CV2011 : Structural Analysis I (AY 20/21 sem 1)

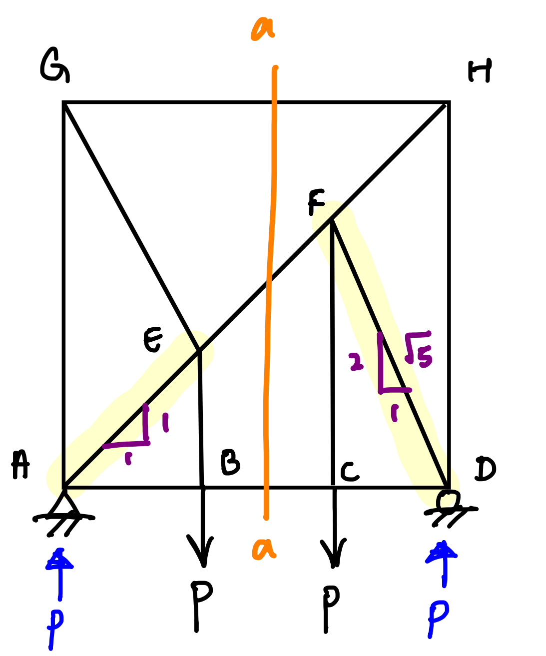
Done by : Tham Win Yen

1. (a) $j = 8,\ b = 13,\ r = 3$

$\overline{DOF} = 2(8) - 13 - 3 = 0$ #

$\therefore$ SD #

(b)



support reactions:

$A_y = D_y = P$

$A_x = 0$

cut along a–a:

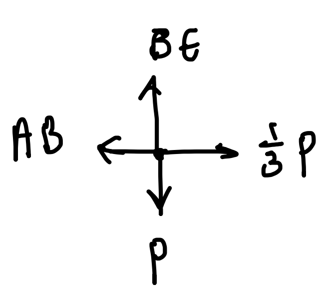
$\circlearrowleft + \ \Sigma M_H = 0$

$P(3d) - P(2d) - BC(3d) = 0$

$Pd = BC(3d)$

$BC = \frac{1}{3}P$

Joint B:

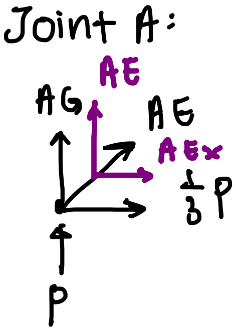


$\Sigma F_y = 0$

$BE = P$

$AB = \frac{1}{3}P$

Joint A:



$\Sigma F_x = 0$

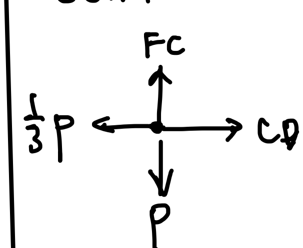
$AE_x + \frac{1}{3}P = 0$

$AE \sin 45 = -\frac{1}{3}P$

$AE = -0.47P$

$\therefore AE = 0.47P\ (C)$ #

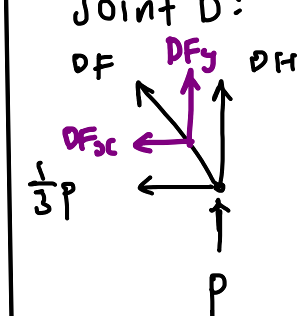
Joint C:



$FC = P$

$CD = \frac{1}{3}P$

Joint D:



$DF_y = \frac{2}{\sqrt{5}} DF$

$DF_x = \frac{1}{\sqrt{5}} DF$

$\Sigma F_x = 0$

$DF_x = -\frac{1}{3}P$

$DF\left(\frac{1}{\sqrt{5}}\right) = -\frac{1}{3}P$

$DF = -\frac{\sqrt{5}}{3}P$

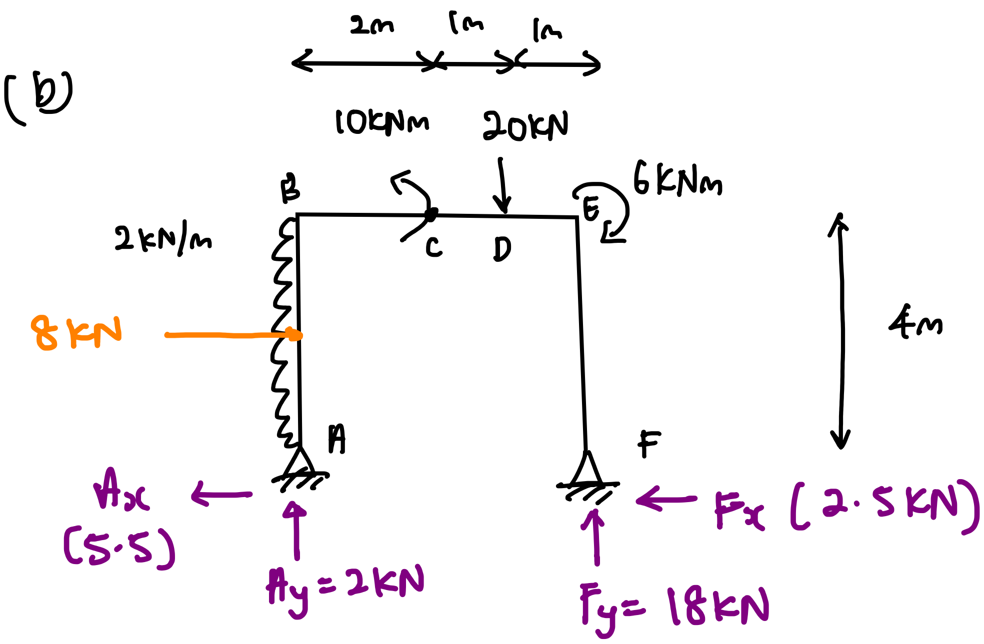
$DF = \frac{\sqrt{5}}{3}P\ (C)$ #

2. (a) $n = 2,\ R = 0,\ p = 3,\ L/r = 0$

$\overline{DOF} = 3(2) - 2(3) = 0$

$\therefore$ SD.

(b)



$\circlearrowleft + \sum M_A = 0$

$8(2) - 10 + 20(3) + 6 - F_y(4) = 0$

$F_y = 18\text{kN}$

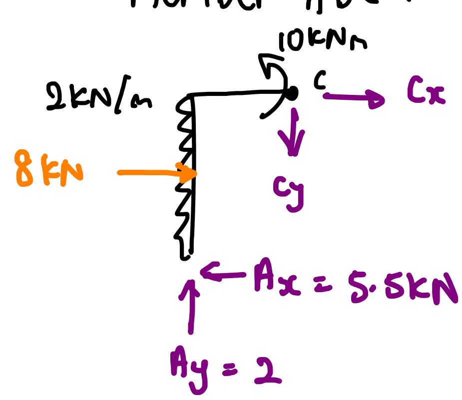
$\uparrow = \downarrow$

$A_y + F_y = 20$

$A_y = 20 - 18$

$A_y = 2\text{kN}$

Member ABC :

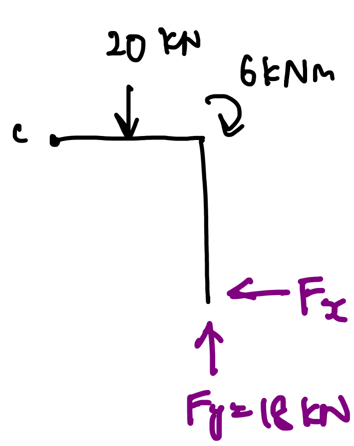


$\circlearrowleft + \sum M_c = 0$

$-10 - 8(2) + 2(2) + A_x(4) = 0$

$A_x = 5.5\text{kN}$

Member CEF:



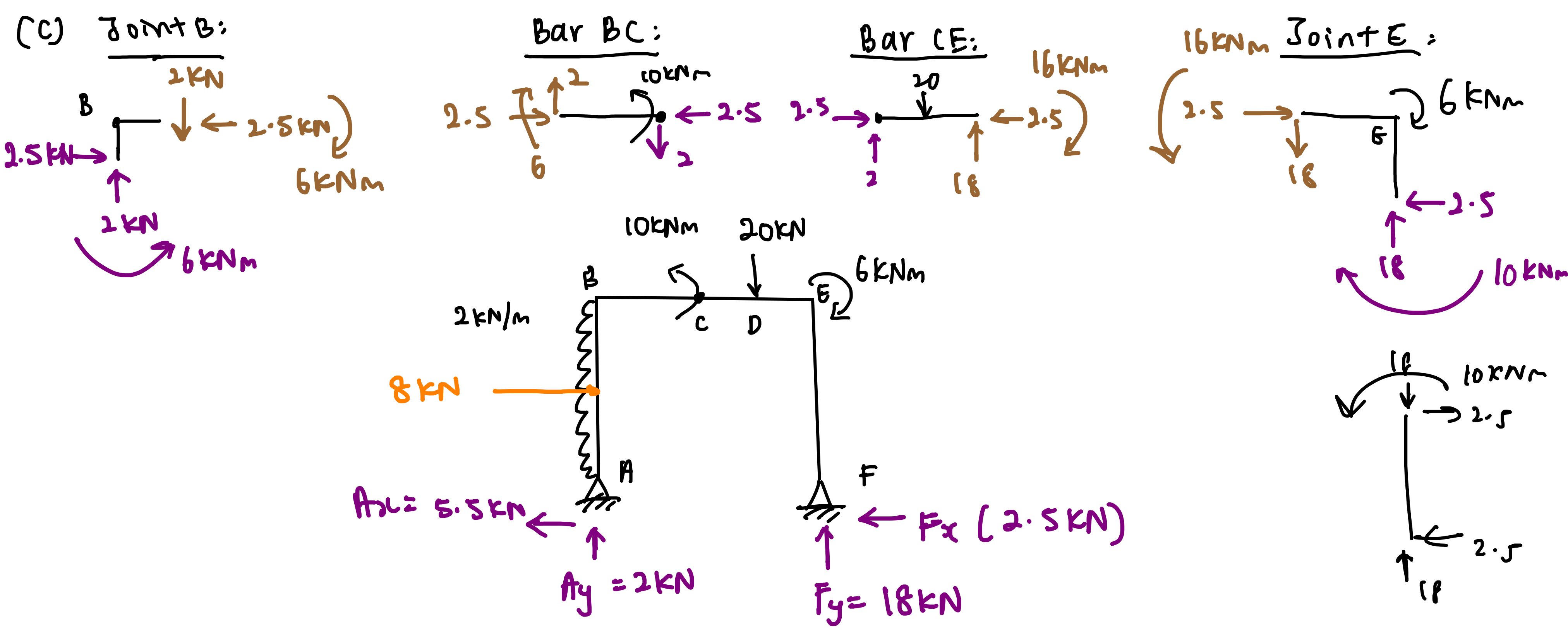
$\circlearrowleft + \sum M_c = 0$

$6 + 20(1) = 18(2) - F_x(4)$

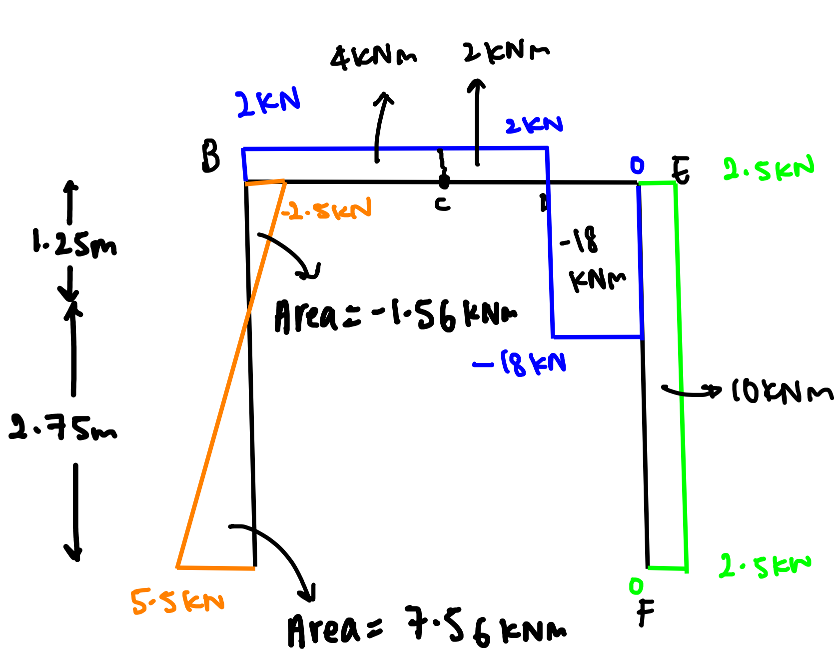
$F_x = +2.5\text{kN}$

Check: $\leftarrow = \rightarrow$: $A_x + F_x = 5.5 + 2.5 = 8\text{ kN}$ #

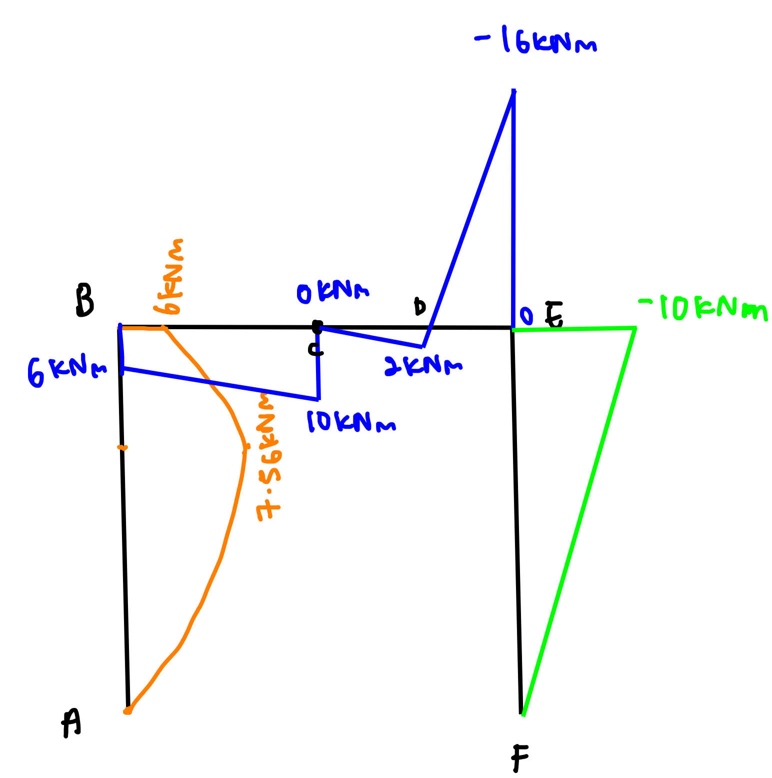
ok.


(c) Joint B:
2KN
2.5KN
2.5KN
6KNm
2KN
6KNm
Bar BC:
2.5
2
6
10KNm
2.5
2
Bar CE:
2.5
20
2.5
16KNm
2
18
Joint E:
16KNm
2.5
16
6KNm
2.5
18
10KNm
10KNm
20KN
6KNm
2KN/m
8KN
Ax = 5.5KN
Ay = 2KN
Fx (2.5KN)
Fy = 18KN
18
10KNm
2.5
2.5
18

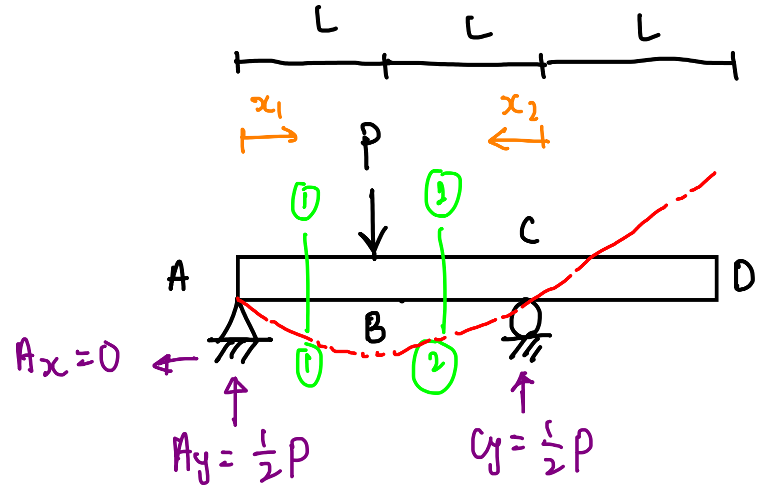
SFD


4KNm
2KNm
2KN
2KN
-2.5KN
1.25m
2.75m
Area = -1.56 KNm
-18 KNm
-18KN
0
2.5KN
10KNm
5.5KN
Area = 7.56 KNm
2.5KN
0

