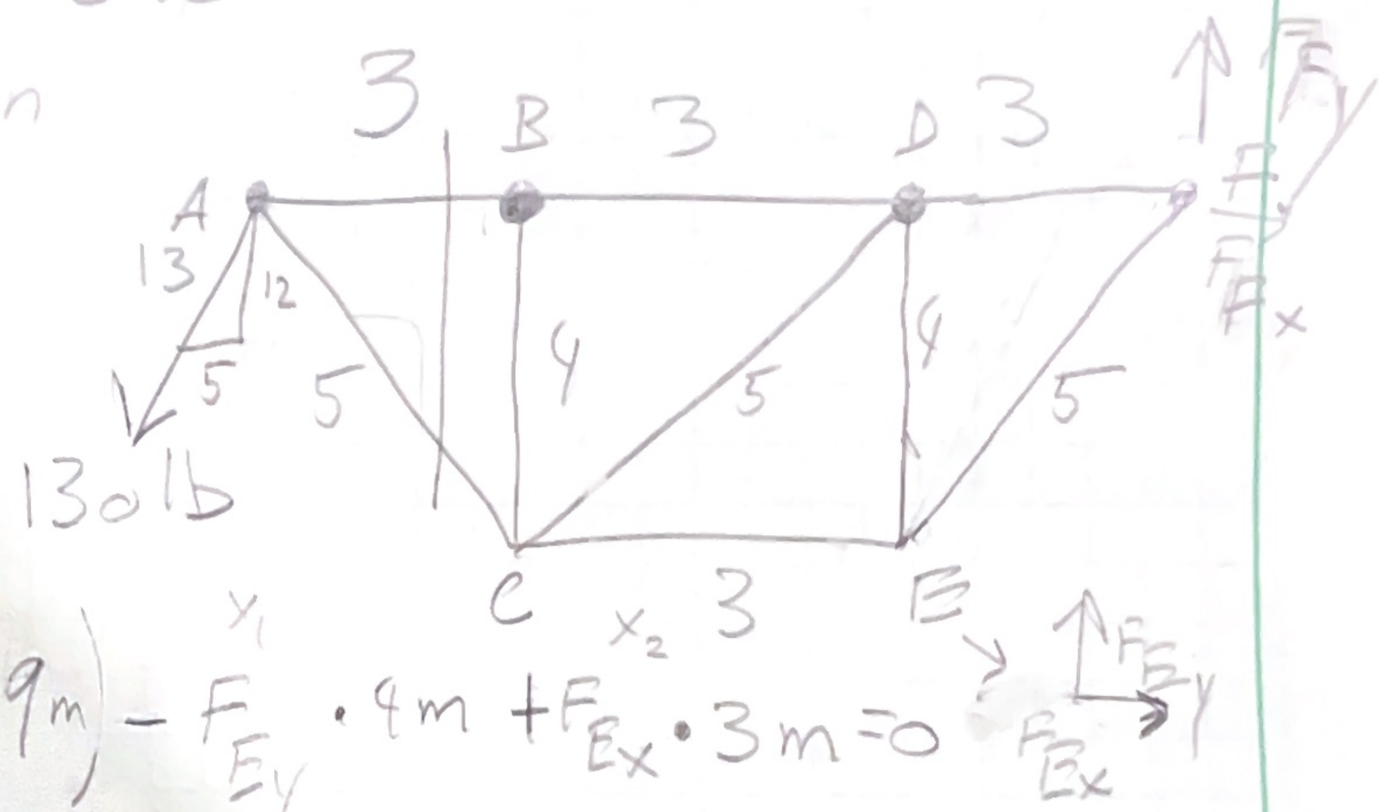
HW 9

Danel Warshafsky | 6.3 | 11/29/24

1/4

given: diagram, P = 130 lb

find: All forces within trosses.



