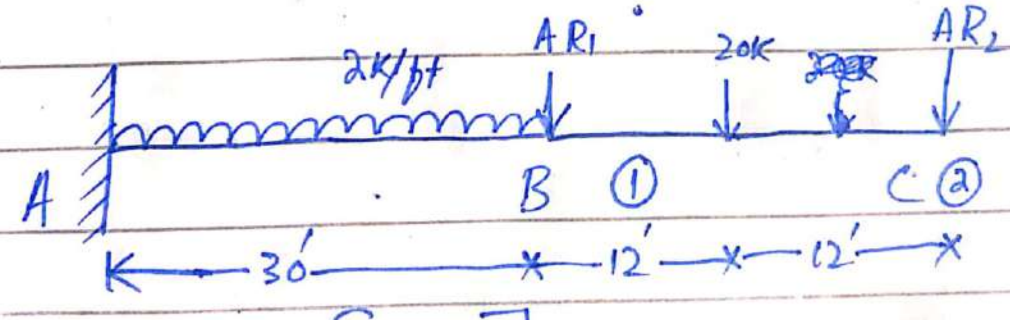
$$EI = \text{Constant}$$

Required Data: S.F.D = ?

B.M.D = ?

Solution:

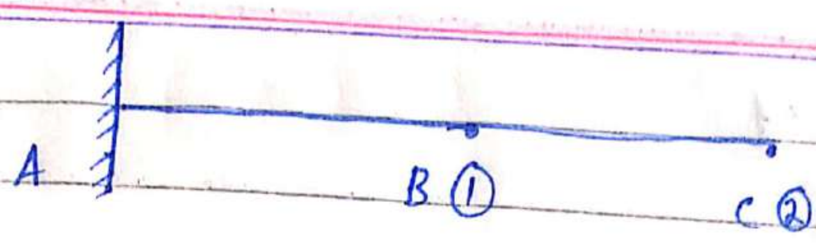
$$S.I = r - 3n = 5 - 3(1) = 2^\circ$$



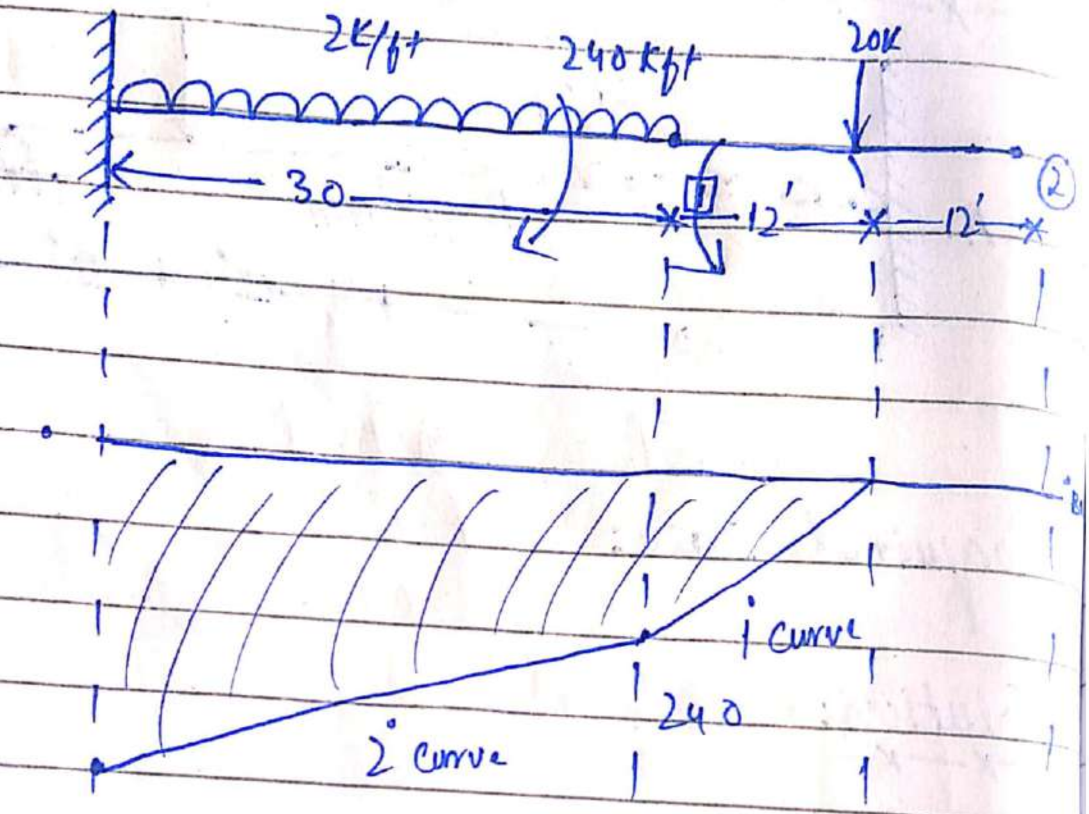
$$[AR] = \begin{bmatrix} AR_1 \\ AR_2 \end{bmatrix}$$

$$[DRS] = \begin{bmatrix} DRS_1 \\ DRS_2 \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

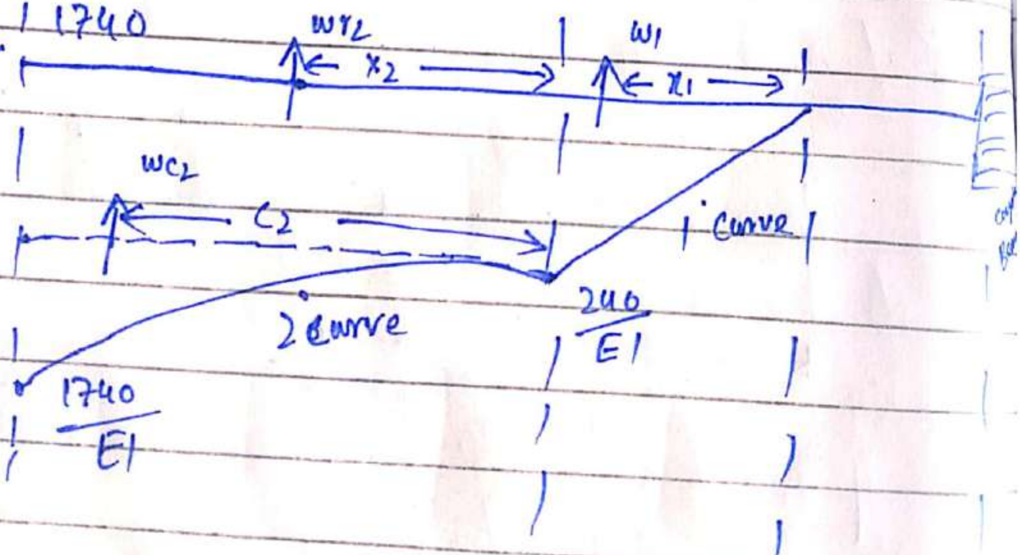
Scanned with CamScanner



Compute [DRL] Matrix.

