

# Structural Analysis I

## HW #5

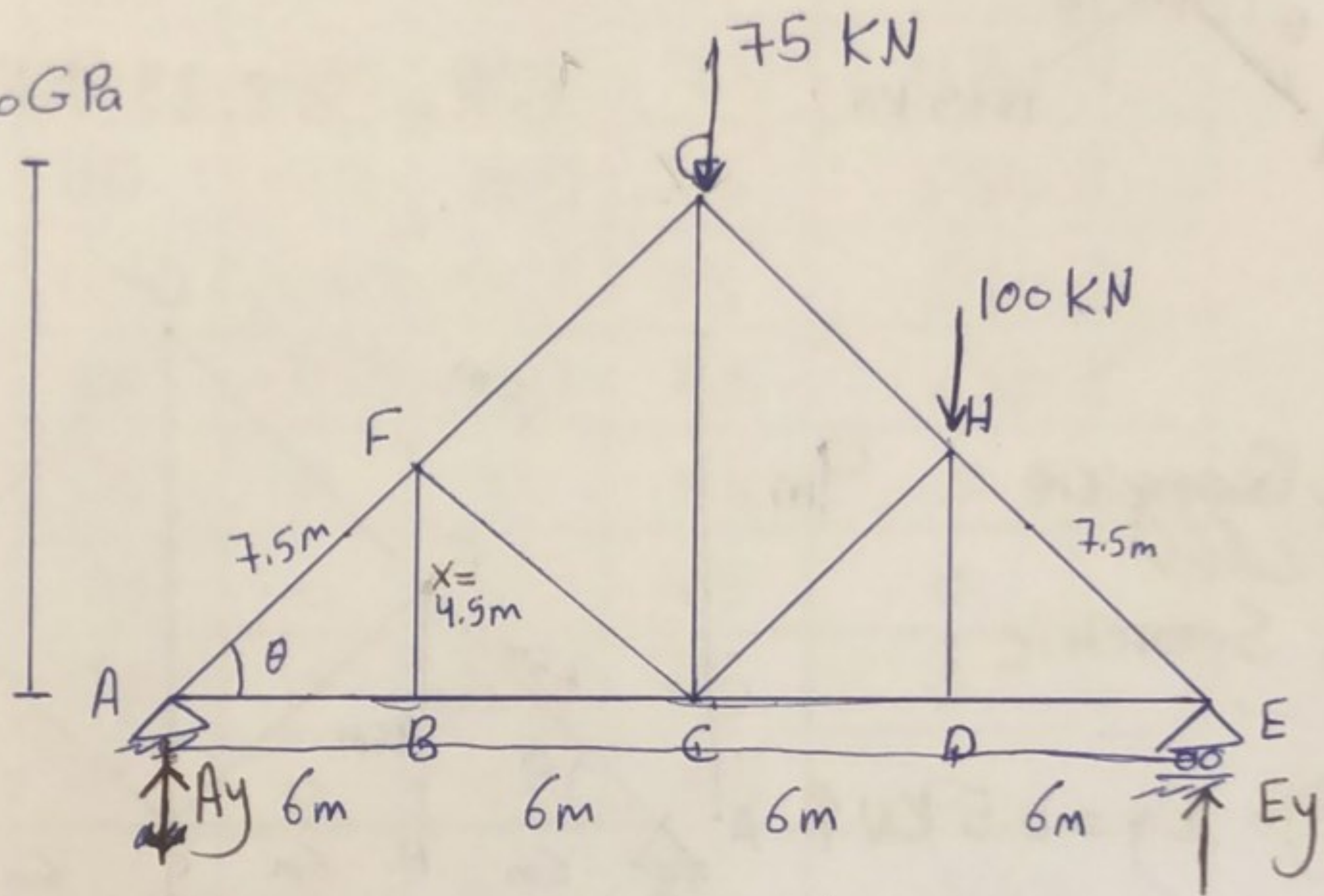
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1181136