① $\Sigma M_F = \left(P \cdot \frac{12}{13}\right)(9m) - F_{Ey} \cdot 4m + F_{Ex} \cdot 3m = 0$

② $\Sigma F_x = \left(-P \cdot \frac{5}{13}\right) + \cancel{F_{Ex}} + F_{Fx} = 0$

③ $\Sigma F_y = \left(-P \cdot \frac{12}{13}\right) + F_{Ey} + F_{Fy} = 0$

4 variables
3 eq

→ relate F_{Ex} to F_{Ey}

$\Sigma M_A : (F_{Fy} \cdot 9m) + F_{Ey} \cdot 6 + \cancel{F_{Ex}} \cdot 4 = 0$

→ system of equations

	F_{Ey}	$\cancel{F_{Ex}}$	F_{Fy}	F_{Fx}	C
①	-4	3	0	0	-1000
②	0	1	0	1	50
③	1	0	1	0	120
④	6	4	9	0	0

$E_y = 154.28$, $\cancel{E_x} = -154.28$

$F_y = -34.28$, $F_x = 204.28$

→ forget about roller. I use diagram to verify

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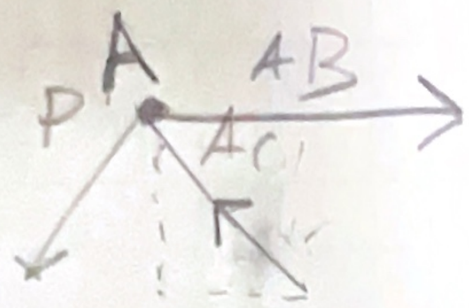
a Fbd and moments.
Sections.



$$\Sigma F_{A_x} = AB - \frac{3}{5}AC - \frac{5}{13}P = 0$$

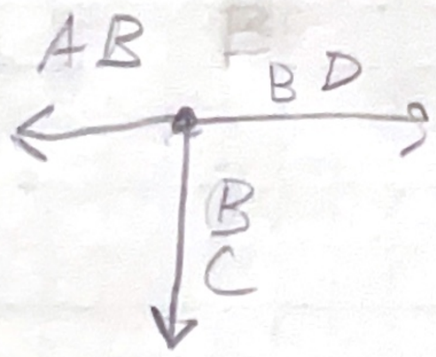
$$\Sigma F_{Ay} : \frac{4}{5}AC - \frac{12}{13}P = 0$$

$$AC = \frac{5}{4} \cdot \frac{12}{13} \cdot 130\,lb$$

$$\boxed{AC = 150 \rightarrow \text{compression}}$$

$$AB = \left(130 \cdot \frac{5}{13}\right) + \left(\frac{3}{5} \cdot 150\right)$$

$$\boxed{AB = 140\,lb \text{ Tension}}$$



$$\Sigma F_{By} = BC = 0$$

$$\boxed{BC = 0}$$

$$\Sigma F_x = -AB + BD = 0$$

$$AB = BD$$

$$\boxed{BD = 140\,lb}$$

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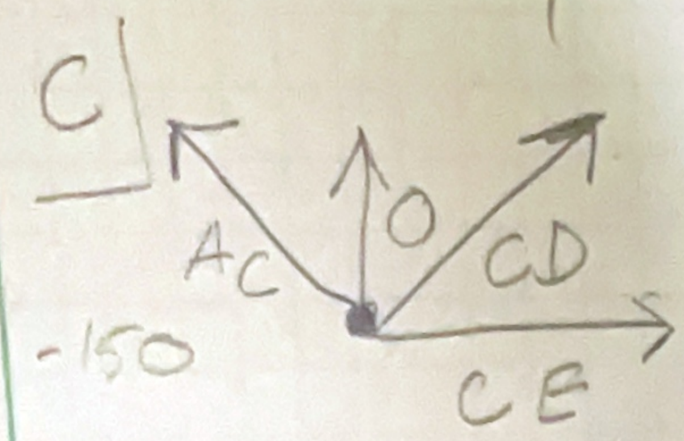