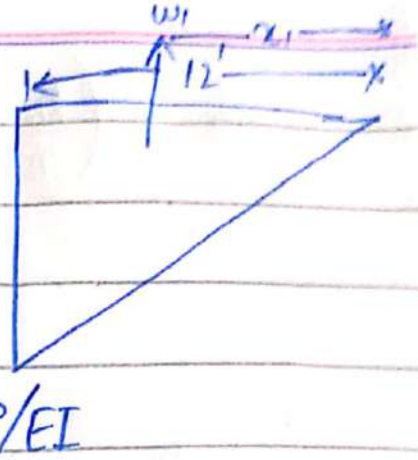


Diagram



$w_1 = \frac{1}{2} \times 12 \times \frac{240}{EI}$

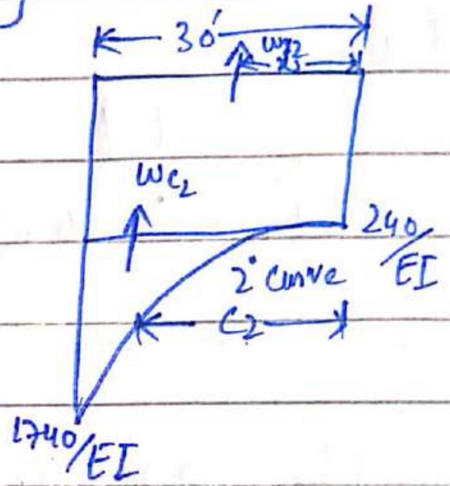
$$\boxed{w_1 = \frac{1440}{EI} \, K}$$



$$\boxed{x_1 = \frac{2}{3}(12) = 8 \text{ feet}}$$

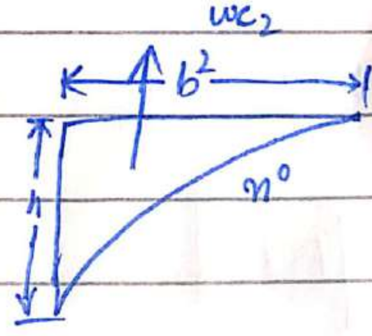
$w_{r_2} = 30 \times \frac{240}{EI}$

$$\boxed{w_{r_2} = \frac{7200}{EI} \, K}$$



$x_2 = \frac{1}{2}(30')$

$$\boxed{x_2 = 15 (ft)}$$



$W_{c_2} = A = \frac{bh}{n+1}$

$w_{c_2} = \frac{30 \times 1500/EI}{2+1}$

$h = \frac{1740}{EI} - \frac{240}{EI}$

$h = \frac{1500}{EI}$

$$\boxed{w_{c_2} = 15000/EI \, K}$$

$$C_2 = \left(\frac{n+1}{n+2}\right)(b) = \left(\frac{2+1}{2+2}\right)(30)$$

$$\boxed{C_2 = 22.5\,ft}$$