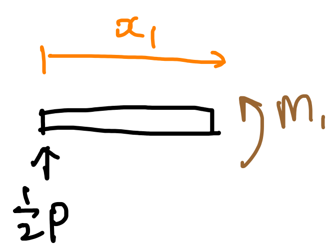
BMD


-16KNm
6KNm
0KNm
0
-10KNm
6KNm
2KNm
10KNm
7.56KNm

3. (a)



For $0<x_1<L$,



$$\Sigma M_1=0$$

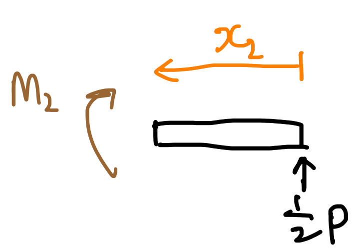
$$M_1=\frac{1}{2}Px_1=EIv''(x_1)$$

$$EIv'(x_1)=\int M_1=\int \frac{1}{2}Px_1\,dx_1=\frac{Px_1^2}{4}+A$$

$$EIv(x_1)=\int \frac{Px_1^2}{4}+A\;dx_1=\frac{Px_1^3}{12}+Ax_1+\cancel{B}^{0}$$

BC1 : $v_A=0 \Rightarrow B=0$

For $0<x_2<L$,



$$\Sigma M_2=0$$

$$M_2=\frac{1}{2}Px_2=EIv''(x_2)$$

$$EIv'(x_2)=\int M_2=\frac{Px_2^2}{4}+C$$

$$EIv(x_2)=\int \frac{Px_2^2}{2}+C\;dx_2=\frac{Px_2^3}{12}+Cx_2+\cancel{D}^{0}$$

BC2 : $v_B=0 \Rightarrow D=0$

CC1: at $x=L$, $v_1=v_2$

$$\therefore \frac{PL^3}{12}+AL=\frac{PL^3}{12}+CL$$

$$A=C \longrightarrow (1)$$

CC2: at $x=L$, $\theta_1=-\theta_2$

$$\therefore \frac{PL^2}{4}+A=-\frac{PL^2}{4}-C$$

$$A=-\frac{1}{2}PL^2-C \longrightarrow (2)$$

$\therefore$ sub (1) in (2)

$$2A=-\frac{1}{2}PL^2$$

$$A=-\frac{1}{4}PL^2=C$$

$\therefore$ segment AB:

$$v(x_1)=\frac{1}{EI}\left[\frac{Px_1^3}{12}-\frac{1}{4}PL^2x_1\right]$$ #

segment BC:

$$v(x_2)=\frac{1}{EI}\left[\frac{Px_2^3}{12}-\frac{1}{4}PL^2x_2\right]$$ #

3(a) continue...

Slope at point C:

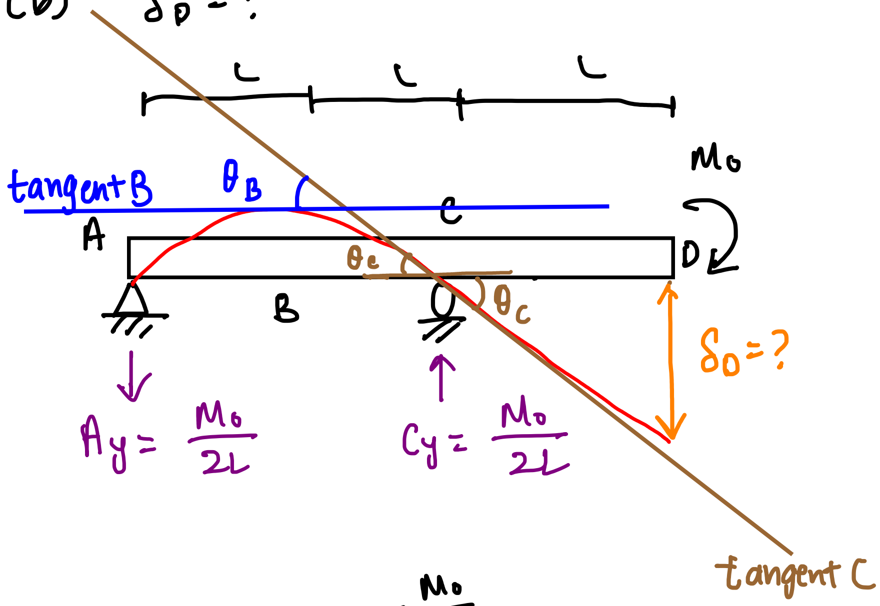
$$EIv'(x_2) = \frac{Px_2^2}{4} + C = \frac{Px_2^2}{4} - \frac{1}{4}PL^2$$