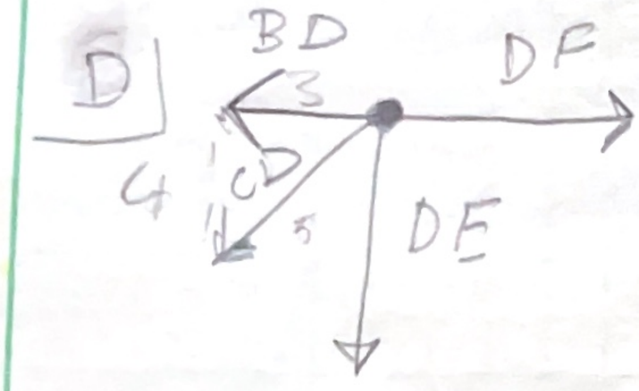
$\Sigma F_y = \left(-AC \cdot \frac{4}{5}\right) + \frac{4}{5} CD = 0$ → y dir positive for both

$\boxed{CD = 150 lb}$ ✓ T

$\Sigma F_x = -AC \cdot \frac{3}{5} + CD \cdot \frac{3}{5} + CE = 0$

$150 \cdot \frac{3}{5} + 150 \cdot \frac{3}{5} = -CE$

$\boxed{CE = -180 \text{ lb}}$ ✓



$\Sigma F_x = DF - BD - CD \cdot \frac{3}{5} = 0$

$DF = \frac{3}{5}(140) + 150$

$\boxed{DF = 234 lb}$ ✓

$\Sigma F_y = -\frac{4}{5} CD - DE = 0$

$DE = -\frac{4}{5}(150)$

$\boxed{DE = -120 lb}$ ✓

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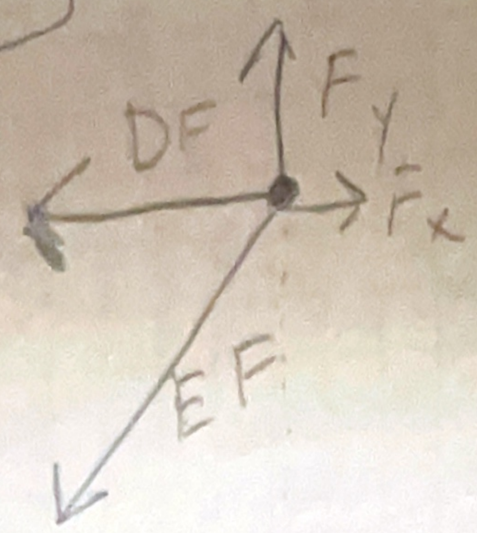
F)



$DF = 230$

$F_y = -34.28$

$F_x = 204.28$

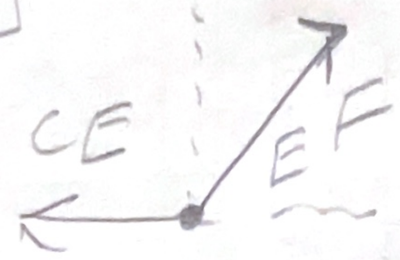
$\Sigma F_y = F_y - EF \cdot \frac{4}{5} = 0$

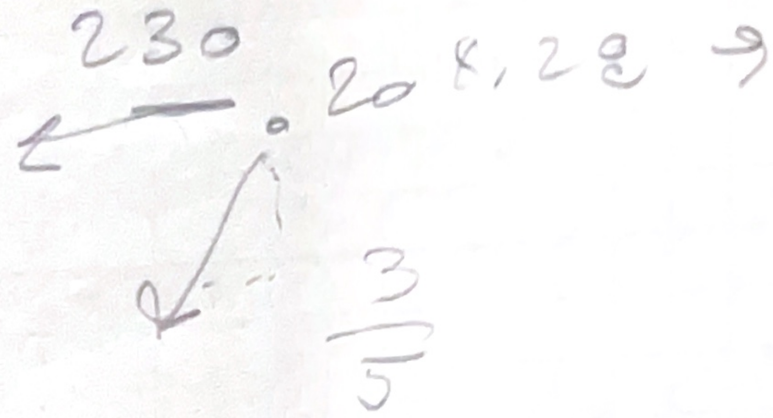
$EF = -34.28 \cdot \frac{5}{4}$

-42.85

WTF? → hinges don't exert forces here?