Q1 :-)  $E = 200 \text{ GPa}$

$\cos \theta = 0.8$  9m

$\sin \theta = 0.6$



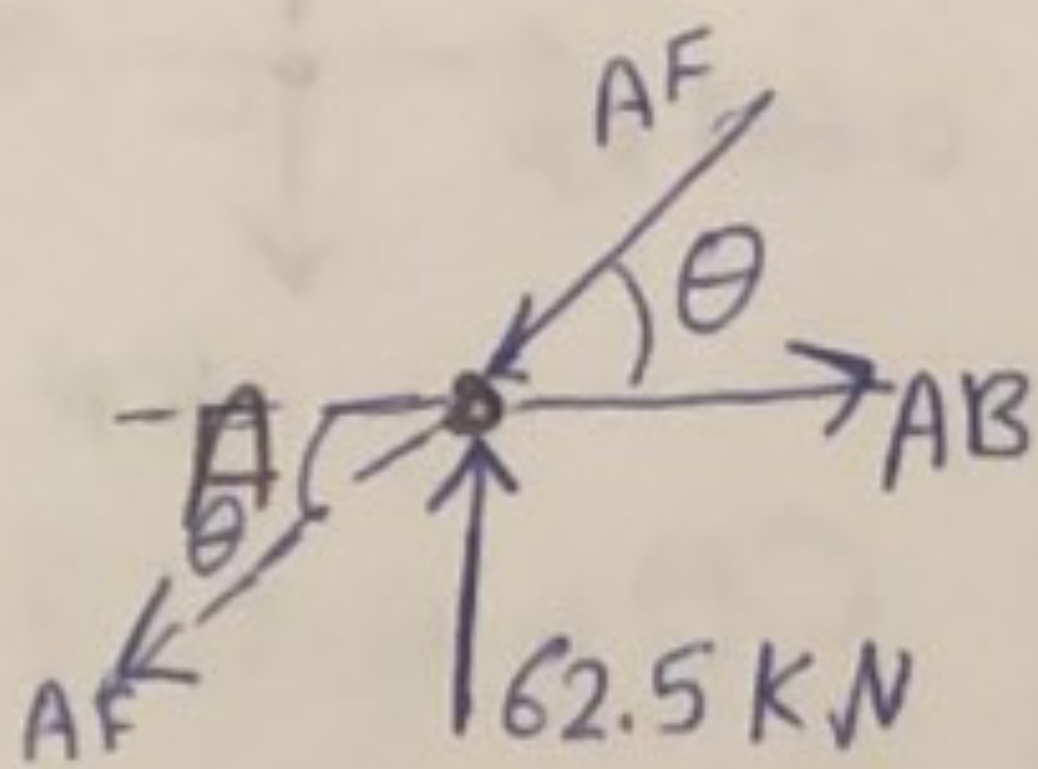
$$\sum M_E = 0 : 24 A_y = 900 + 600$$

$$A_y = 62.5 \text{ kN}$$

$$\sum F_y = 0 : E_y = 112.5 \text{ kN}$$

$$\frac{9}{12} = \frac{x}{6}$$

$$x = 4.5 \text{ m}$$



$$AF = \frac{62.5}{\sin \theta} = 104.17 \text{ kN "C"}$$

$$AB = AF \cos \theta = 83.33 \text{ kN "T"}$$

$$BC = AB = 83.33 \text{ kN "T"}$$

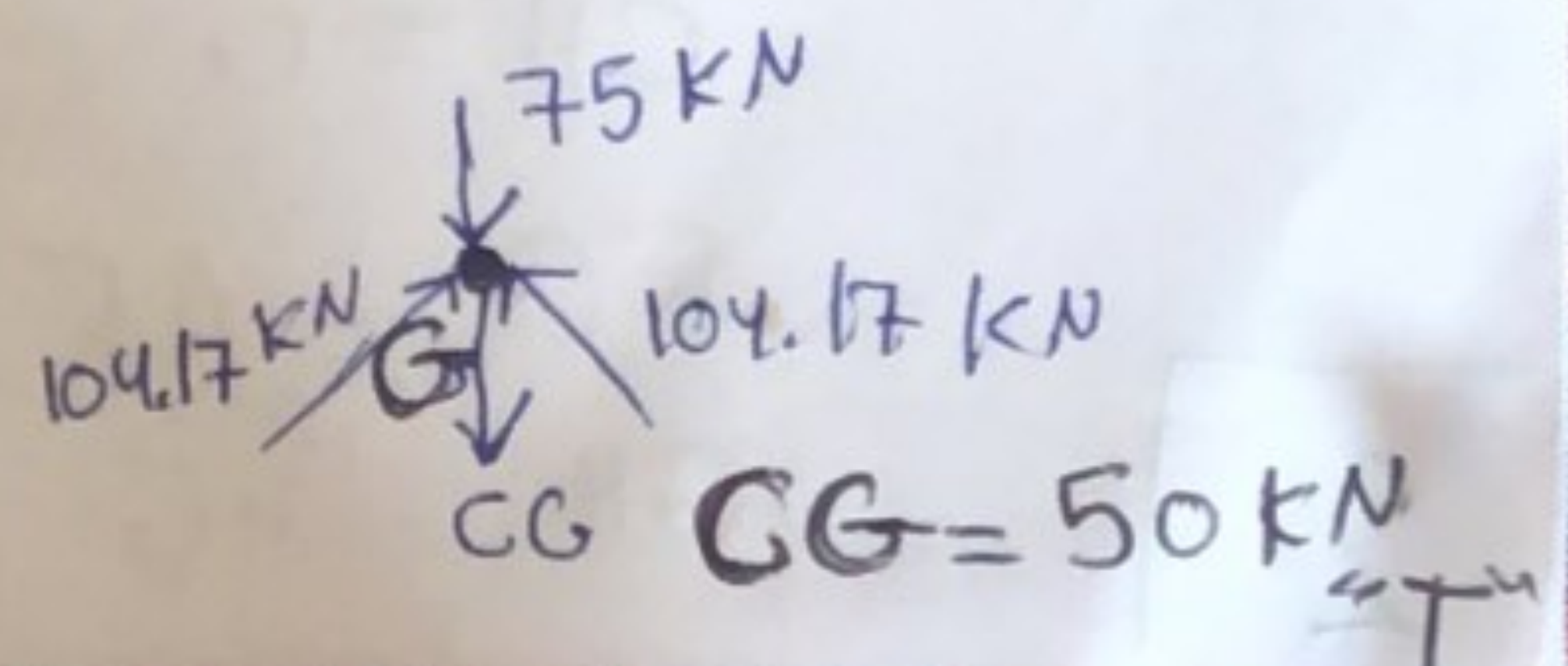
$$FB = 0$$

$$FC = 0$$

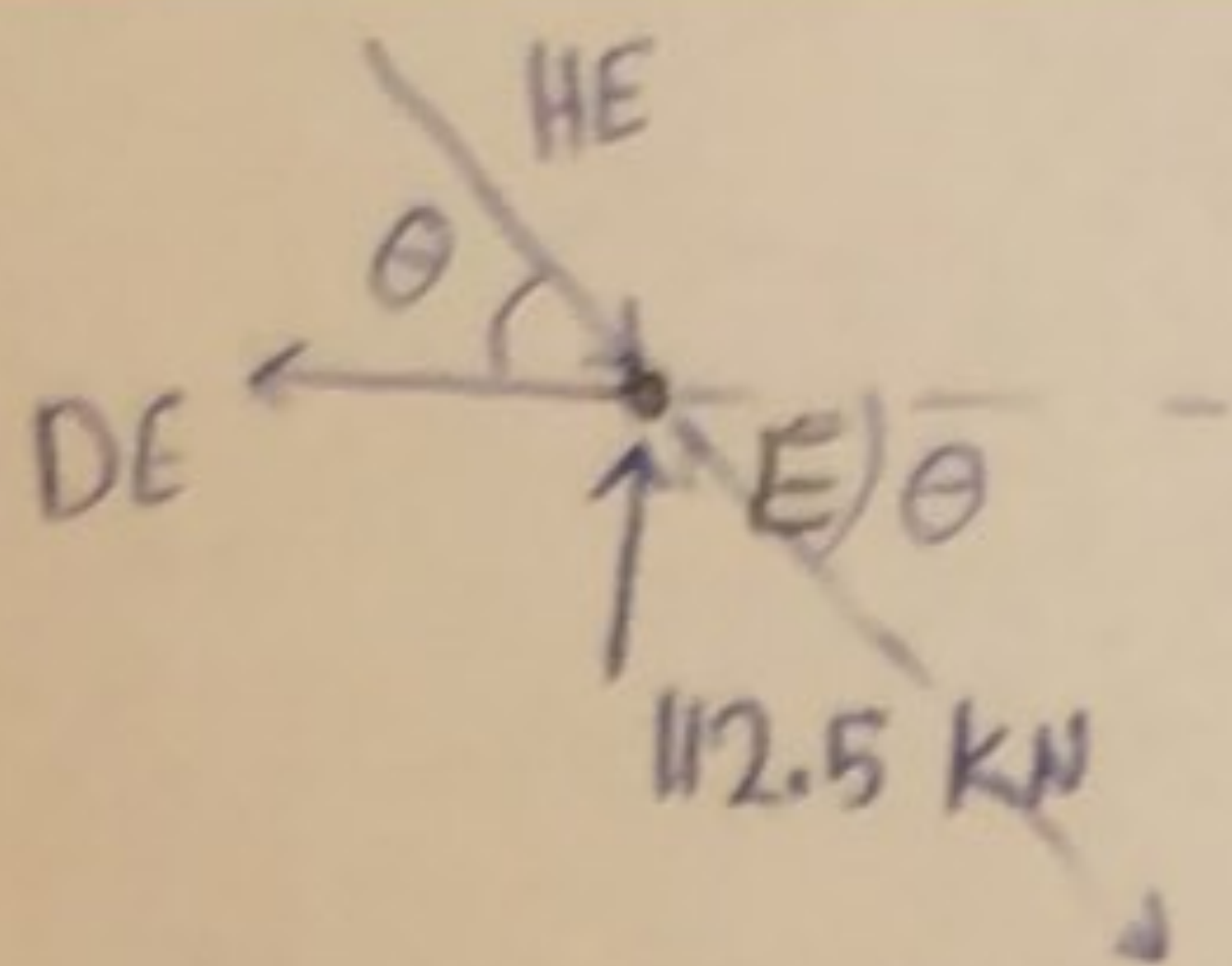
$$FG = AF = 104.17 \text{ kN}$$

$$GH = FG = 104.17 \text{ kN "C"}$$

$$DH = 0$$



$$CG = 50 \text{ kN "T"}$$



$$HE = \frac{112.5}{\sin \theta} = 187.5 \text{ KN "C"}$$

$$DE = HE \cos \theta = 150 \text{ KN "T"}$$

$$CD = DE = 150 \text{ KN "T"}$$

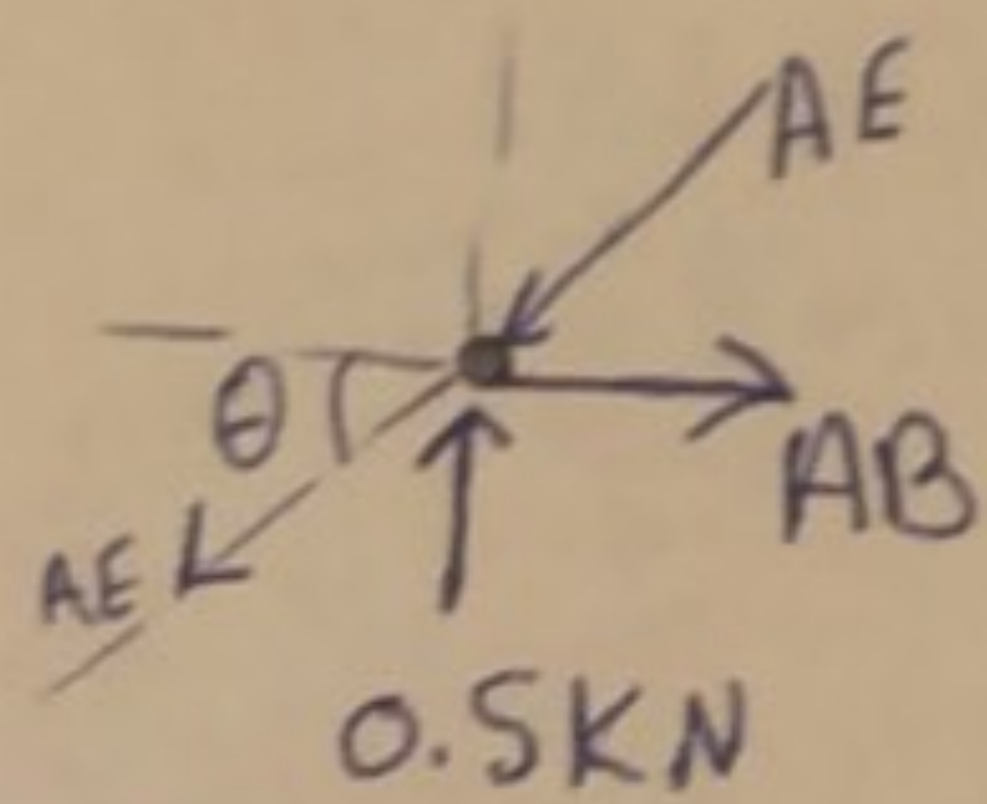
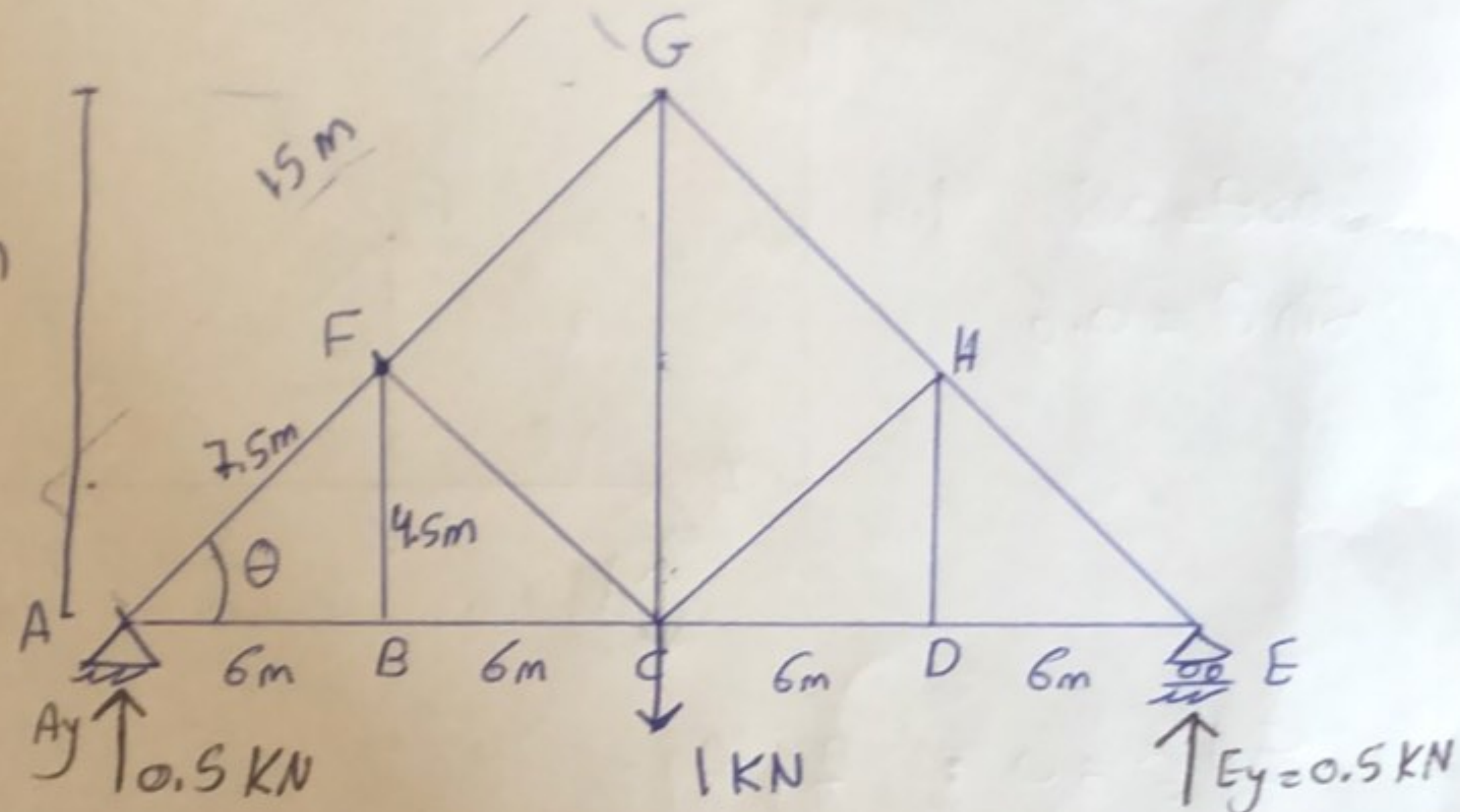


$$CH \sin \theta + 187.5 \sin \theta = 100 \sin \theta + 100$$

$$CH = 83.33 \text{ KN "C"}$$

By Symmetric:  
By Symmetric:

$$A_y = E_y = 0.5 \text{ KN } \uparrow$$



$$AF = \frac{0.5}{\sin \theta} = 0.833 \text{ KN "C"}$$

$$AB = AF \cos \theta = 0.667 \text{ KN "T"}$$

$$BC = AB = 0.667 \text{ KN "T"}$$

$$FB = 0$$

$$FC = 0$$

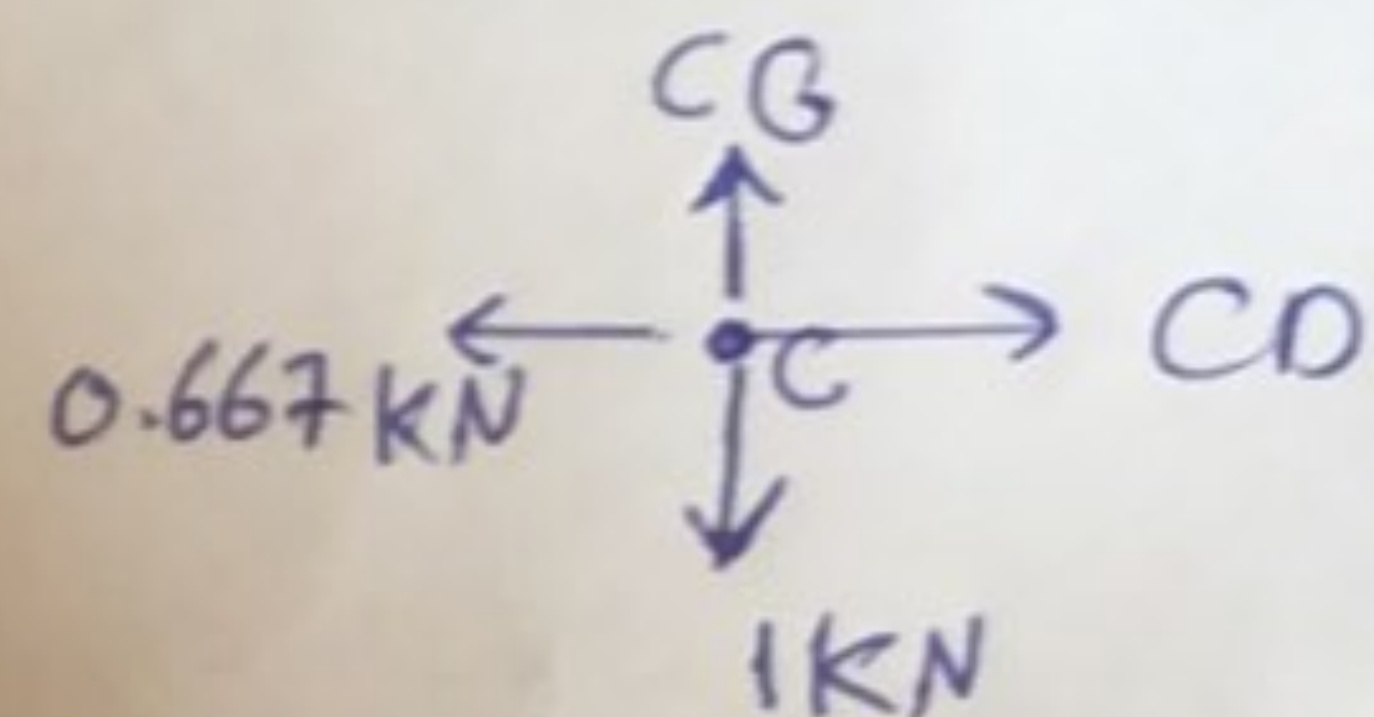
$$HD = 0$$

$$CH = 0$$

$$FG = AF = 0.833 \text{ KN "C"}$$

$$GH = FG = 0.833 \text{ KN "C"}$$

$$EH = GH = 0.833 \text{ KN "C"}$$



$$CD = 0.667 \text{ KN "T"}$$

$$CG = 1 \text{ KN "T"}$$

$$DE = CD = 0.667 \text{ KN "T"}$$

	n	N	L	nNL
AB	0.667	83.33	6	333.5
BC	0.667	83.33	6	333.5
CD	0.667	150	6	600.3
DE	0.667	150	6	600.3
EH	-0.833	-187.5	7.5	1171.4
HG	-0.833	-104.17	7.5	650.8
GF	-0.833	-104.17	7.5	650.8
AF	-0.833	-104.17	7.5	650.8
FB	0	0	4.5	0
HD	0	0	4.5	0
CH	0	-83.33	7.5	0
FC	0	0	7.5	0
CG	1	50	9	450

note:  $A_{FB} = A_{HD} = A_{CH} = A_{FC} = 2000 \text{ mm}^2$

But All ~~of~~ these the internal forces of them = 0, so we don't need it.

$$\textcircled{1} \Delta C_1 = \frac{\sum nNL}{AE} = \frac{5441.4}{3000 * 10^{-6} * 200 * 10^6}$$

$$\rightarrow \Delta C_1 = 9.069 * 10^{-3} \text{ m}$$

$$= 9.07 \text{ mm}$$

$$\Delta G_1 = \Delta C_1 - \left( \frac{P_{CG} L}{AE} \right) \rightarrow \delta_{CG}$$

$$= 9.07 * 10^{-3} - \frac{450}{3000 * 10^{-6} * 200 * 10^6}$$

$$= 8.32 * 10^{-3} \text{ m} = 8.32 \text{ mm}$$

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$$\begin{aligned}
 \textcircled{2} \quad \Delta C_2 &= \sum n \times \Delta T L \\
 &= (-0.833 * 12 * 10^{-6} * -40 * 7.5) + (-0.833 * 12 * 10^{-6} * -40 * 7.5) \\
 &\approx 6 * 10^{-3} \text{ mm} \\
 &= 6 \text{ mm} = \Delta G_2 \quad \text{"}\Delta C_2 = \Delta G_2\text{"}
 \end{aligned}$$

$\textcircled{3}$  No change, because "n" for member HD and member FB = 0

$$\text{So, } \Delta C_3 = 0$$

$$\Delta G_3 = 0$$

$\textcircled{4}$  Conditions 1 and 2 :-

$$\Delta C = \Delta C_1 + \Delta C_2$$

$$= 9.07 + 6$$

$$= 15.07 \text{ mm}$$

$$\Delta G = \Delta G_1 + \Delta G_2$$

$$= 8.32 + 6$$

$$= 14.32 \text{ mm}$$

$$\textcircled{5} \quad \Delta C = 9.07 \text{ mm} + 0 = 9.07 \text{ mm}$$

$$\Delta G = 8.32 \text{ mm} + 0 = 8.32 \text{ mm}$$

$$\textcircled{6} \quad \Delta C = \overset{.2}{15.07} \text{ mm} + \overset{.3}{0} = 15.07 \text{ mm}$$

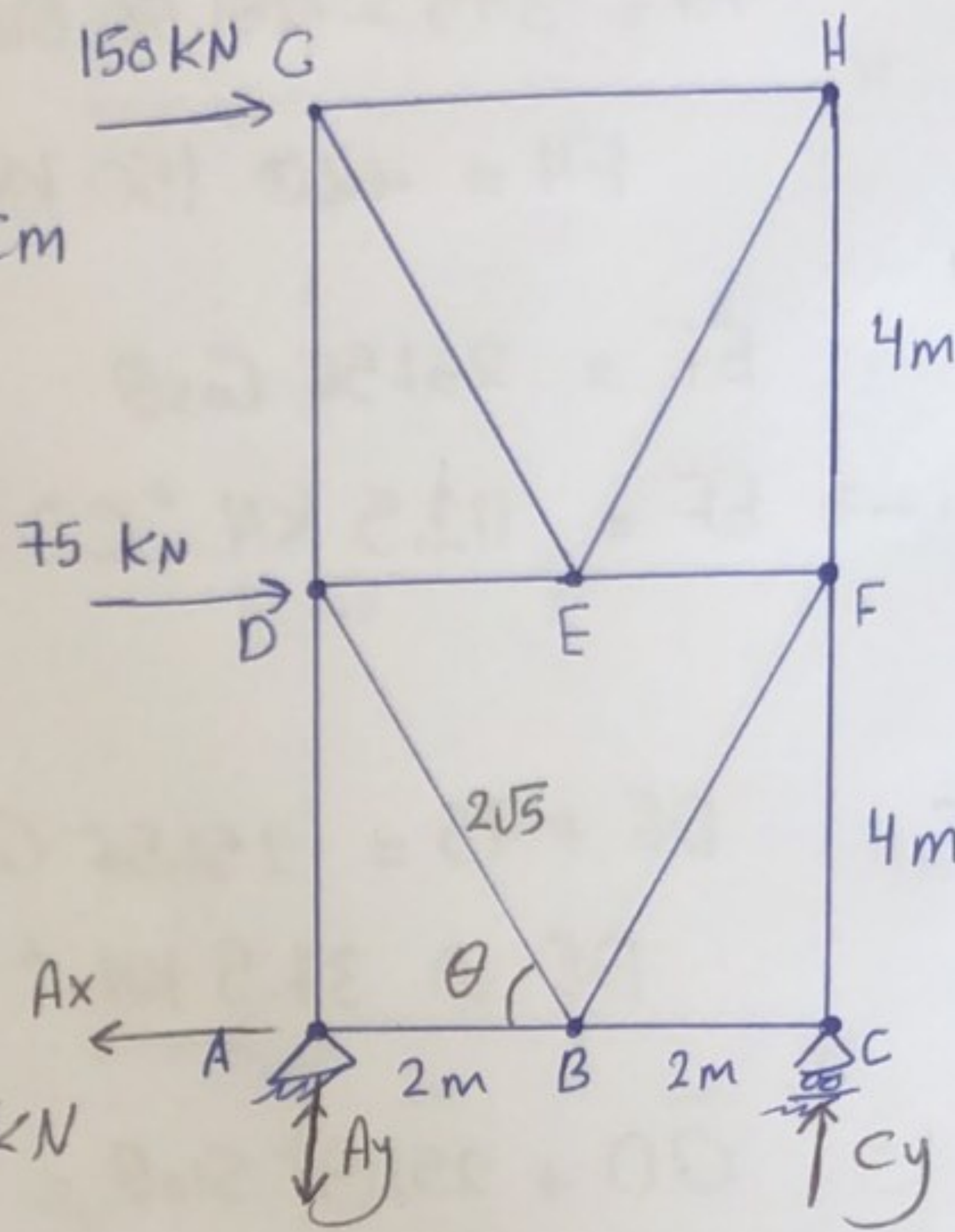
$$\Delta G = 14.32 \text{ mm} + 0 = 14.32 \text{ mm}$$

Q 2:-)

Maximum Horizontal sway = 3 cm

find A?