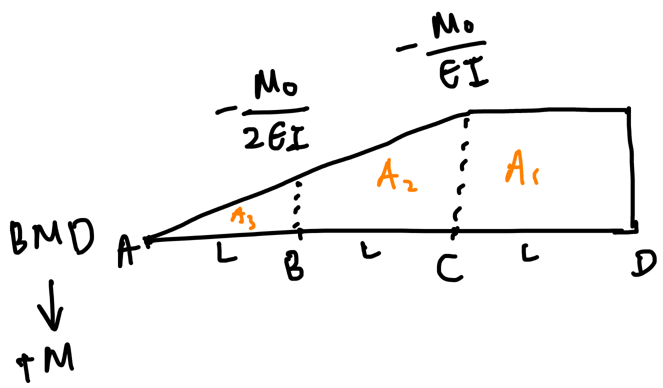
at point C, $x_2 = 0$

$$\therefore \theta_C = v'(x_2 = 0) = \frac{1}{EI}\left[0 - \frac{1}{4}PL^2\right] = -\frac{PL^2}{4EI} = \frac{PL^2}{4EI} \quad \text{(CCW)}$$

#

3(b) $\delta_D = ?$





$$A_1 = -\frac{M_o L}{EI}$$

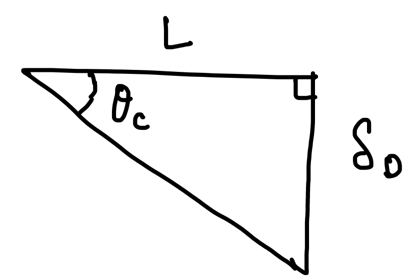
$$A_2 = \frac{1}{2} \times L \times \left(-\frac{3}{2}\frac{M_o}{EI}\right) = -\frac{3}{4}\frac{M_o L}{EI}$$