E)





$\Sigma F_{y_E} = \frac{3}{5} EF - CE = 0$

$EF = \frac{5}{3}(-180\,lb)$

$EF = -300\,lb$ ✓ → ~~this is against laws of physics btw~~

hum reller.

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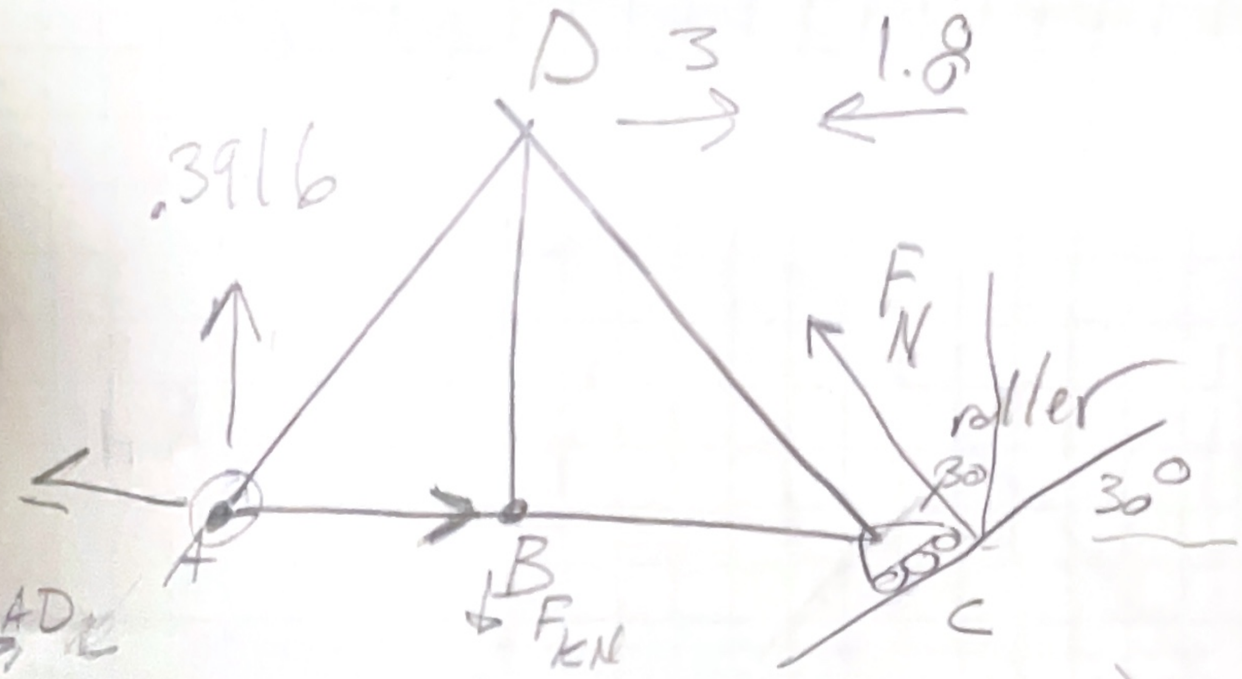
given: $\theta = 30°$

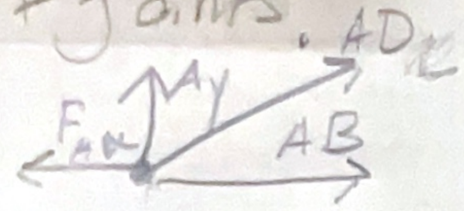
find: $F_{AB} = F_{BC}$

F_{AD}, F_{CD}



method of joints.