$E = 200 \text{ GPa}$



$$\cos \theta = \frac{1}{\sqrt{5}}$$

$$\sin \theta = \frac{2}{\sqrt{5}}$$

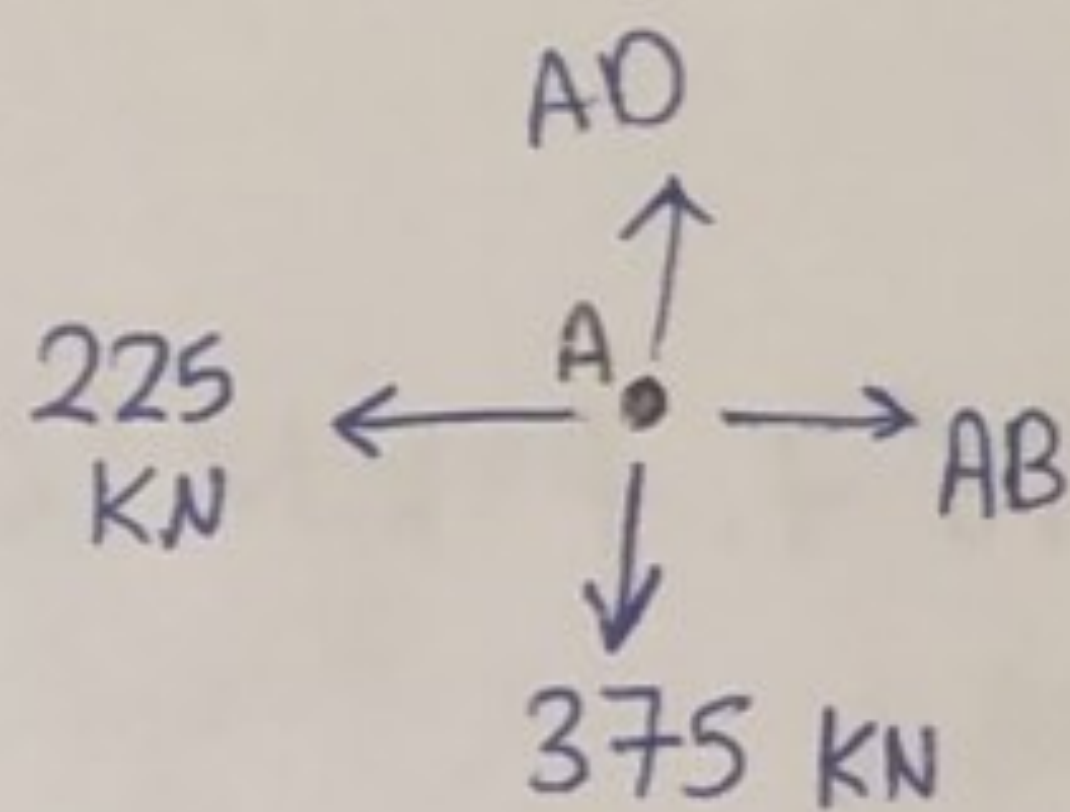
$$\sum F_x = 0: A_x = 225 \text{ kN}$$

$$\sum M_C = 0: 4A_y = 300 + 1200$$

$$A_y = 375 \text{ kN} \downarrow$$

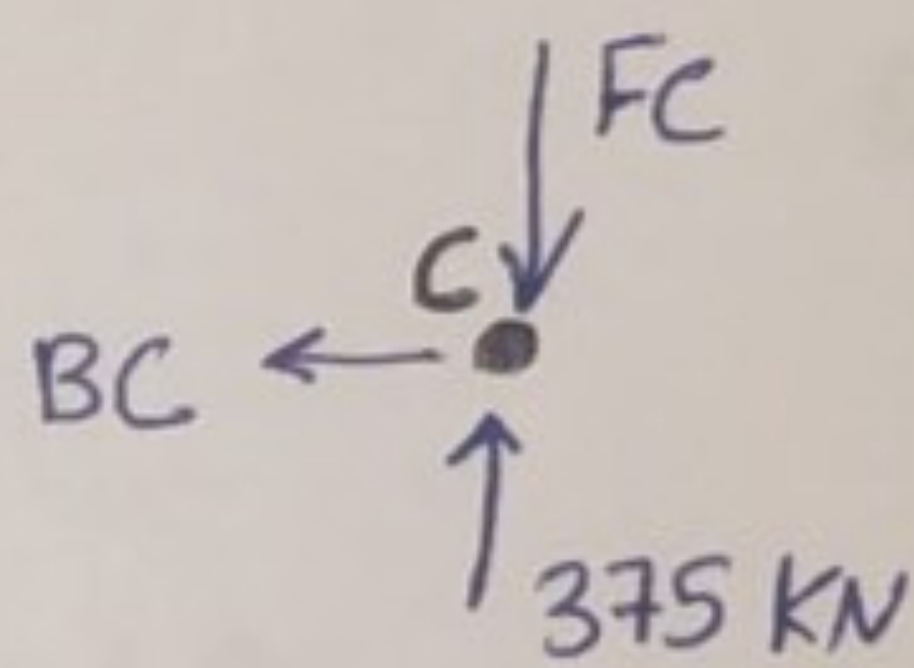
$$\sum F_y = 0: C_y = 375 \text{ kN} \uparrow$$

\* Method of joints to find N for each member:



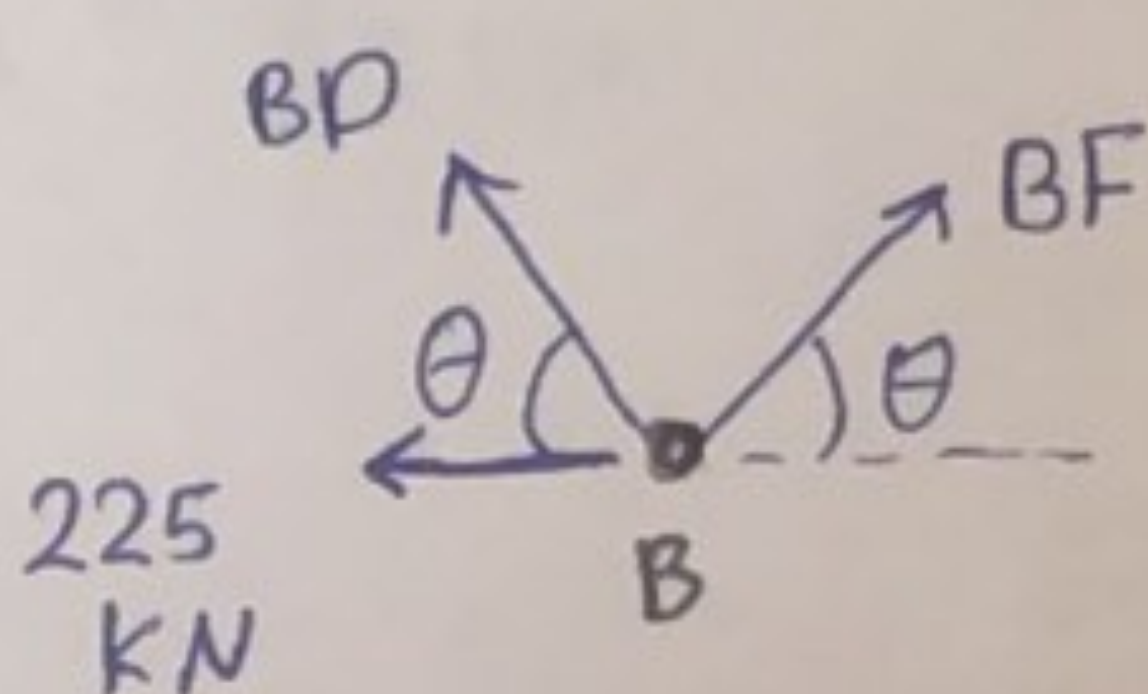
$$AB = 225 \text{ kN "T"}$$

$$AD = 375 \text{ kN "T"}$$



$$BC = 0$$

$$FC = 375 \text{ kN "C"}$$



$$\sum F_y = 0:$$

$$BD = -BF$$

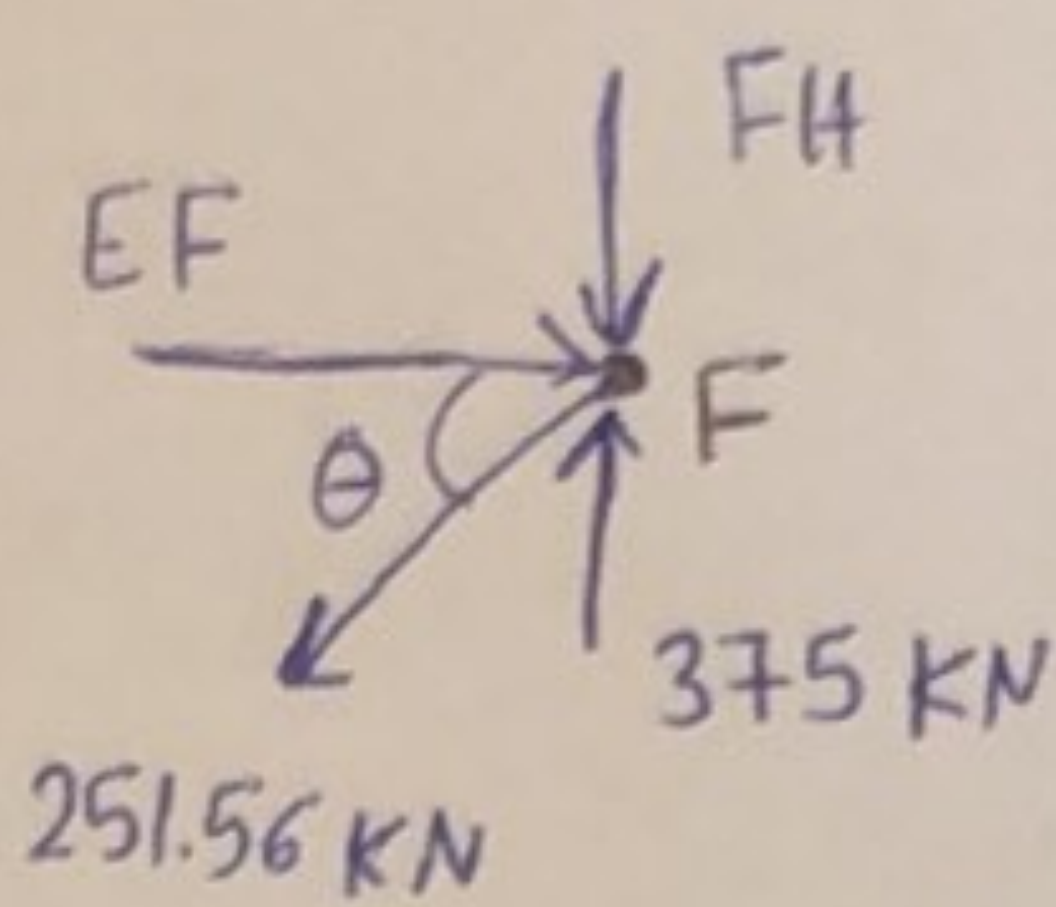
$$\sum F_x = 0: BF \cos \theta = 225 + BD \cos \theta$$

$$2BF \cos \theta = 225$$

$$BF = 251.56 \text{ kN "T"}$$

$$BD = -251.56 \text{ kN} = 251.56 \text{ "C"}$$

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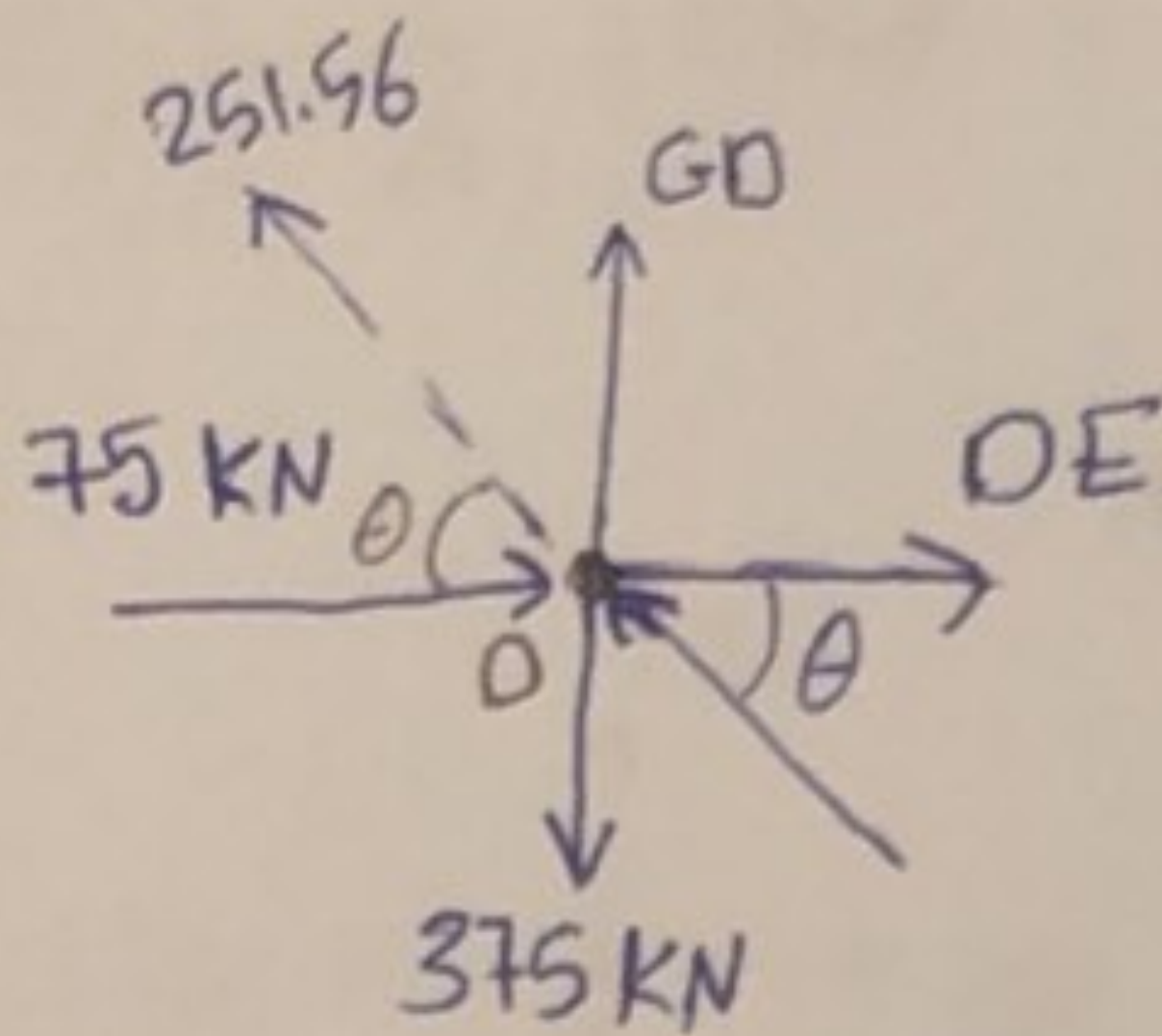