$$A_3 = \frac{1}{2} \times L \times -\frac{M_o}{2EI} = -\frac{M_o L}{4EI}$$

Note: $\theta_B = \theta_C$

$$\theta_B = \theta_{B/C} = A_2 = -\frac{3}{4}\frac{M_o L}{EI}$$

$$\therefore |\theta_C| = |\theta_B| = \frac{3}{4}\frac{M_o L}{EI}$$



$$\tan\theta_C = \frac{\delta_D}{L}$$

since θ_C is very small,

$$\tan\theta_C \approx \theta_C$$

$$\therefore \theta_C = \frac{\delta_D}{L}$$

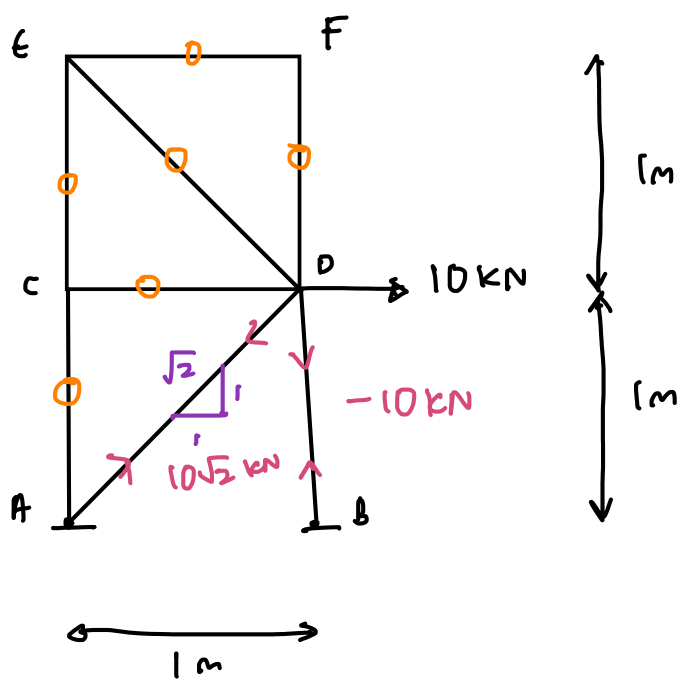
$$\delta_D = L\theta_C$$

$$= L \times \frac{3}{4}\frac{M_o L}{EI}$$

$$= \frac{3}{4}\frac{M_o L^2}{EI} \quad (\downarrow)$$

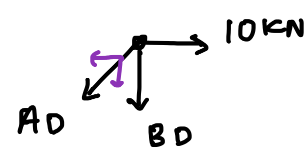
#

4. (a)



Real load (N):

Joint D:



$\Sigma F_x = 0$

$AD_x = 10$

$AD = 10\sqrt{2}$ kN

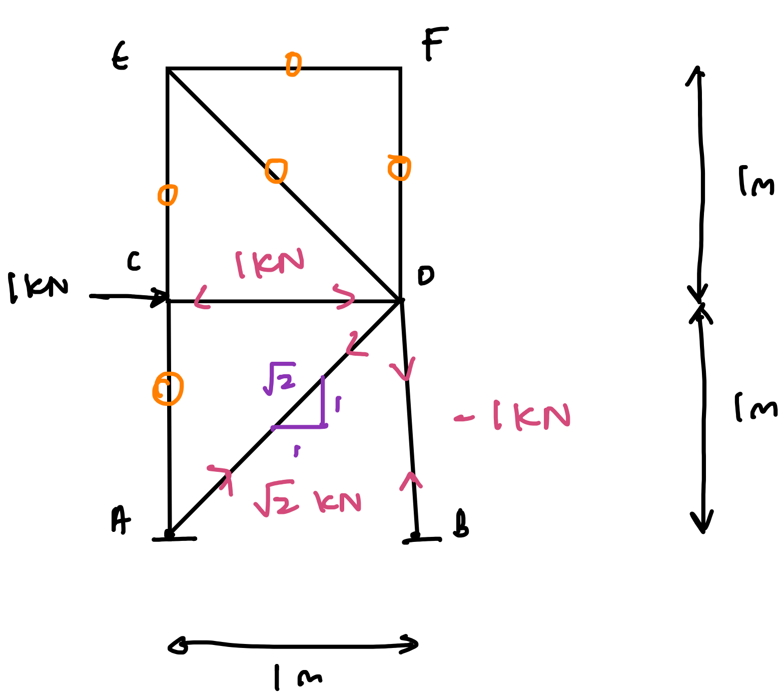
$\Sigma F_y = 0$

$BD = -AD_y$

$BD = -10$ kN

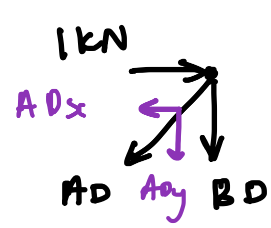
$AD_y = AD\left(\frac{1}{\sqrt{2}}\right)$

$AD_x = AD\left(\frac{1}{\sqrt{2}}\right)$



Virtual load:

Joint D:



$\Sigma F_x = 0$

$AD_x = 1$ kN

$AD = \sqrt{2}$ kN

$\Sigma F_y = 0$

$AD_y = -BD$

$BD = -\sqrt{2}\left(\frac{1}{\sqrt{2}}\right)$

$BD = -1$ kN

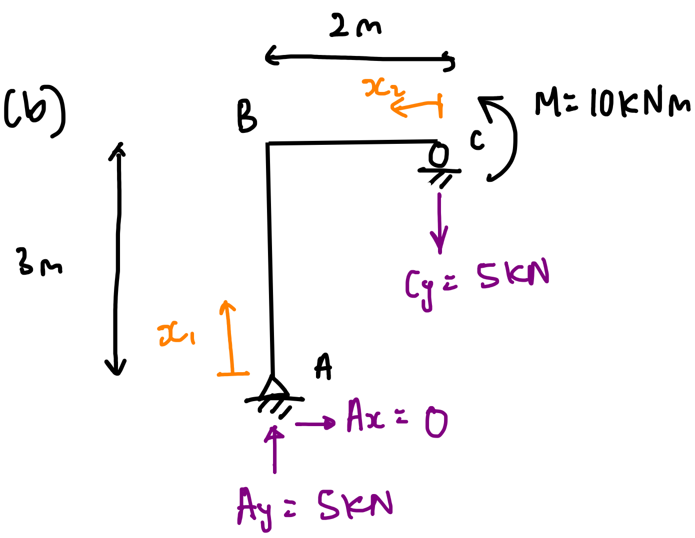
Bar	N_i (kN)	n_i (kN)	L_i (m)	$n_i N_i L_i$
BD	-10	-1	1	10
AD	$10\sqrt{2}$	$\sqrt{2}$	$\sqrt{2}$	$20\sqrt{2}$
				38.3

$\therefore 1 \cdot \Delta_c = \sum_i \frac{n_i N_i L_i}{AE}$

$\Delta_c = \frac{38.3}{AE} \quad (\rightarrow)$

#

4(b)

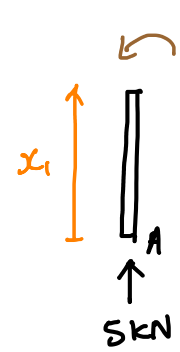


Support reactions:

$\Sigma M_A = 0$, $C_y(2) = 10 \rightarrow \therefore C_y = 5kN = A_y \,(\uparrow = \downarrow)$

Real loads (M_i):

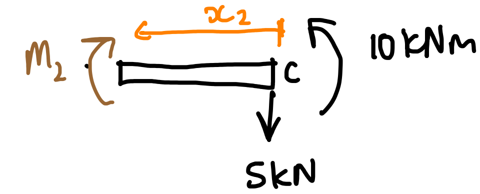
For $0 < x_1 < 3$,



$\Sigma M_1 = 0$

$M_1 = 0$

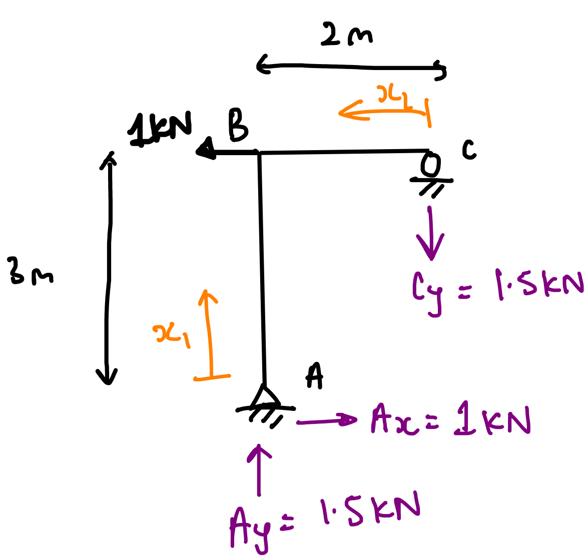
For $0 < x_2 < 2$,



$\Sigma M_2 = 0$

$M_2 + 5x_2 = 10$

$M_2 = (10 - 5x_2)$



Support reactions:

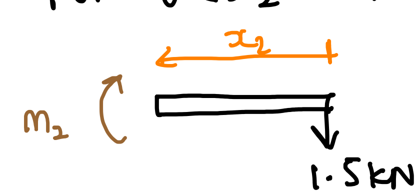
$\Sigma M_A = 0$, $C_y(2) = 1(3) \rightarrow C_y = 1.5kN = A_y$

Virtual loads (m_i):

For $0 < x_1 < 3$,

- Don't need bother as $M_1 = 0$ —

For $0 < x_2 < 2$,



$\Sigma m_2 = 0$, $m_2 = (-1.5x_2)$

$$1 \cdot \Delta_B = \int_0^L \frac{mM}{EI}\,dx$$

$$\Delta_B = \frac{1}{EI}\int_0^L mM\,dx$$

$$= \frac{1}{EI}\left[\int_0^3 m_1(0)\,dx_1 + \int_0^2 -1.5x_2(10 - 5x_2)\,dx_2\right]$$

$$= \frac{1}{EI}(-10) = \frac{10}{EI}\ kN\cdot m^3\ (\rightarrow)$$

#