A:



$\Sigma M_A = (-4 \cdot 2) - (3 \cdot 1.5) = F_{Ny} \cdot 4m$

$F_{Ny} = \frac{12.5}{4} = 3.125$

$\Sigma F_x: F_{Ax} - F_{Ny} \tan(30) + B = 0$, $\Sigma F_y: F_{Ay} + F_{Ny} = 4$

$F_{Ax} = 1.2$ kN, $F_{Ay} = 4 - 3.125$

$F_{Ay} = 0.875$

$\Sigma F_{Ay}: AD \cdot \frac{1.5}{2.5} + .875 = 0$

$\boxed{AD = -1.458 \text{ kN}}$ ✓

$\Sigma F_{Ax}: \left(AD \cdot \frac{2}{2.5}\right) + AB = 1.2$ kN

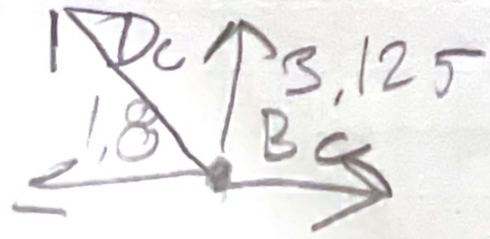
$AB = 1.2 + 1.167$

$\boxed{AB = 2.367 \text{ kN}}$ ✓ $= BC$

$\Sigma F_{By} = -4 \text{ kN} + \overline{BD} = 0$

$\boxed{BD = 4 \text{ kN}}$ ✓

C:



$Dc_y = -3.125$

$Dc = \frac{Dc_y}{\left(\frac{1.5}{2.5}\right)}$

$\boxed{Dc = -5.21 \text{ kN}}$ ✓

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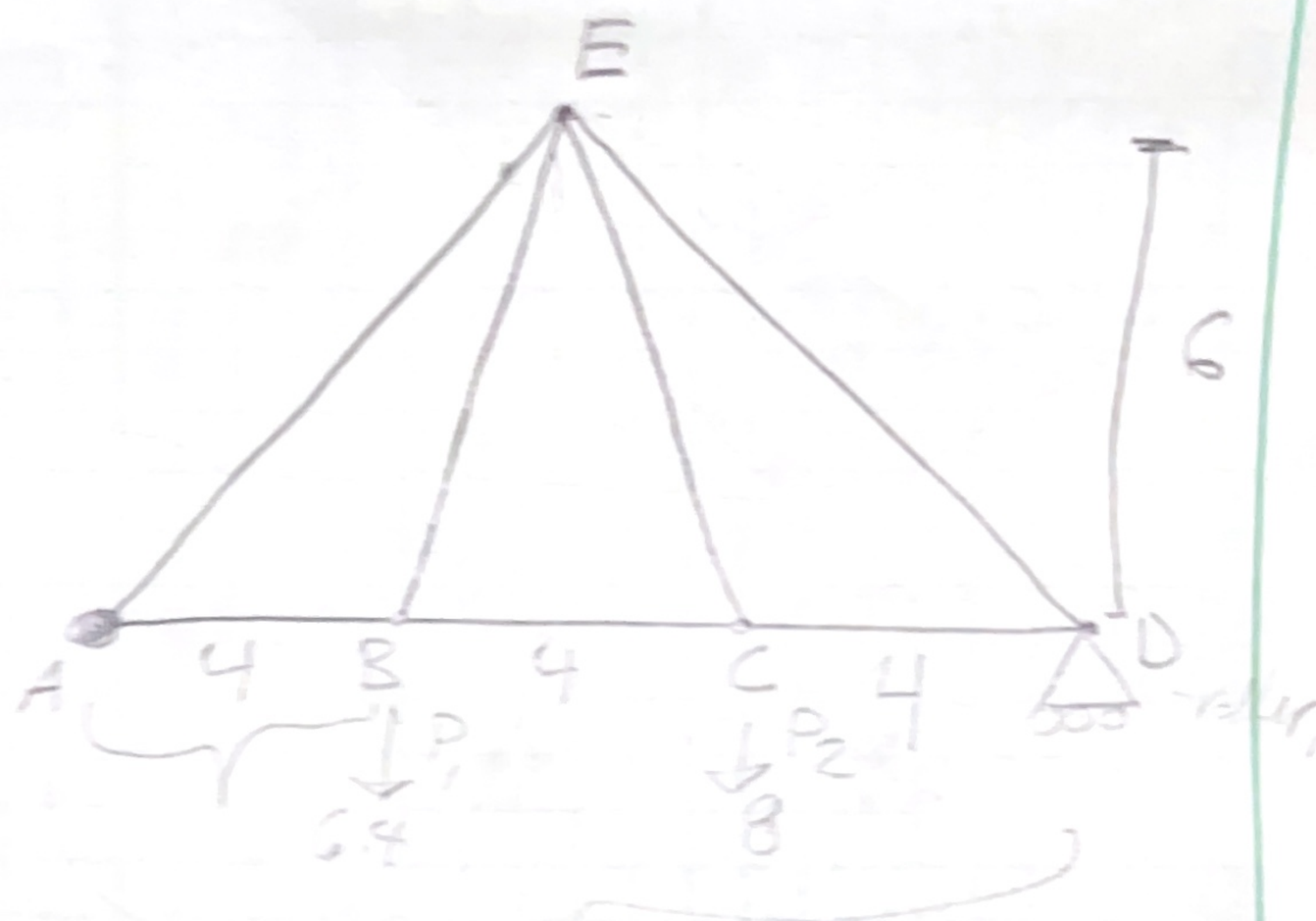
given: $P_1 = 6.4$ kN
$P_2 = 8$ kN