$$FH = 375 - (251.56 \sin \theta)$$

$$FH = 150 \text{ kN "C"}$$

$$EF = 251.56 \cos \theta$$

$$\rightarrow EF = 112.5 \text{ kN "C"}$$

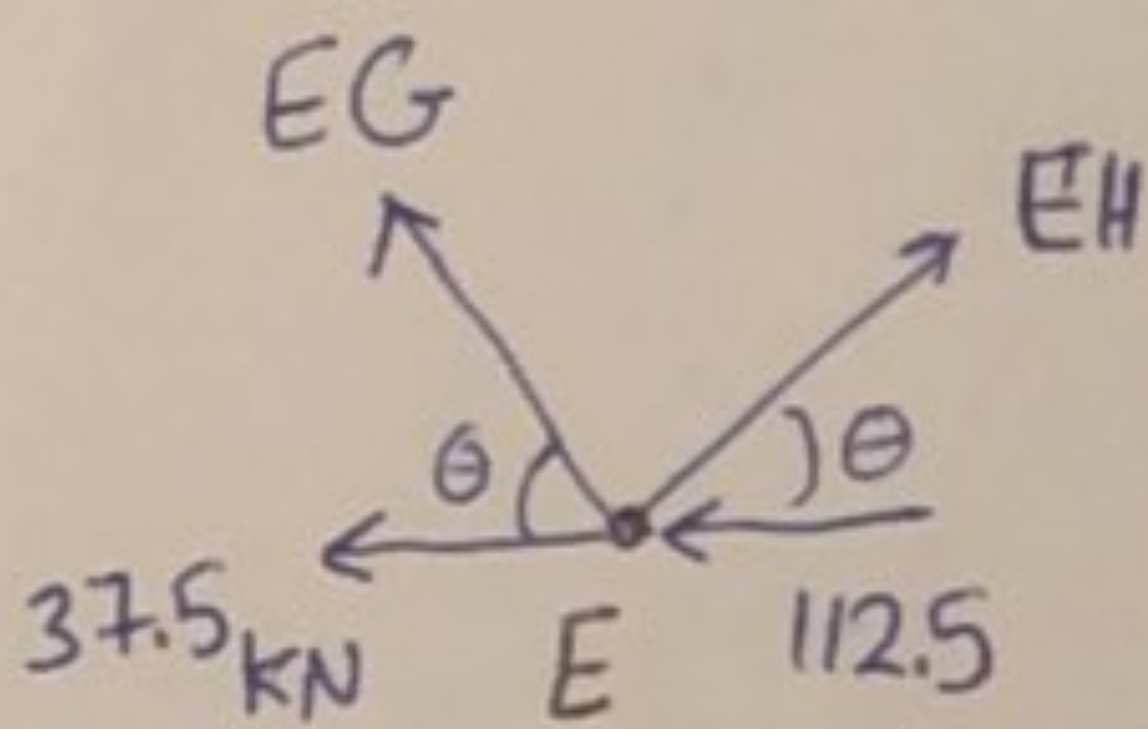


$$DE + 75 = 251.56 \cos \theta$$

$$DE = 37.5 \text{ kN "T"}$$

$$GD + 251.56 \sin \theta = 375$$

$$GD = 150 \text{ kN "T"}$$



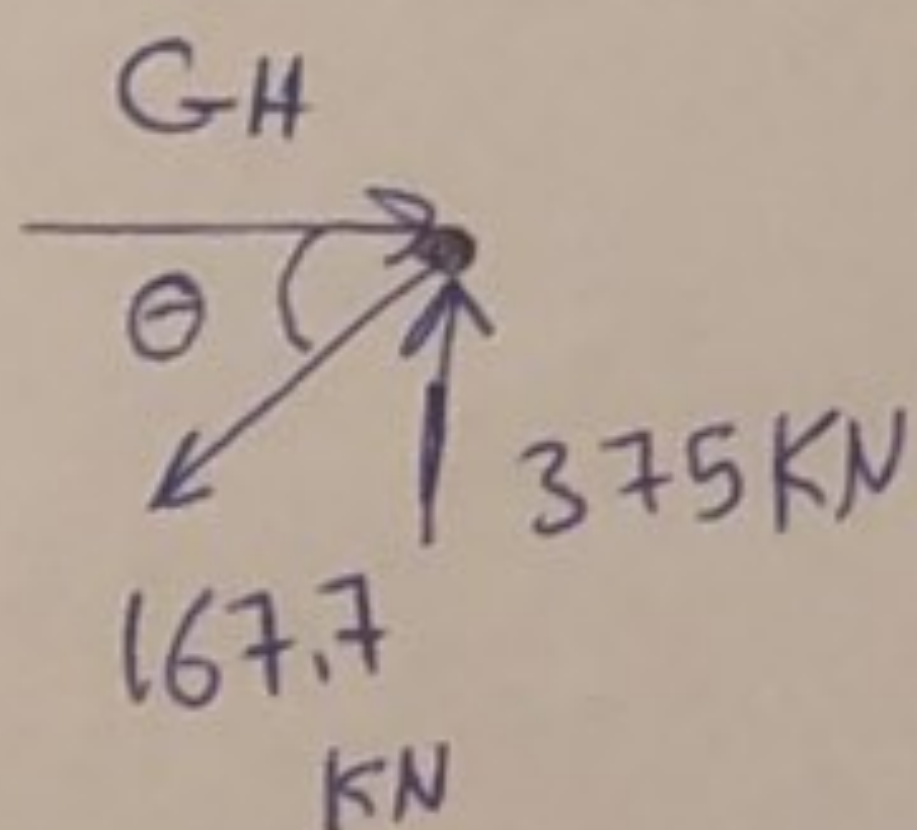
$$\Sigma F_y = 0: EG = -EH$$

$$\Sigma F_x = 0: 112.5 + 37.5 + EG \cos \theta = EH \cos \theta$$

$$2EH \cos \theta = 150$$

$$EH = 167.7 \text{ kN "T"}$$

$$EG = -167.7 \text{ kN} = 167.7 \text{ kN "C"}$$



$$GH = 167.7 \cos \theta$$

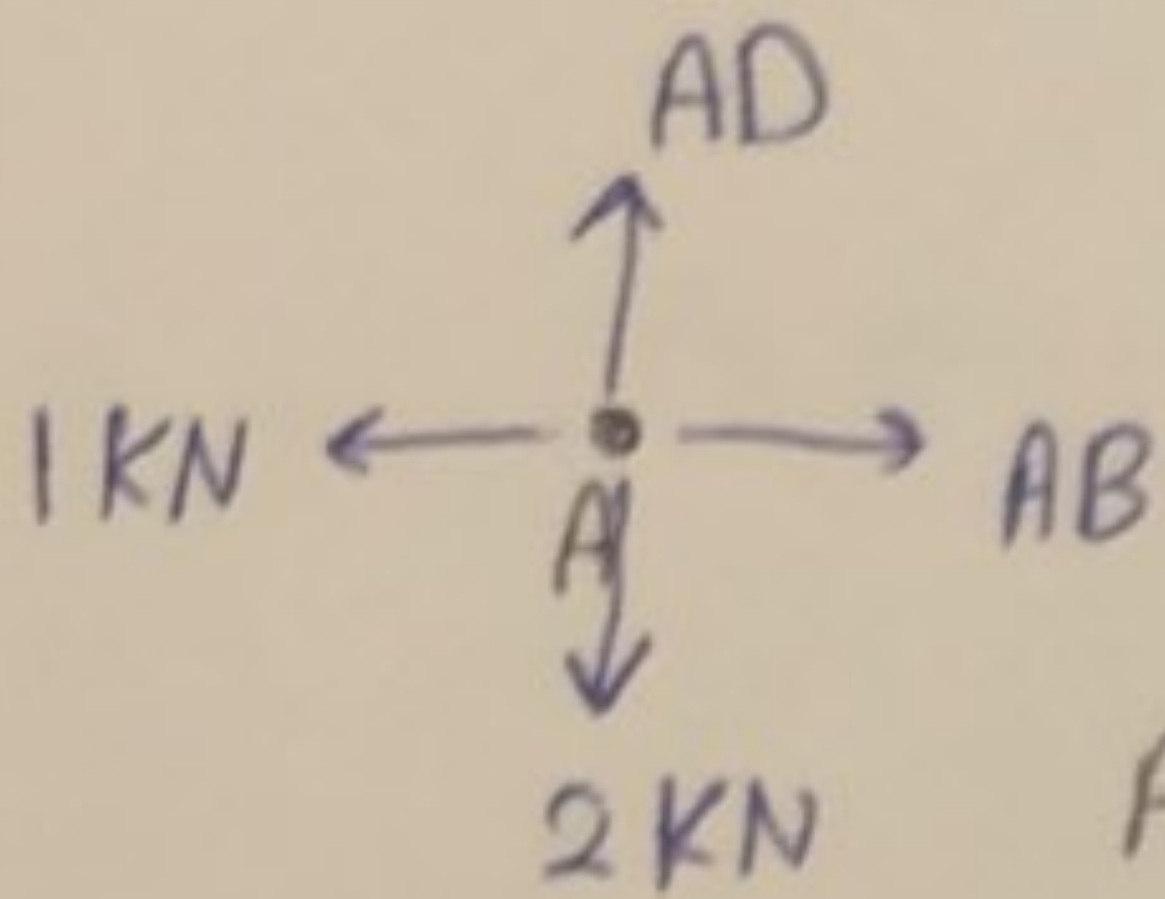
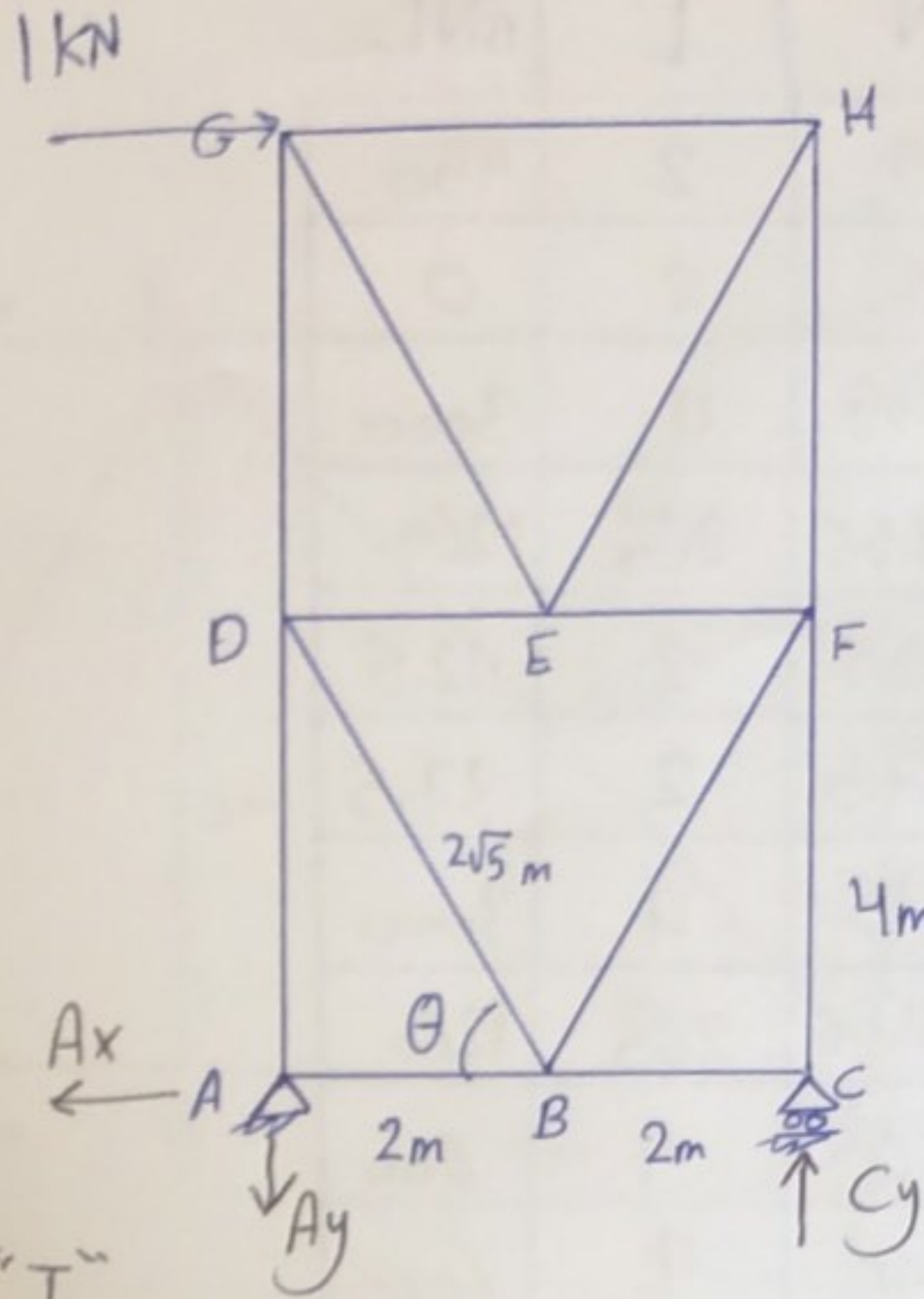
$$GH = 75 \text{ kN "C"}$$