$$DRL_1 = w_{r_2}\, x_2 + w_{c_2} \times C_2$$

$$DRL_1 = \frac{7200}{EI} \times 15 + \frac{15000}{EI} \times 22.5$$

$$\boxed{DRL_1 = 445500/EI}$$

$$DRL_2 = w_{r_2}(x_2+24) + w_{c_2}(24+C_2) + w_1(x_1+12)$$

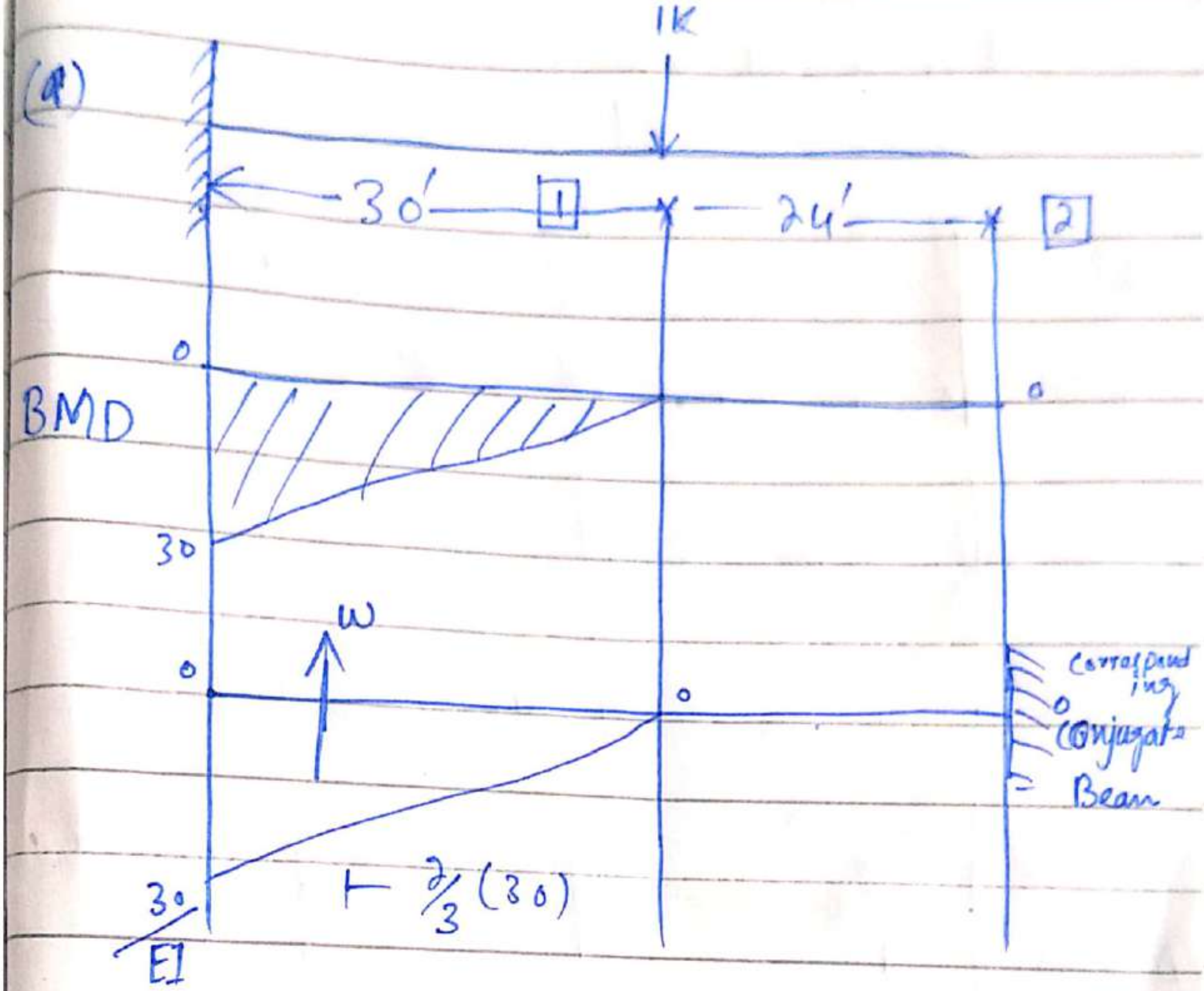
$$DRL_2 = \frac{7200}{EI}(15+24) + \frac{15000}{EI}(24+22.5) + \frac{1440}{EI}(8+12)$$

$$\boxed{DRL_2 = 1007100/EI}$$

$$[DRL] = \begin{bmatrix} DRL_1 \\ DRL_2 \end{bmatrix} = \frac{1}{EI}\begin{pmatrix} 445500 \\ 1007100 \end{pmatrix}$$

Compute flexibility matrix [F]

(a)



$$w = \frac{1}{2} \times 30 \times \frac{30}{EI}$$

$$w = 450/EI$$

Moment arm $= \frac{2}{3}(20) = 20$

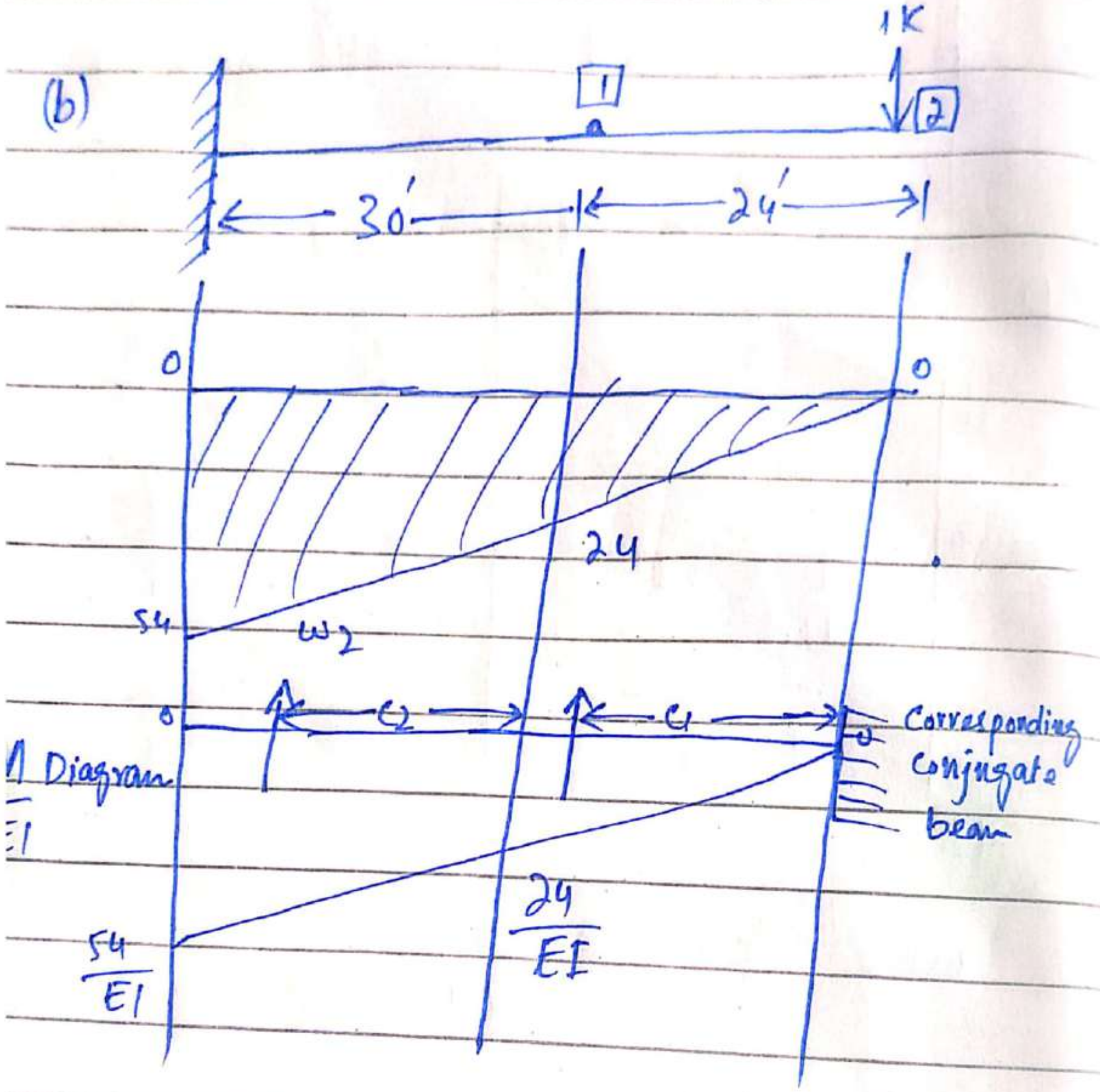
$$\Delta_{\boxed{1}} = F_{11} = \frac{450}{EI} \times 20$$