$$\sum F_x = 0: A_x = 1 \text{ KN}$$

$$\sum M_C = 0: 4A_y = 8$$

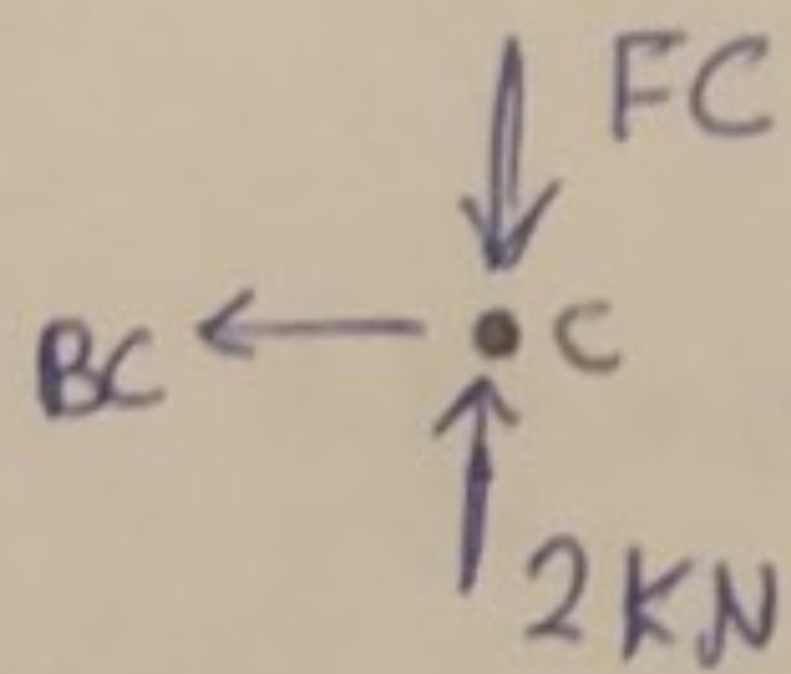
$$A_y = 2 \text{ KN } \downarrow$$

$$\sum F_y = 0: C_y = 2 \text{ KN } \uparrow$$



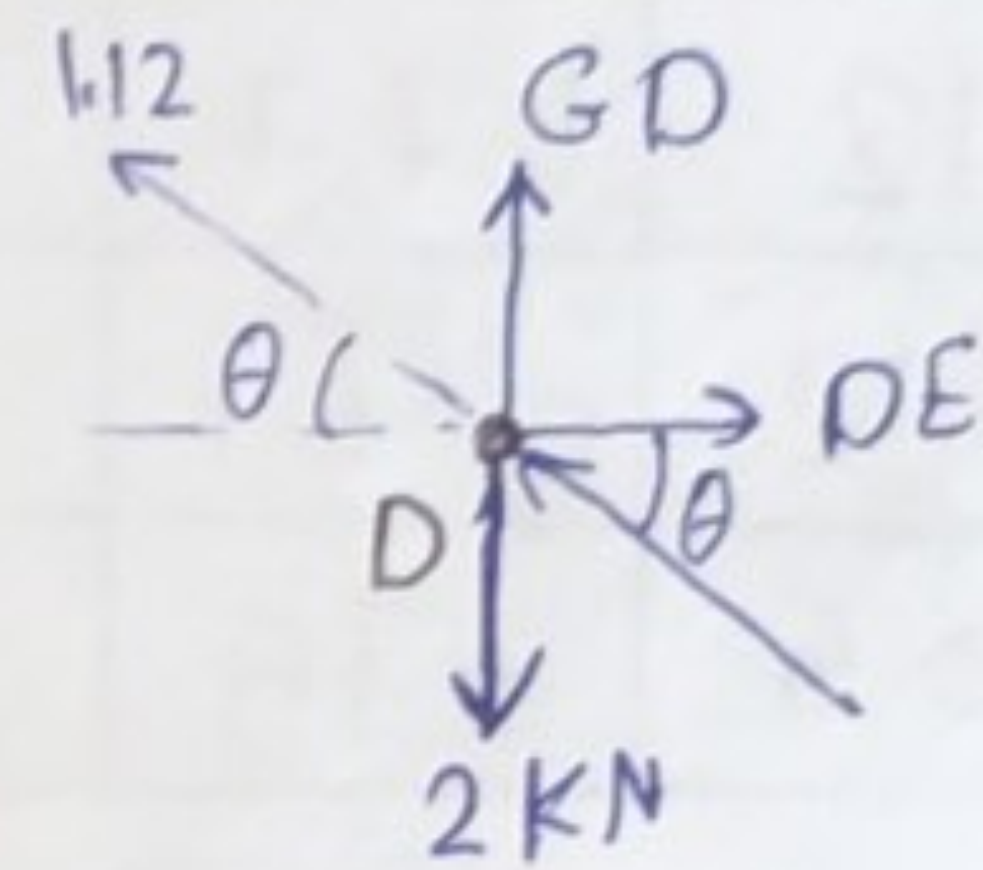
$$AD = 2 \text{ KN "T"}$$

$$AB = 1 \text{ KN "T"}$$



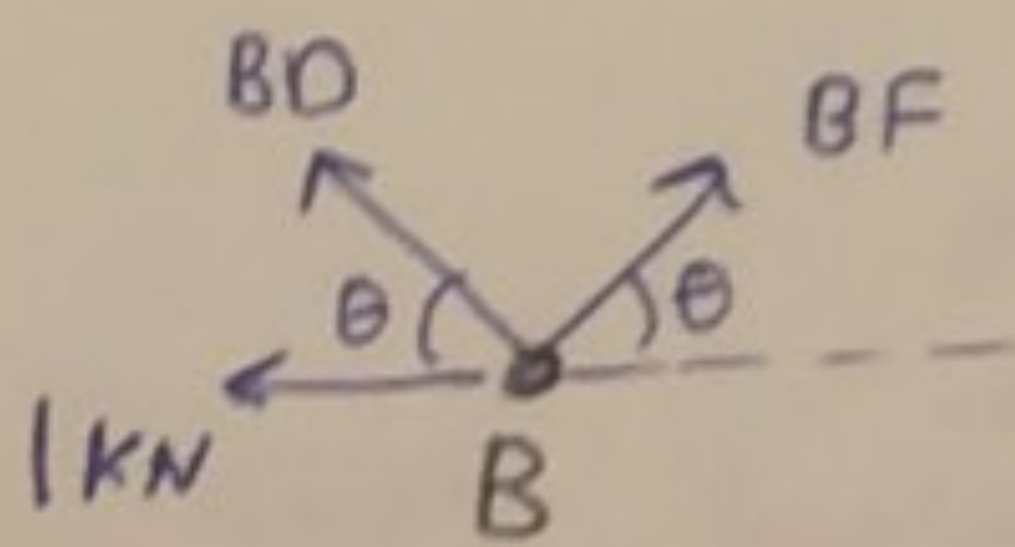
$$BC = 0$$

$$FC = 2 \text{ KN "C"}$$



$$DE = 1.12 \cos\theta = 0.5 \text{ KN "T"}$$

$$GD = 2 - 1.12 \sin\theta = 1 \text{ KN "T"}$$

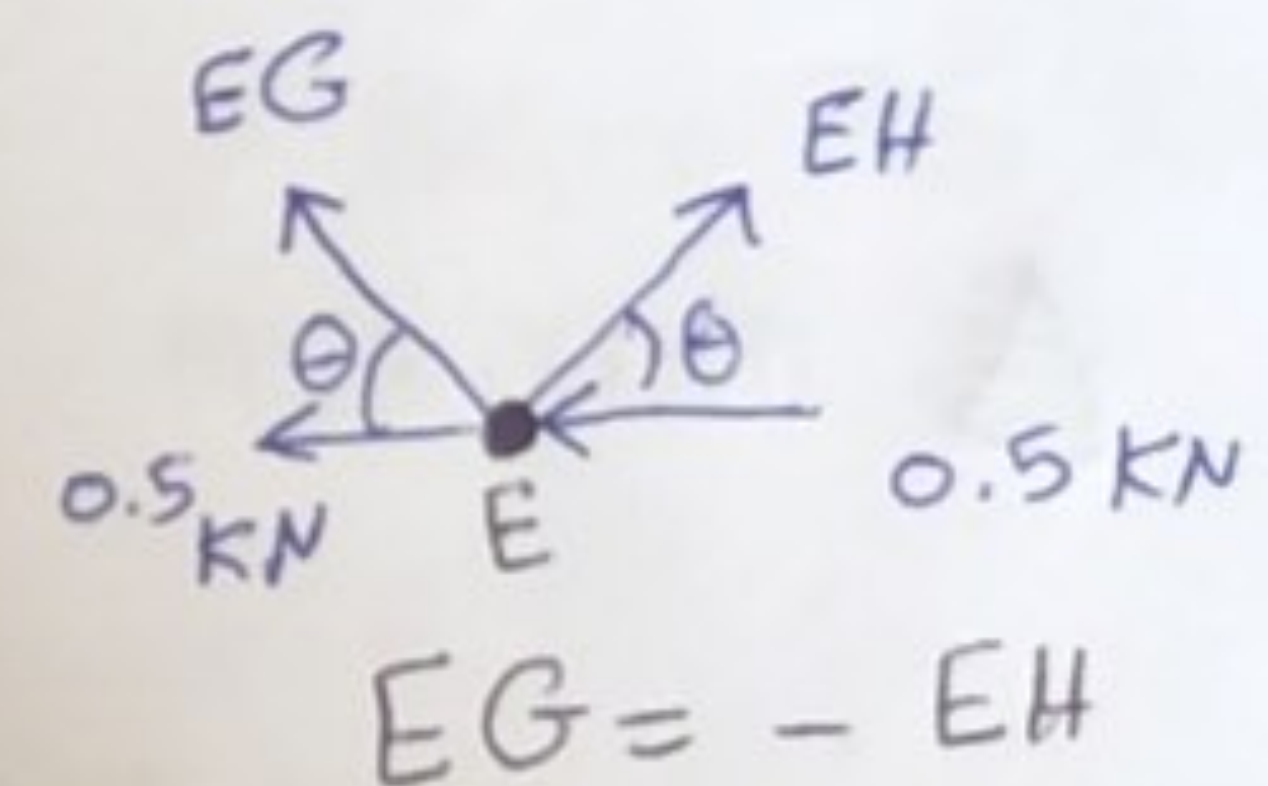


$$BD = -BF \text{ --- (1)}$$

$$BF \cos\theta = 1 - BF \cos\theta$$

$$BF = 1.12 \text{ KN "T"}$$

$$BD = 1.12 \text{ KN "C"}$$

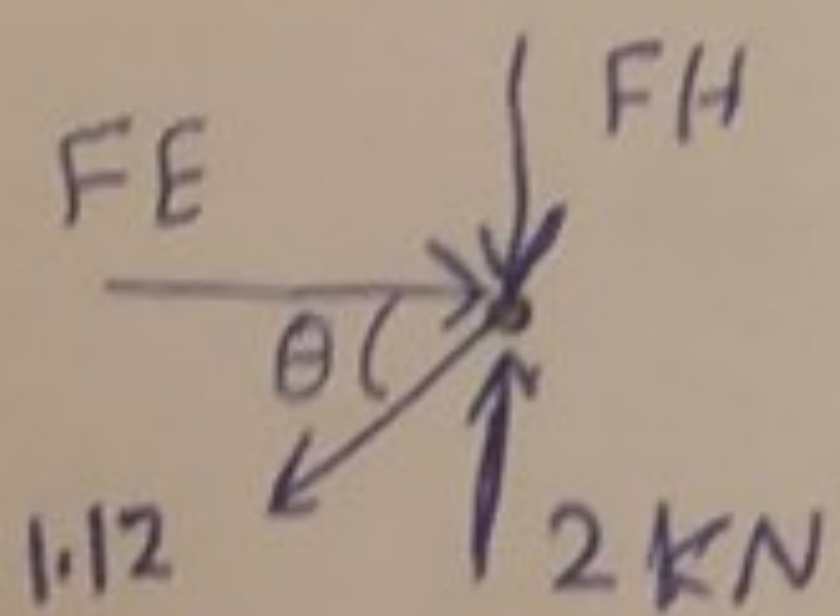


$$EG = -EH$$

$$EH \cos\theta = 1 - EH \cos\theta$$

$$EH = 1.12 \text{ KN "T"}$$

$$\rightarrow EG = 1.12 \text{ KN "C"}$$

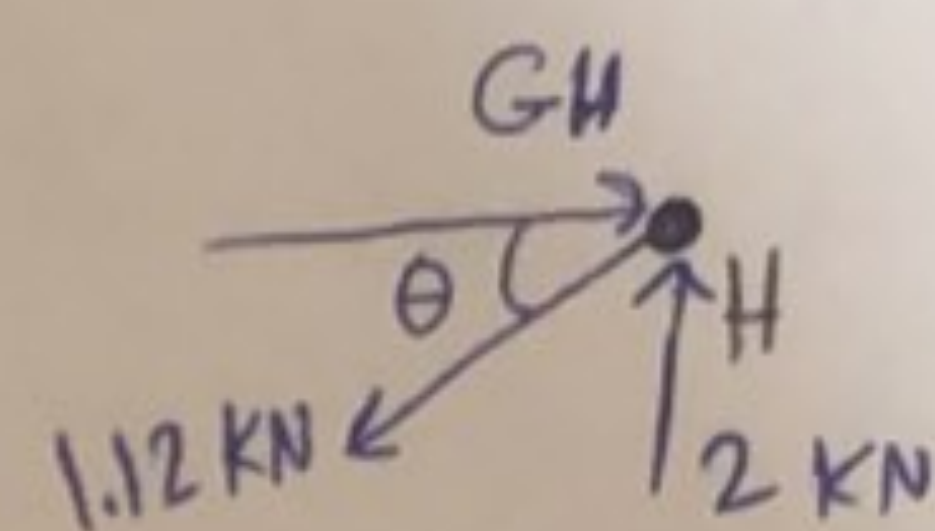


$$FE = 1.12 \cos\theta$$

$$\rightarrow FE = 0.5 \text{ KN "C"}$$

$$FH + 1.12 \sin\theta = 2$$

$$FH = 1 \text{ KN "C"}$$



$$GH = 1.12 \cos\theta$$

$$GH = 0.5 \text{ KN "C"}$$

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	n	N	L	nNL
AB	1	225	2	450
BC	0	0	2	0
CF	-2	-375	4	3000
FB	1.12	251.56	$2\sqrt{5}$	1260
FE	-0.5	-112.5	2	112.5
DE	0.5	37.5	2	37.5
AD	2	375	4	3000
DB	-1.12	-251.56	$2\sqrt{5}$	1260
DG	1	150	4	600
HF	-1	-150	4	600
HE	1.12	167.7	$2\sqrt{5}$	839.97
GE	-1.12	-167.7	$2\sqrt{5}$	839.97
GH	-0.5	-75	4	150