$$\boxed{F_{11} = \frac{9000}{EI}}$$

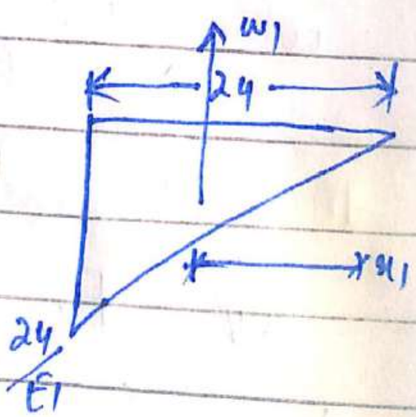
$$\Delta_{\boxed{2}} = F_{21} = \frac{450}{EI} \times (24+20)$$

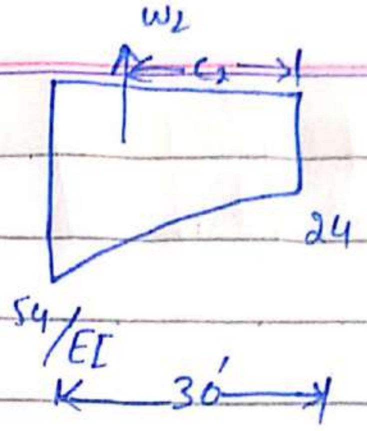
$$F_{21} = 19800/EI$$

(b)



$$w_1 = \frac{1}{2} \times 24 \times 24/EI$$





$$x_1 = \frac{2}{3}(24)$$

$$\boxed{x_1 = 16\,ft}$$

$$w_2 = \left(\frac{a+b}{2}\right)L = \left(\frac{54/EI + 24/EI}{2}\right)(30)$$

$$\boxed{w_2 = 1170/EI}$$

$$C_2 = \frac{L}{3}\left(\frac{2a+b}{a+b}\right) = \frac{30}{3}\left(\frac{2(54)+24}{54+24}\right)$$

$$\boxed{C_2 = 16.92\,ft}$$

$$\Delta_{\boxed{1}} = f_{12} = w_2 \times C_2 = \frac{1170}{EI} \times 16.92$$

$$\boxed{F_{12} = 19800/EI}$$

$$\Delta_{\boxed{2}} = f_{22} = w_1 \times x_1 + w_2 \times (c_2 + 24)$$

$$\boxed{f_{22} = 52485/EI}$$

Scanned with CamScanner

$$[f] = \begin{bmatrix} F_{11} & F_{12} \\ F_{21} & F_{22} \end{bmatrix} = \frac{1}{EI} \begin{bmatrix} 9000 & 19800 \\ 19800 & 52485 \end{bmatrix}$$

Now

Apply the Compatibility equation

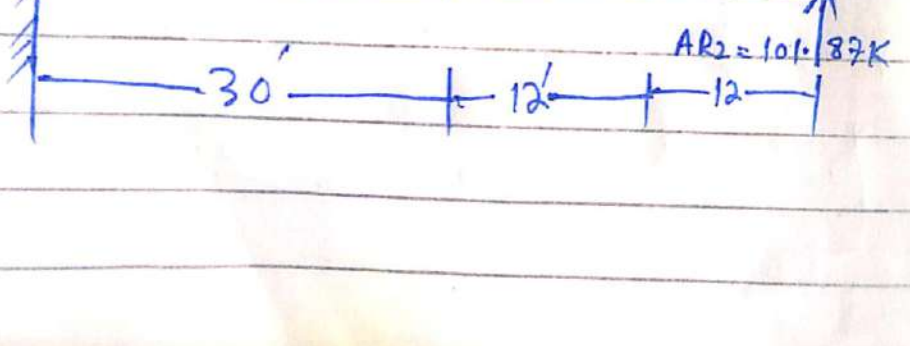
$$[DRS] = [DRL] + [F][AR]$$

$$[AR] = [f]^{-1} (DRS - DRL)$$

$$[AR] = \cancel{EI} \begin{bmatrix} 9000 & 19800 \\ 19800 & 52485 \end{bmatrix}^{-1} \begin{bmatrix} 0 - 445500 \\ 0 - 1007100 \end{bmatrix} \frac{1}{\cancel{EI}}$$

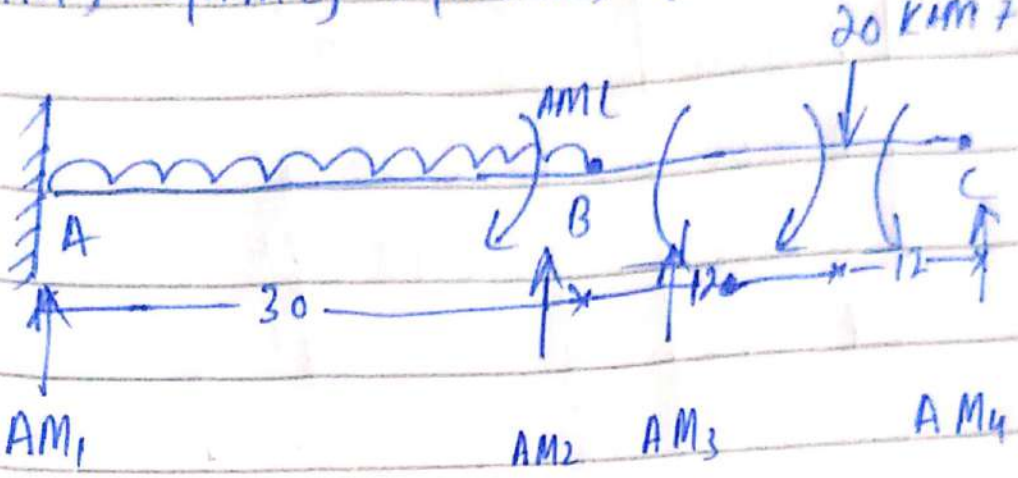
$$[AR] = \begin{bmatrix} 219.174\ K \\ -101.87\ K \end{bmatrix}$$