$$\sum nNL = 12149.94$$

$$\Delta \text{ maximum horizontal sway} = \frac{\sum nNL}{AE}$$

$$0.03 = \frac{12149.94}{A * 200 * 10^6}$$

$$A = 2.025 * 10^{-3} \text{ m}^2$$

$$A = 20.25 \text{ cm}^2$$

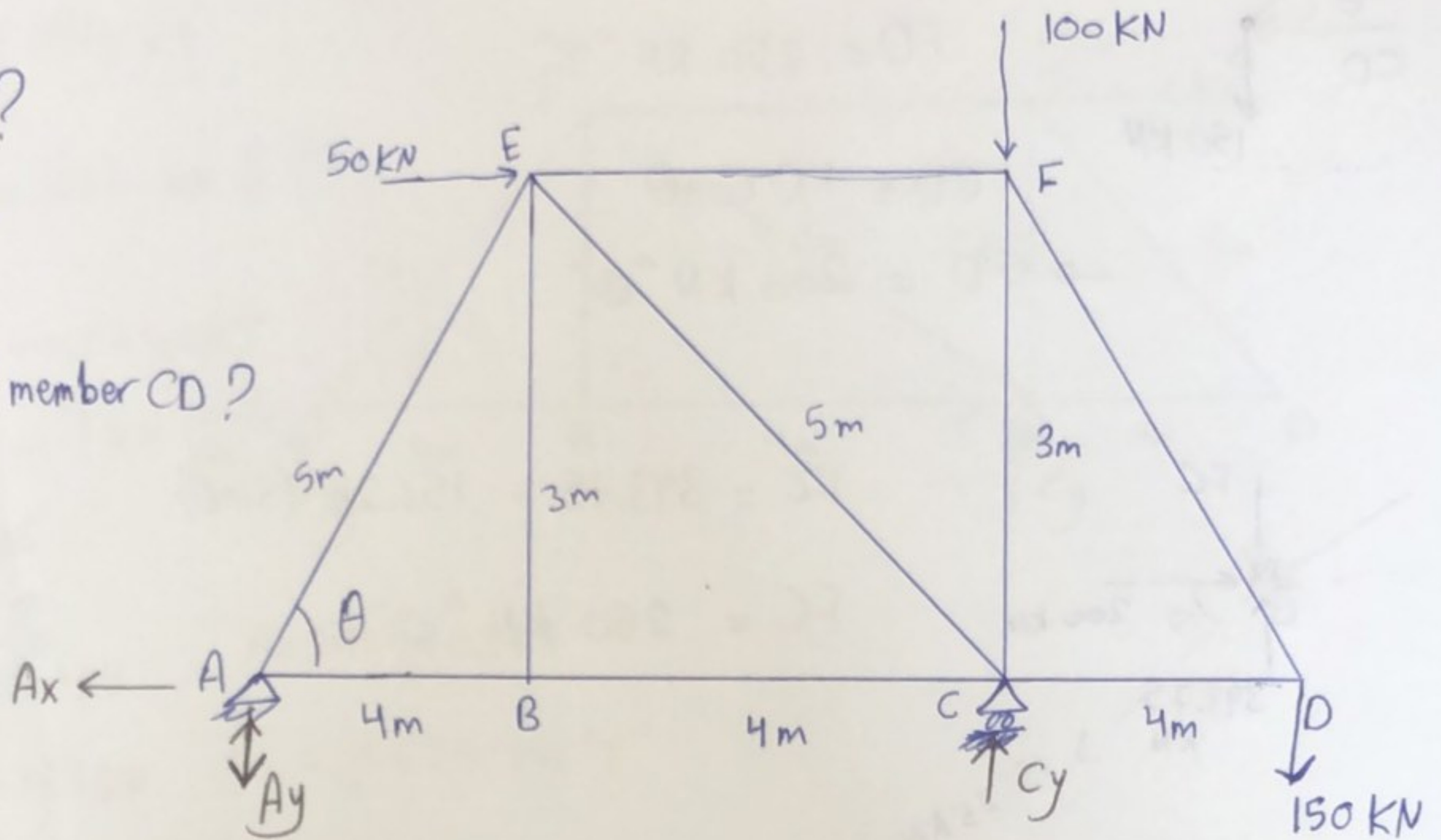
$$= 2025 \text{ mm}^2$$

Q 3:-)

①  $\Delta_D$  ?

②  $\Delta_F$  ?

③ Rotation of member CD ?



$$\sum M_C = 0: 8A_y = 150 + 600$$

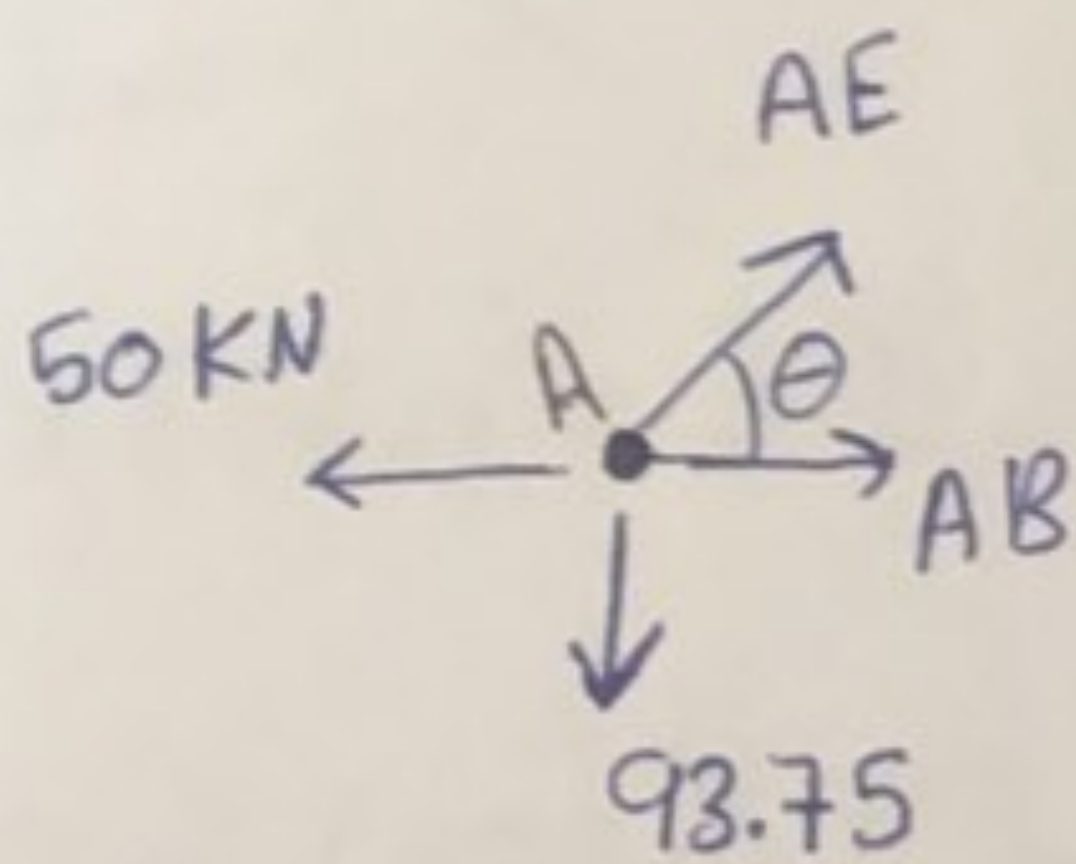
$$A_y = 93.75 \text{ kN} \downarrow$$

$$\cos \theta = 0.8$$

$$\sin \theta = 0.6$$

$$\sum F_y = 0: C_y = 343.75 \text{ kN} \uparrow$$

$$\sum F_x = 0: A_x = 50 \text{ kN} \leftarrow$$

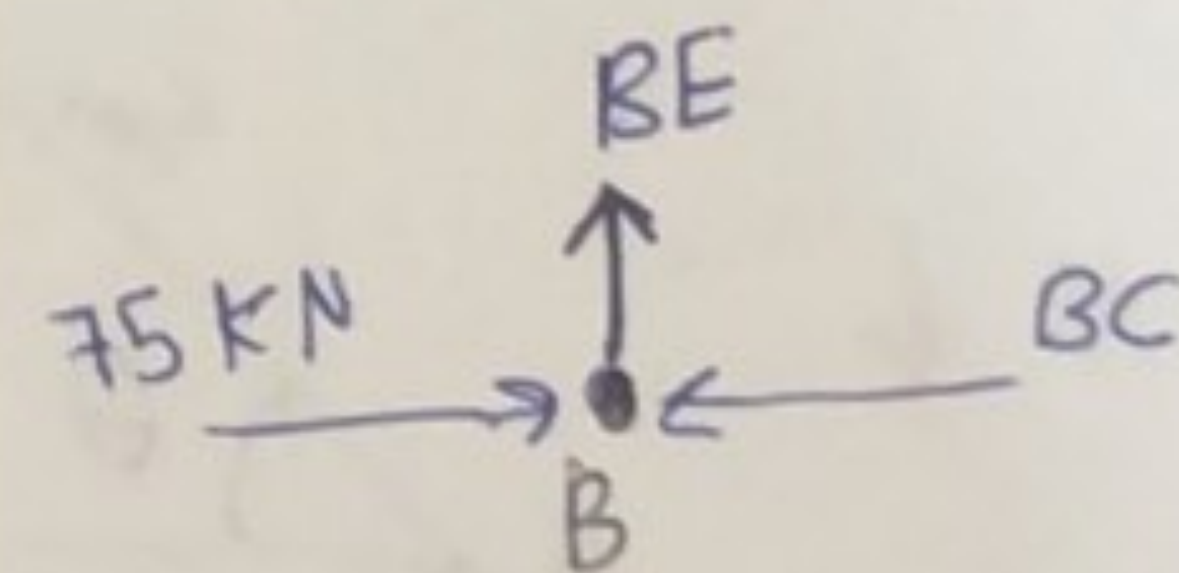


$$AE \sin \theta = 93.75$$

$$AE = 156.25 \text{ kN "T"}$$

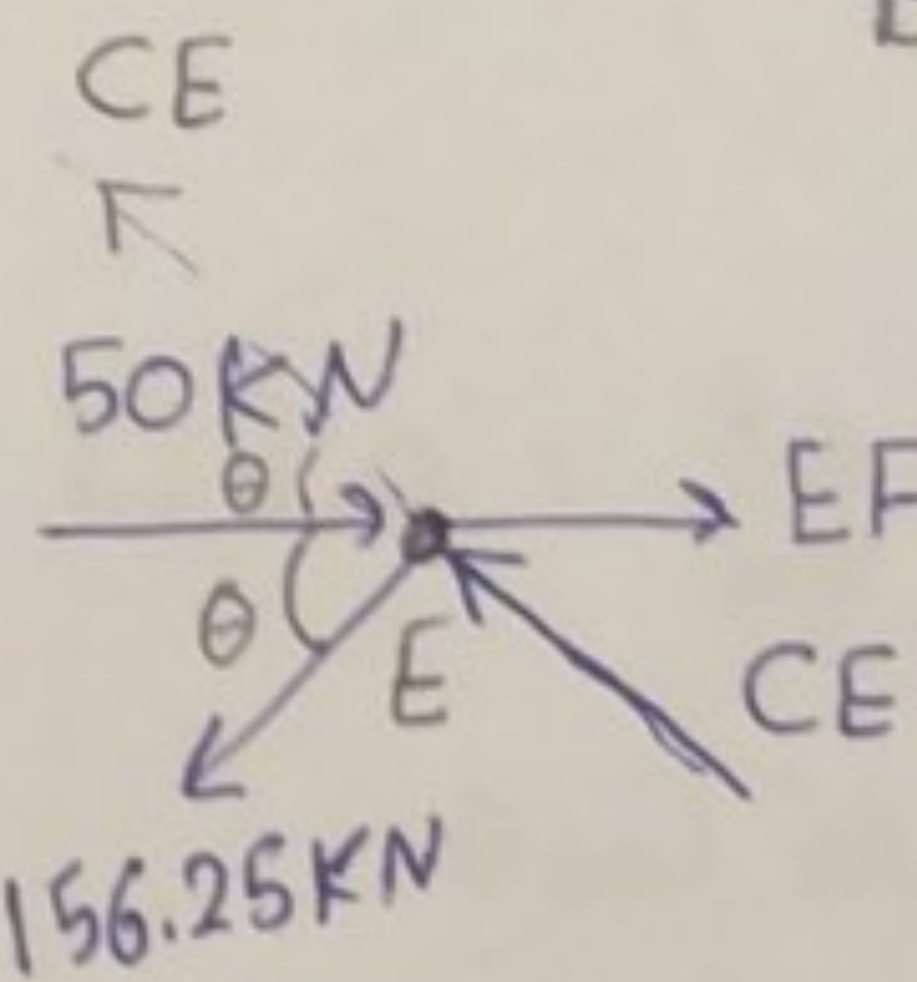
$$AB = 50 - 156.25 \cos \theta$$

$$AB = -75 \text{ kN} = 75 \text{ kN "C"}$$



$$BE = 0$$

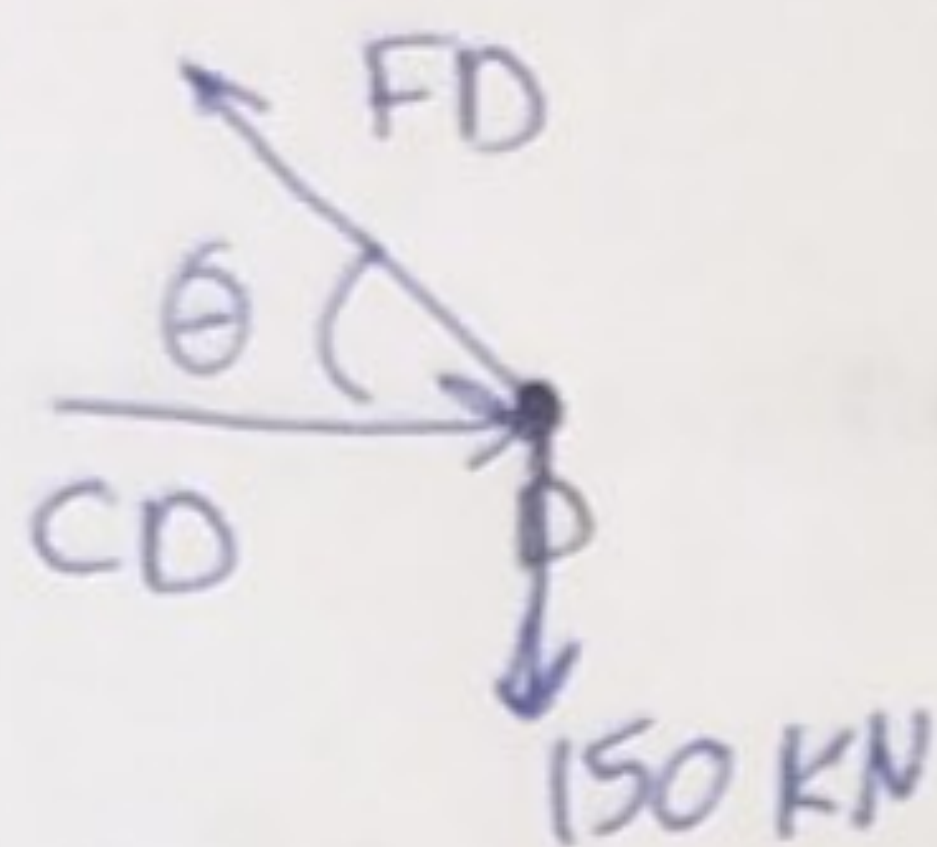
$$BC = 75 \text{ kN "C"}$$



$$\sum F_y = 0: CE = 156.25 \text{ kN "C"}$$

$$EF + 50 = (156.25 \cos \theta) * 2$$

$$EF = 200 \text{ kN "T"}$$

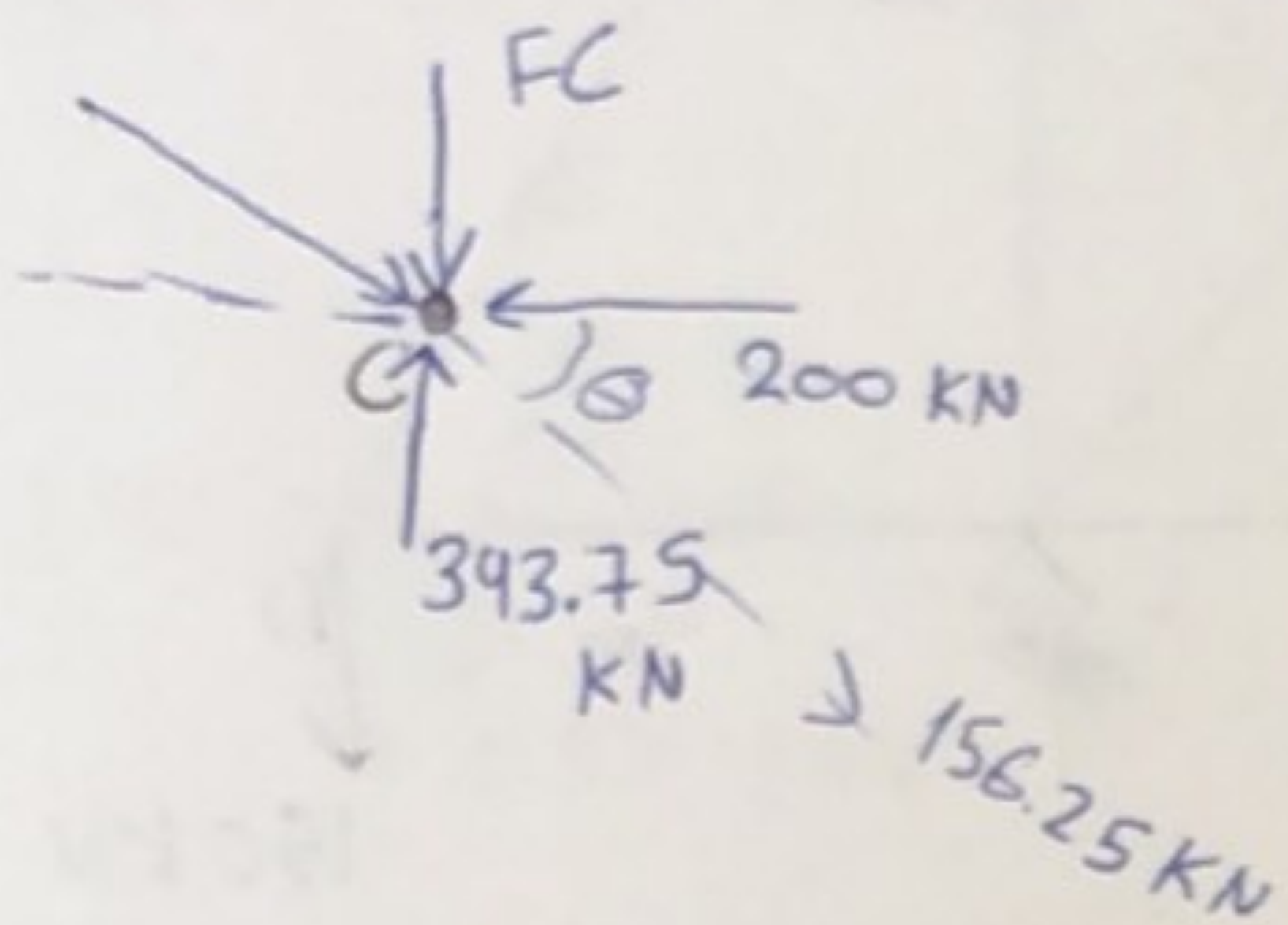


$$FD \sin \theta = 150$$

$$FD = 250 \text{ KN "T"}$$

$$CD = FD \cos \theta$$

$$\rightarrow CD = 200 \text{ KN "C"}$$



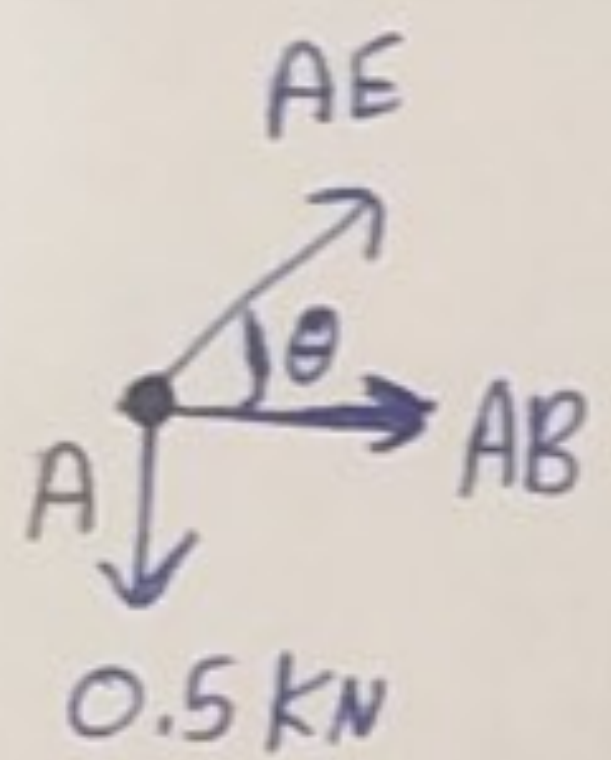
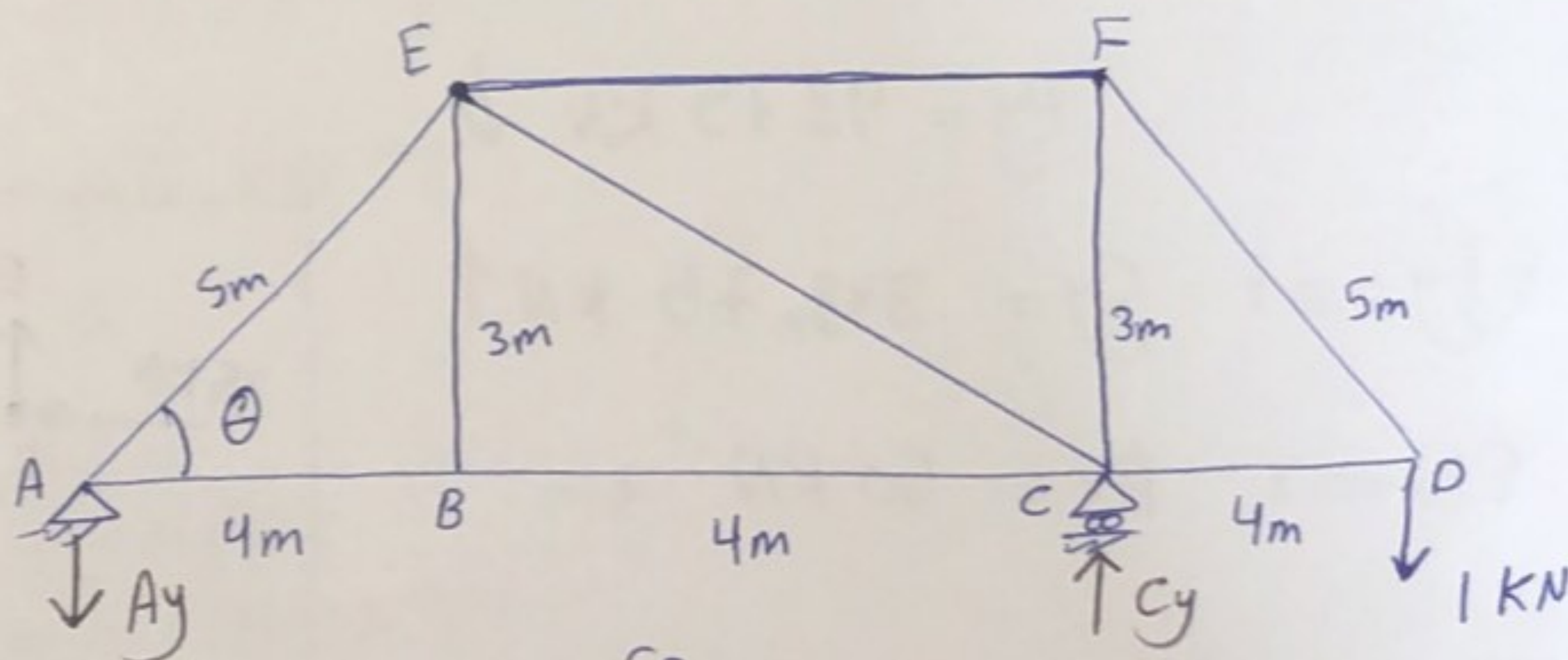
$$FC = 343.75 - 156.25 (\sin \theta)$$

$$FC = 250 \text{ KN "C"}$$

$$\sum M_c = 0: 8A_y = 4$$

$$A_y = 0.5 \text{ KN } \downarrow$$

$$\sum F_y = 0: C_y = 1.5 \text{ KN } \uparrow$$



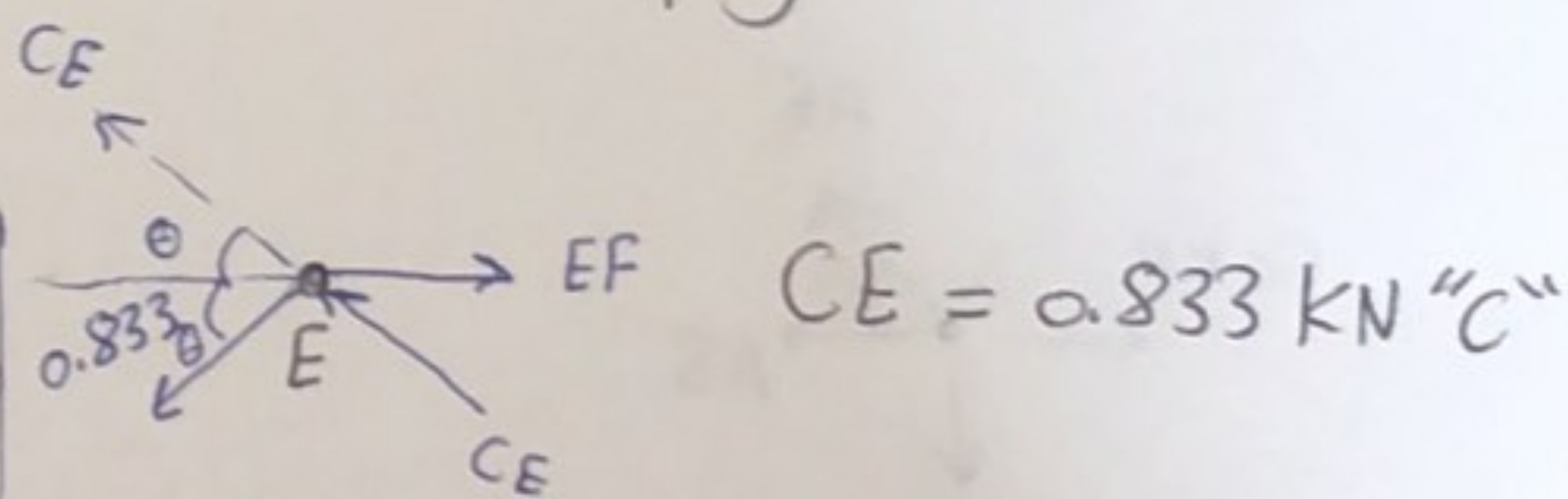
$$AE = \frac{0.5}{\sin \theta} = 0.833 \text{ KN "T"}$$