Where $AR_2 = -101.87K$ Shows That the Choosen direction is incorrect and thus acts vertically upward



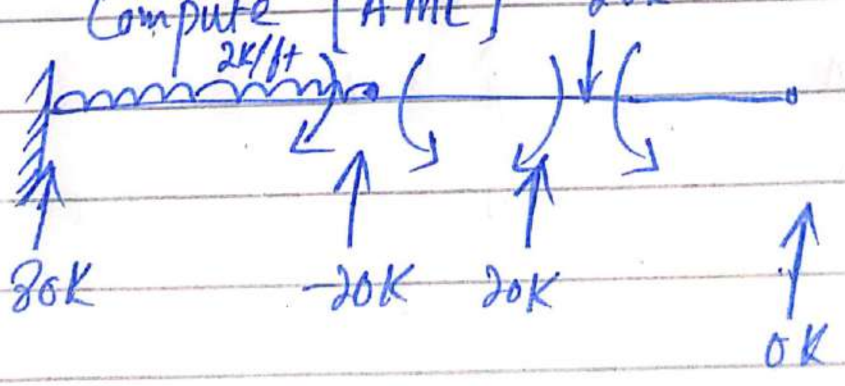
Compute members end actions

$[AM] = [AML] + [AMR][AR]$



$$[AM] = \begin{bmatrix} AM_1 \\ AM_2 \\ AM_3 \\ AM_4 \\ AM_5 \\ AM_6 \\ AM_7 \end{bmatrix} = \begin{bmatrix} ? \\ ? \\ ? \\ ? \\ ? \\ ? \\ ? \end{bmatrix}$$

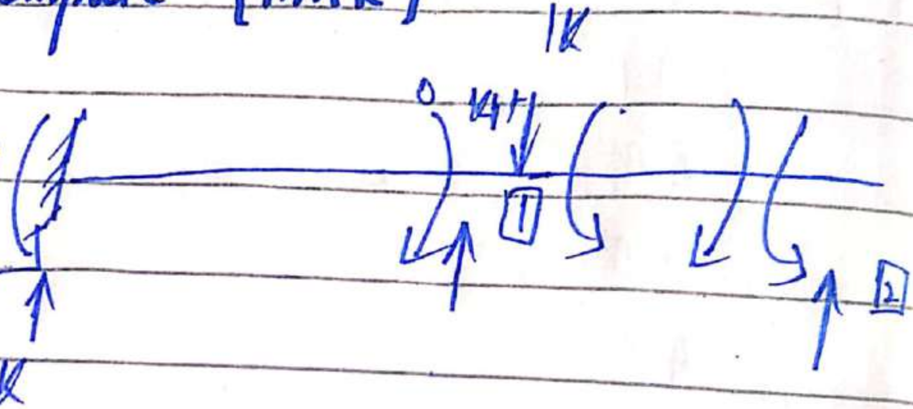
(a) Compute [AML]



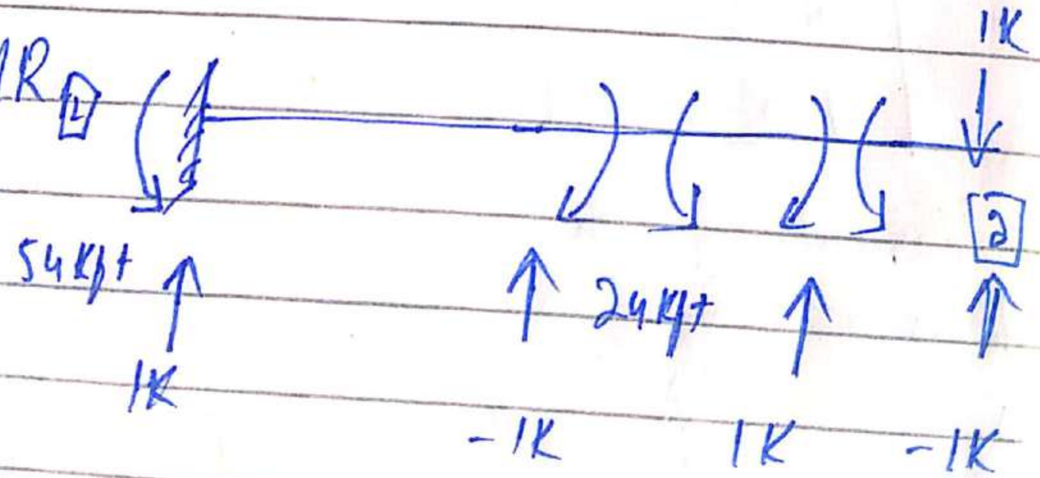
$$[AML] = \begin{bmatrix} AML_1 \\ AML_2 \\ AML_3 \\ AML_4 \\ AML_5 \\ AML_6 \\ AML_7 \end{bmatrix} = \begin{bmatrix} 80\,K \\ -20\,K \\ 20\,K \\ 0\,K \\ 1740\,Kft \\ 240\,Kft \\ 0\,Kft \end{bmatrix}$$

(b) Compute [AMR]