$$AB = -AE \cos \theta$$

$$\rightarrow AB = -0.667 = 0.667 \text{ KN "C"}$$

$$BC = 0.667 \text{ KN "C"}$$

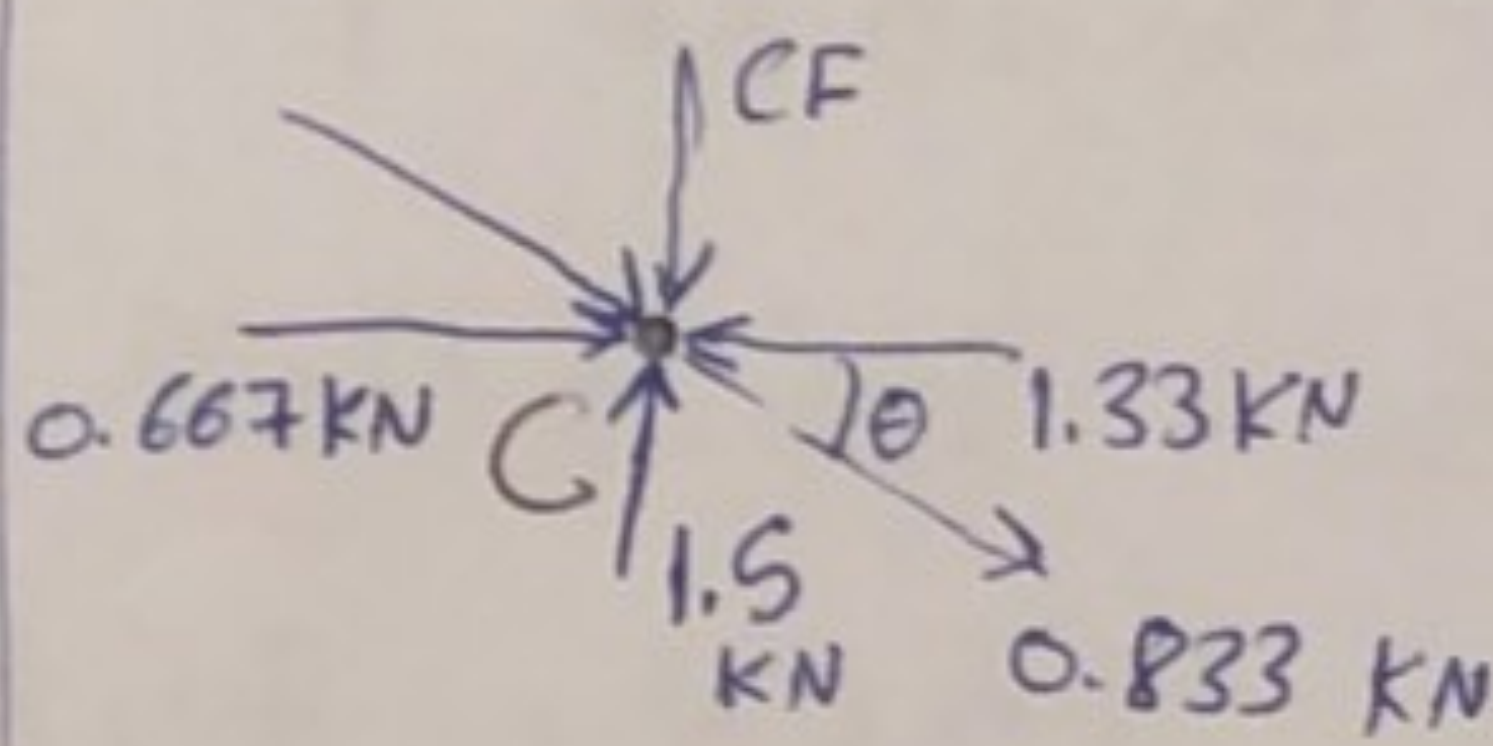
$$BE = 0$$



$$CE = 0.833 \text{ KN "C"}$$

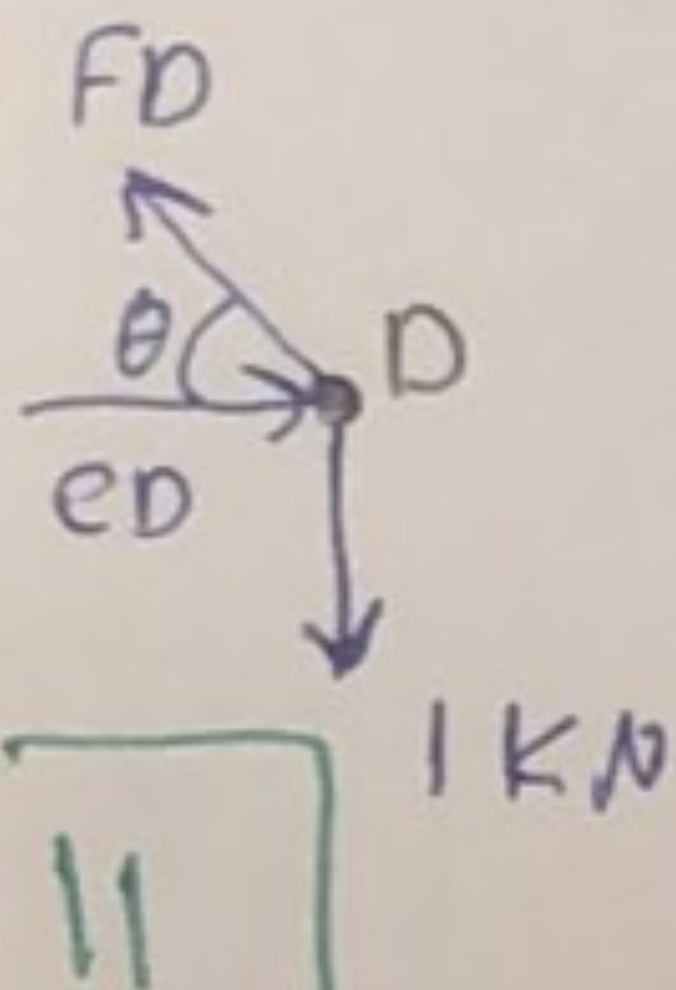
$$EF = 2(0.833)(0.8)$$

$$\rightarrow EF = 1.333 \text{ KN "T"}$$



$$CF = 1.5 - 0.833 (0.6)$$

$$\rightarrow CF = 1 \text{ KN "C"}$$



$$FD = \frac{1}{\sin \theta} = 1.667 \text{ KN "T"}$$

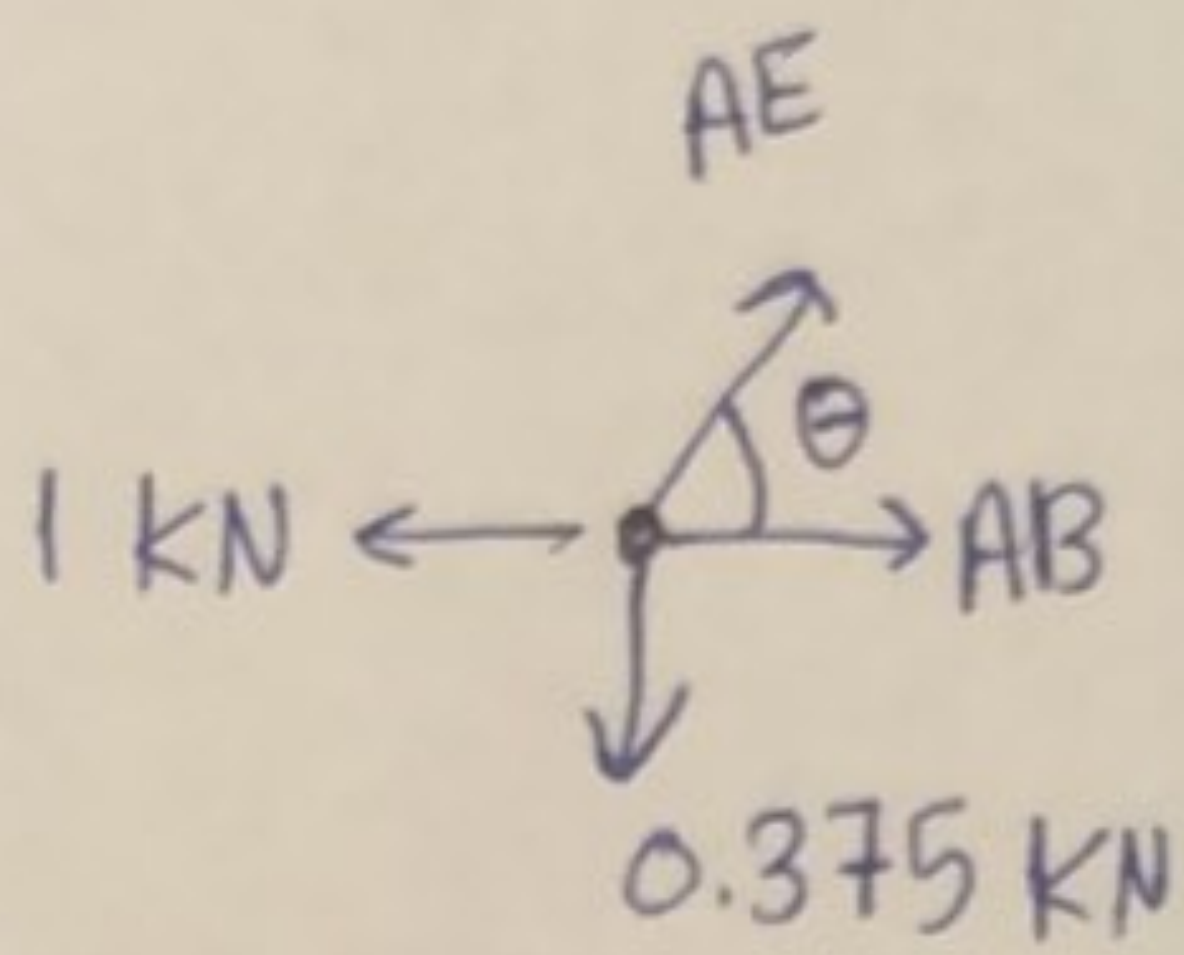
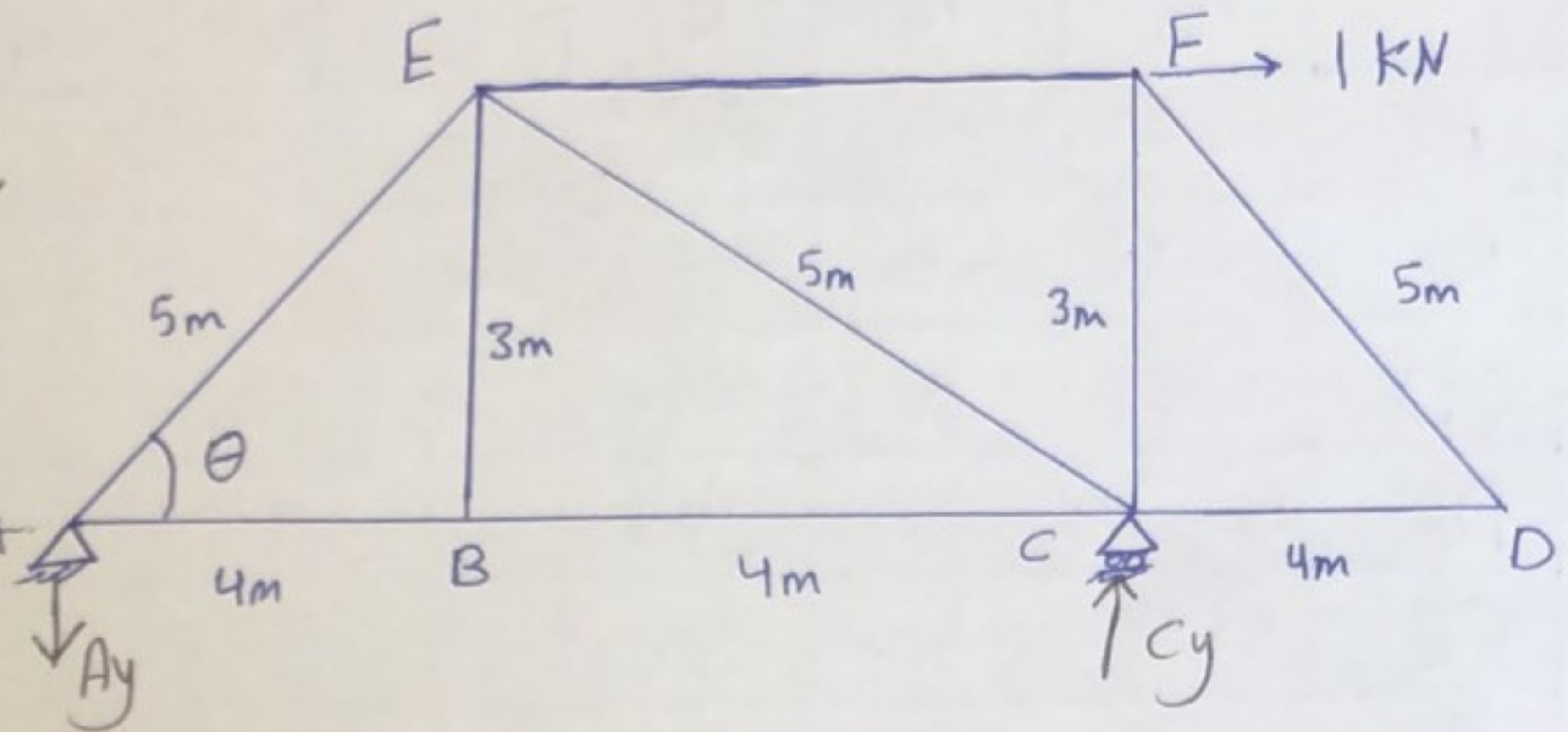
$$CD = FD \cos \theta = 1.333 \text{ KN "C"}$$

$$\sum M_C = 0: 8A_y = 3$$

$$A_y = 0.375 \text{ KN} \downarrow$$

$$\sum F_y = 0: c_y = 0.375 \text{ KN} \uparrow$$

$$\sum F_x = 0: A_x = 1 \text{ KN} \leftarrow$$



$$AE(\sin\theta) = 0.375$$

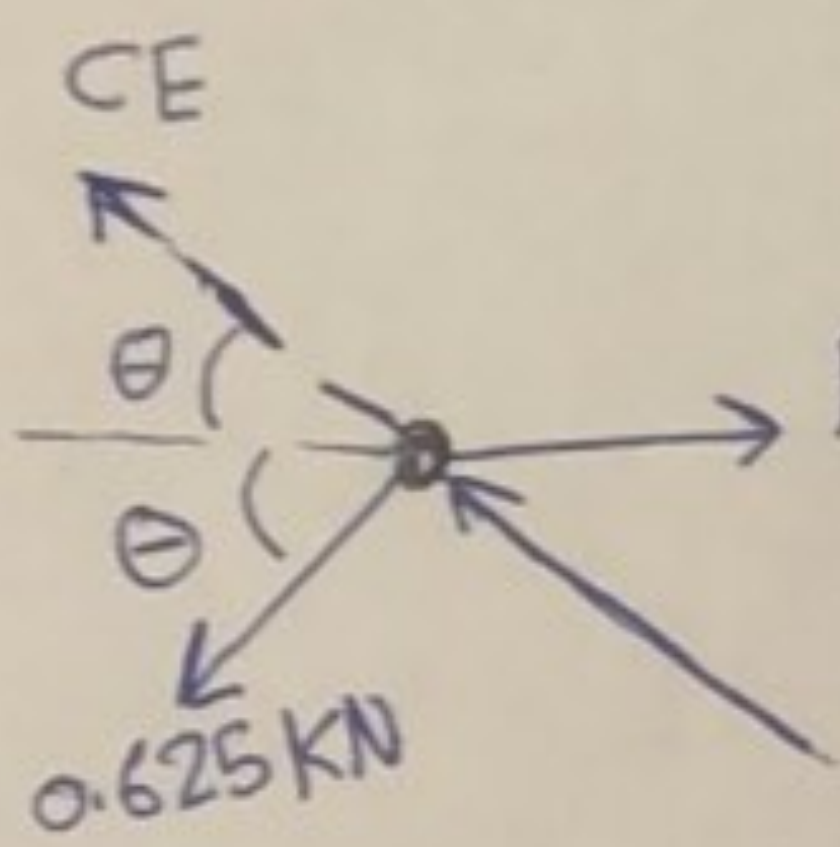
$$AE = 0.625 \text{ KN "T"}$$

$$AB = -AE \cos\theta + 1$$

$$AB = 0.5 \text{ KN "T"}$$

$$BC = 0.5 \text{ KN "T"}$$

$$BE = 0$$



$$CE = -0.625$$

$$\rightarrow CE = 0.625 \text{ KN "C"}$$

$$FE = 1 \text{ KN "T"}$$

$$FD = 0$$

$$CD = 0$$

$$FC = 0$$

	$n_D$	$n_F$	$N$	$L$	$n_D N L$	$n_F N L$
AB	-0.667	0.5	<del>0.25</del> -75	4	200.1	-150
BC	-0.667	0.5	-75	4	200.1	-150
CD	-1.333	0	-200	4	1066.4	0
DF	1.667	0	250	5	2083.75	0
FE	1.333	1	200	4	1066.4	800
AE	0.833	0.625	156.25	5	650.78125	488.28125
BE	0	0	0	3	0	0
CF	-1	0	-250	3	750	0
EC	-0.833	-0.625	-156.25	5	650.78125	488.28125
/	/	/	/	/	/	/

$$\sum n_D N L = 6668.3125$$

$$\sum n_F N L = 1476.5625$$

$$1 * \Delta_D = \frac{\sum n_D N L}{AE} \rightarrow \Delta_D = \frac{6668.3125}{AE}$$

$$1 * \Delta_F = \frac{\sum n_F N L}{AE} \rightarrow \Delta_F = \frac{1476.5625}{AE}$$

$$\theta_{CD} = \frac{\Delta_D}{L_{CD}} = \frac{6668.3125}{4AE}$$

$$\rightarrow \theta_{CD} = \frac{1667.08}{AE}$$