$AMR_{\boxed{1}}$



$AMR_{\boxed{2}}$

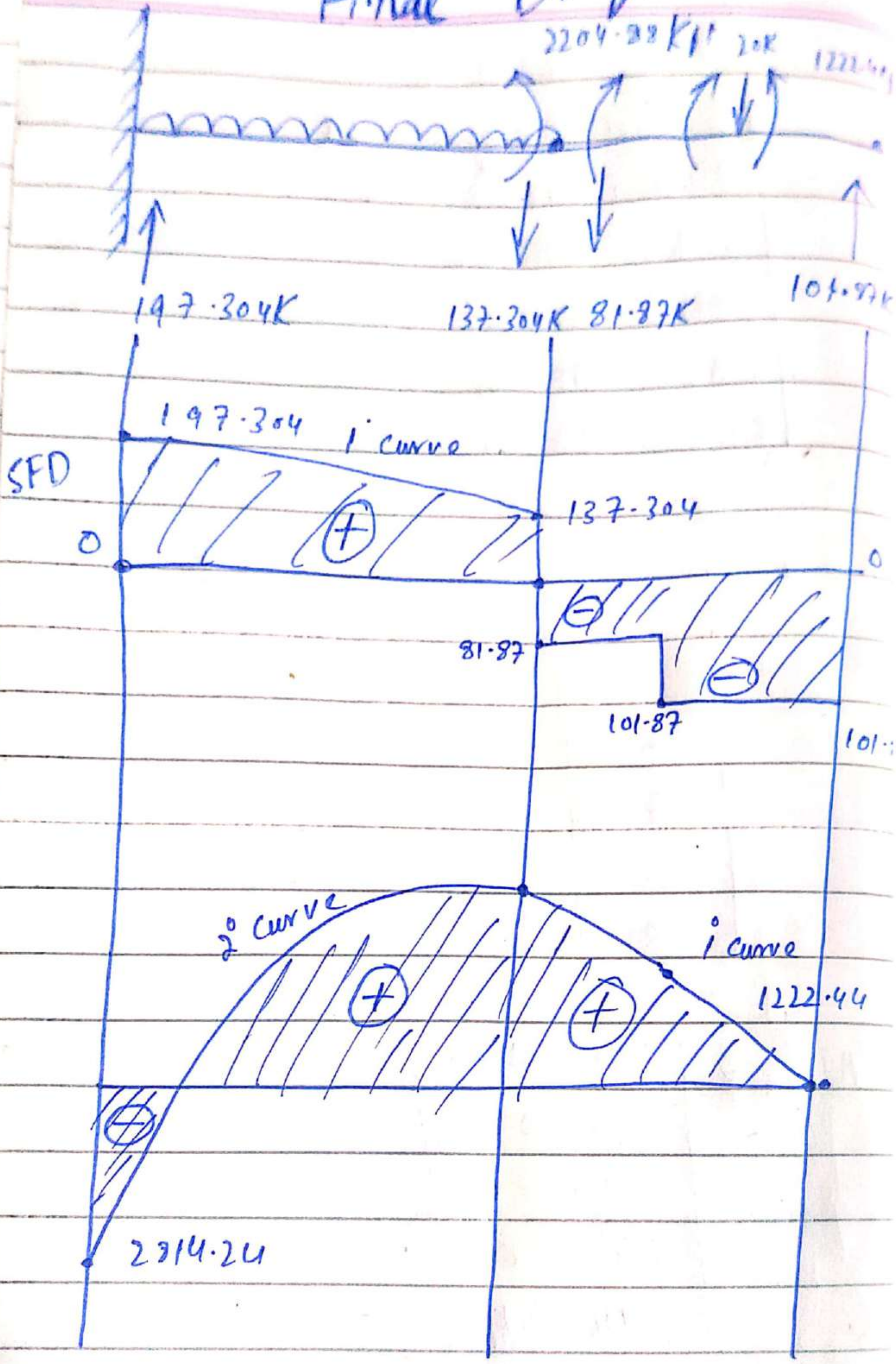


$$AMR = \begin{bmatrix} AMR_{11} & AMR_{12} \\ AMR_{21} & AMR_{22} \\ AMR_{31} & AMR_{32} \\ AMR_{41} & AMR_{42} \\ AMR_{51} & AMR_{52} \\ AMR_{61} & AMR_{62} \\ AMR_{71} & AMR_{72} \end{bmatrix} = \begin{bmatrix} 1 & 1 \\ -1 & -1 \\ 0 & 1 \\ 0 & -1 \\ 30 & 54 \\ 0 & 24 \\ 0 & 12 \end{bmatrix}$$

$$[AM] = \begin{bmatrix} 80 \\ -20 \\ 20 \\ 0 \\ 1740 \\ 240 \\ 0 \end{bmatrix} + \begin{bmatrix} 1 & 1 \\ -1 & -1 \\ 0 & 1 \\ 0 & -1 \\ 30 & 54 \\ 0 & 24 \\ 0 & 12 \end{bmatrix} \begin{bmatrix} 219.174K \\ -101.87K \end{bmatrix}$$

$$[AM] = \begin{bmatrix} 197.304K \\ -137.304K \\ -81.87K \\ 101.87K \\ 2814.24Kft \\ -2204.88Kft \\ -1222.44Kft \end{bmatrix}$$

Final Diagram

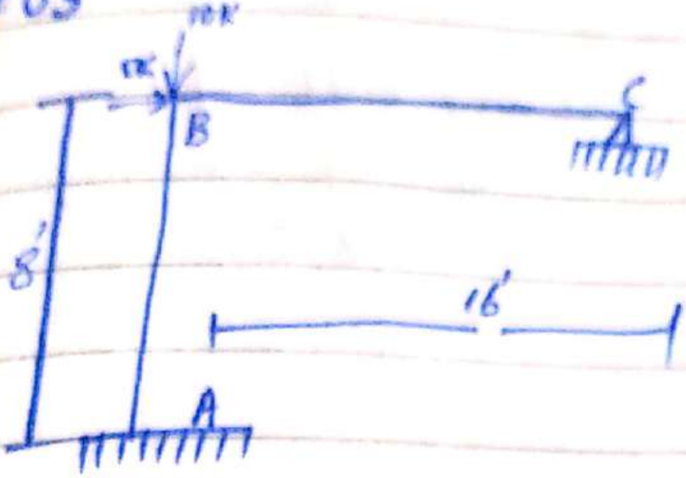


Q02 :-

Force Method	Displacement Method
(1) Ds < DK	Ds > DK
(2) Forces are redundant or unknown	Displacement are redundant or unknown
(3) Starts With equilibrium of forces.	Starts With Compatible deformations
(4) Forces found by Compatibility equations of displacements	displacement found by equilibrium equations of forces
(5) No of Reduandants = Ds	No of reduandants = DK
(6) Not Suitable for Compression	Not sutible for Trusses.

Stiffness method also called Displacement Method is more Suitable for Structure analysis matrix approach, as it is a primary method used in matrix analysis. The main advantage of this method over flexibility method is that it is Conductive To Computer programming. once the analytical model of the Structure has been defined, No further engineering decisions are required in the Stiffness method in order To Carry out the analysis.

Pb # 03



$E = \text{Constant}$

$I_c = I$

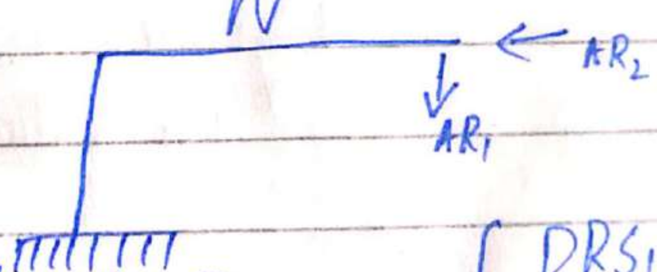
$I_B = 2I$

Sol

Total Statical Indeterminacy

$\Rightarrow R - 3 = 5 - 3 = 2$

Step # 01 Identify Redundant Action



$$\begin{bmatrix} A_{R_1} \\ A_{R_2} \end{bmatrix} = \begin{bmatrix} ? \\ ? \end{bmatrix}, \quad \begin{bmatrix} D_{RS_1} \\ D_{RS_2} \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$$

Step 2 :-

Compute value of [DRL]

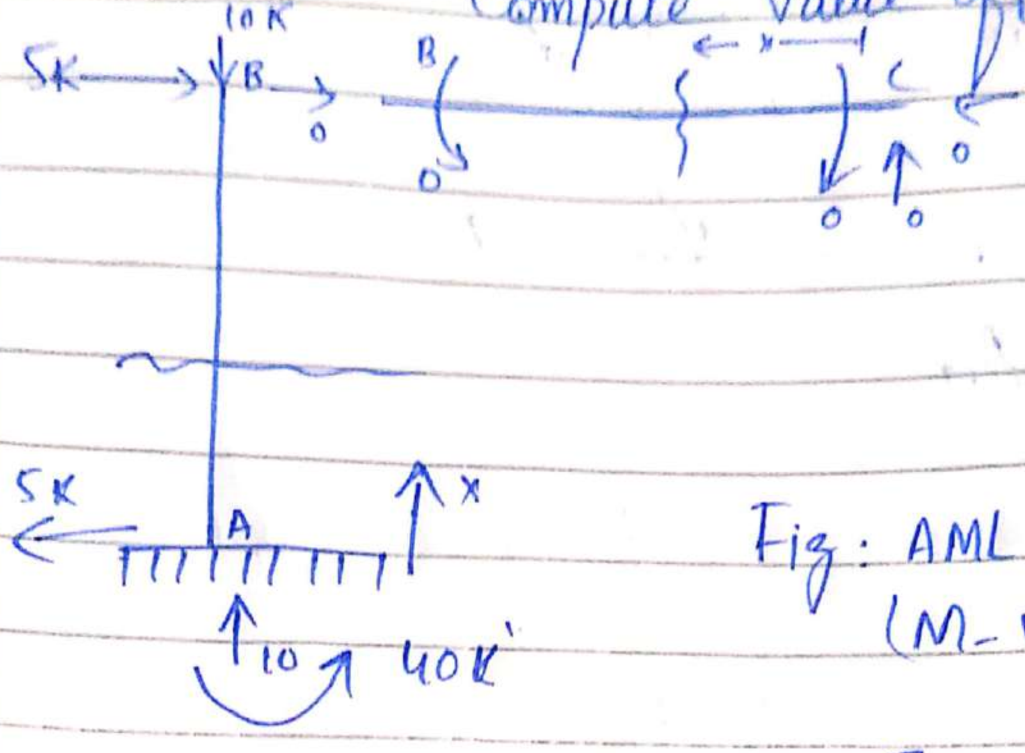


Fig : AML values
(M- values)

Step No 3 :- [F] or [AMR]

(a)

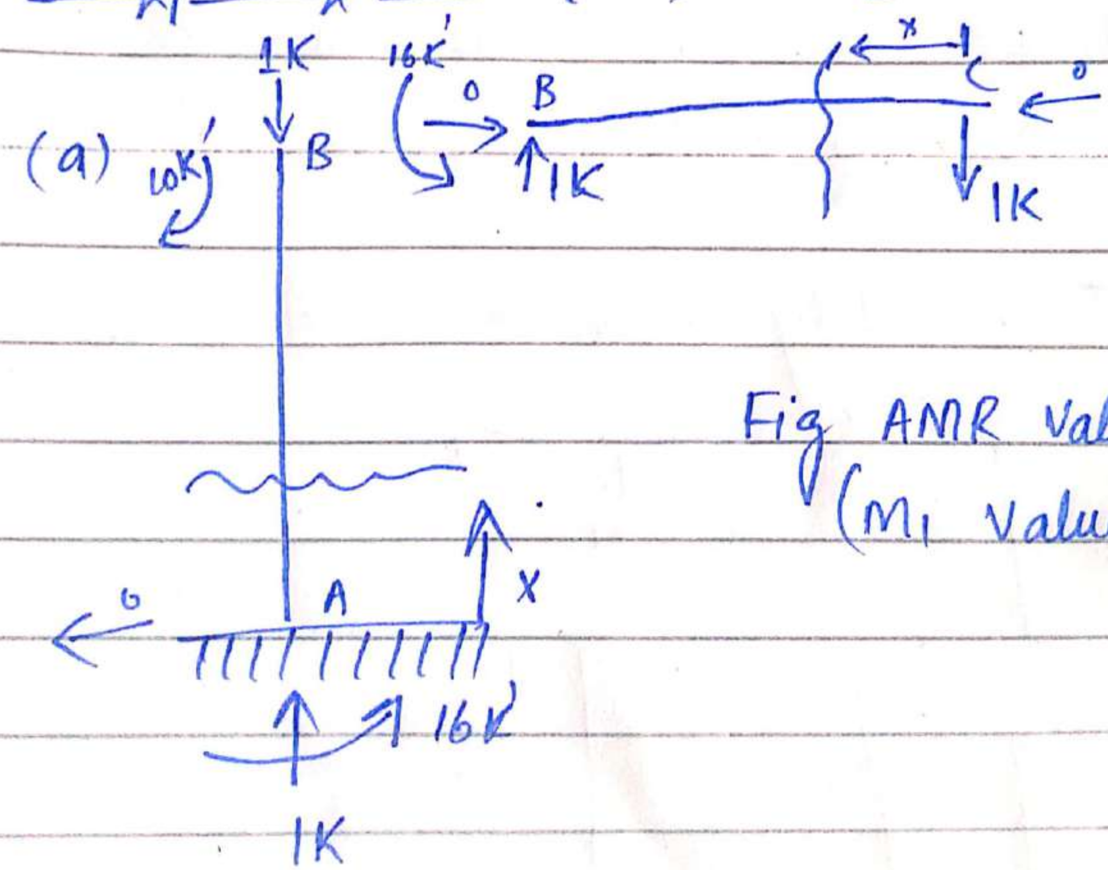


Fig AMR Values
(M₁ values)

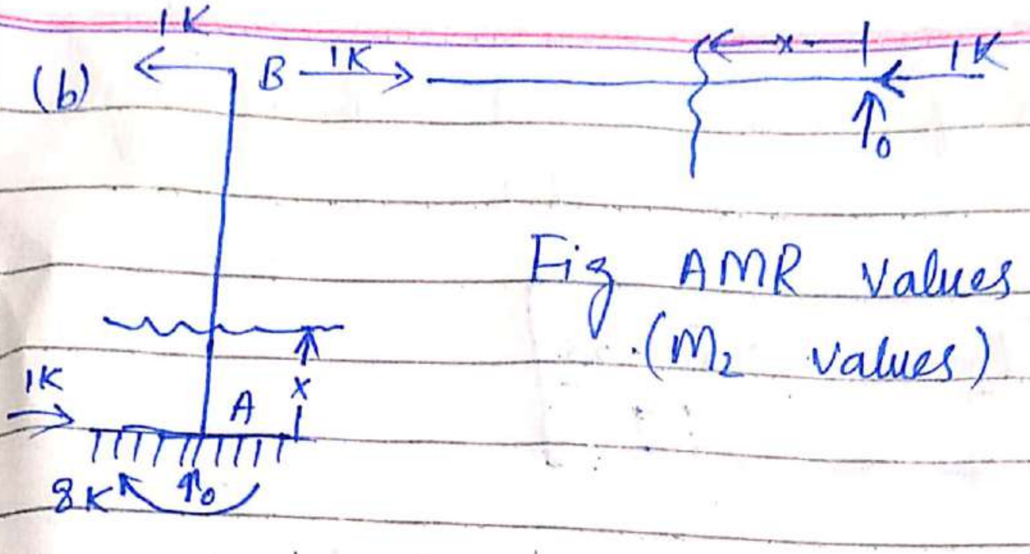


Fig AMR values
(M_2 values)

Member	AB	BC
origin	A	C
Limits	0-8	0-16
I	I	2I
M	$5x-40$	0
m_1	-16	x
M_2	$8-x$	0

→ Take x-section on m_1 Fig from the origen

⇒ For finding the value of DRL

$$DRL_1 = \int_0^8 \frac{M_{AB} \cdot m_1(AB)}{EI} + \int_0^{16} \frac{M_{BC} \cdot M_2(BC)}{EI}$$

$$= \int_0^8 \frac{(5x-40)(-16)}{EI} dx + \int_0^{16} \frac{0 \cdot x \, dx}{E(2I)}$$

$$\boxed{DRL_1 = \frac{2560}{EI}}$$

$$DRY_2 = \int_0^8 \frac{(5x-40)(8-x)\,dx}{EI} + \int_0^{16} \frac{0.0\,d}{E(2I)}$$

$$\boxed{DRL_2 = \frac{-853.33}{EI}}$$

⟹ Compute Flexibility Matrix :-

$$F_{2\times2} = \begin{bmatrix} F_{11} & F_{12} \\ F_{21} & F_{22} \end{bmatrix}$$

$$\Rightarrow F_{11} = \int_0^8 \frac{m_1^2(AB)}{EI} + \int_0^{16} \frac{m_1(BC)}{EI}$$

$$= \int_0^8 \frac{(-16)^2\,dx}{EI} + \int_0^{16} \frac{x^2}{E(2I)}\,dx$$

$$\boxed{F_{11} = \frac{2730.67}{EI}}$$

$$F_{12} = F_{21} = \int_0^8 M_1(AB) \cdot M_2(AB) + \int_0^{16} m_2(BC) \cdot m_2(BC)$$

$$= \int_0^8 \frac{(-16)(8-x)}{EI} dx + \int_0^{16} \frac{(x)(0)}{2EI} dx$$

$$\boxed{F_{12} - F_{21} = -\frac{512}{EI}}$$

$$F_{22} = \int_0^8 (M_2)^2_{AB} \, dx + \int_0^{16} (M_2)^2_{BC} \, dx$$

$$= \int_0^8 \frac{(8-x)^2}{EI} dx + \int_0^{16} \frac{0^2}{2EI} dx$$

$$\boxed{F_{22} = 170.67}$$

As We Know that

$$[DRS] = [DRL] + [AR] \times [F]$$

$$\Rightarrow [AR] = \frac{[DRS] - (DRL)}{[F]}$$

$$(2)\ [AR] = [F]^{-1} \times [DRS - DRL]$$

$$= \begin{bmatrix} 2730.67 & -1512 \\ -512 & 170.67 \end{bmatrix}^{-1} \times \begin{bmatrix} 0 & -2560 \\ 0 & +853.33 \end{bmatrix}$$

$$\begin{bmatrix} AR_1 \\ AR_2 \end{bmatrix} = \begin{bmatrix} -0.00005 \\ 4.997 \end{bmatrix} = \begin{bmatrix} 0 \\ 5 \end{bmatrix}$$