find: force in each member.



ΣM_A:

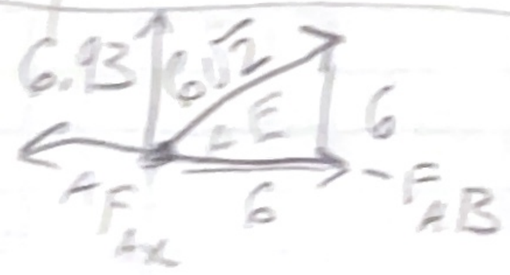
$= 12 \cdot F_D = (4 \cdot 6.4) + (8 \cdot 8)$

$F_D = \frac{25.6 + 64}{12}$; $F_D = 7.467$ kN

ΣF_y: $7.467 - F_{Ay} - 6.4 - 8 = 0$

$F_{Ay} = -6.93$ kN

ΣF_A



ΣF_{Ay}: $6.93 - \frac{1}{\sqrt{2}} AE = 0$

$AE = -6.93\sqrt{2}$

$AE = -9.8052$ kN

ΣF_{Ax}:

$-6.93\sqrt{2} \cdot \frac{1}{\sqrt{2}} + AB = 0$

$AB = 6.93$ kN

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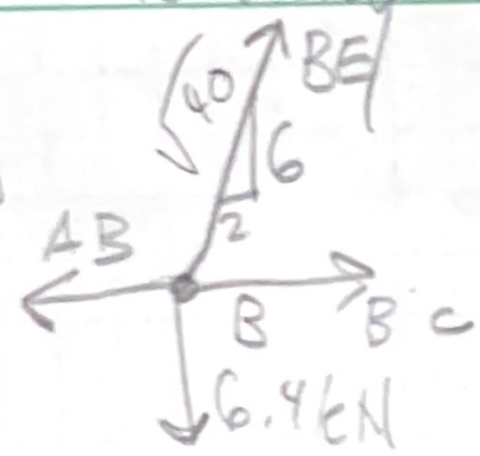
B



$\Sigma F_y : \frac{6}{\sqrt{40}} BE - 6.4 = 0$

$BE = \frac{6.4\sqrt{40}}{6}$

$BE = 6.786 kN$

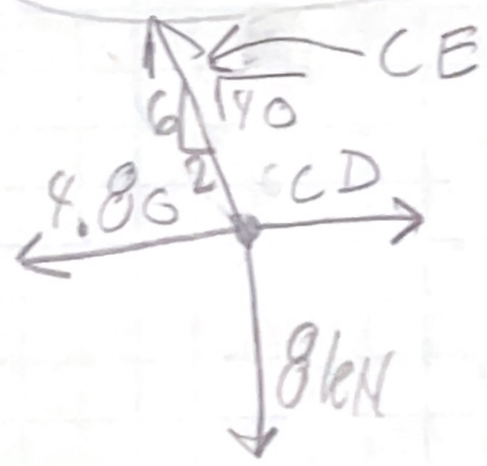
$\Sigma F_x : \frac{2}{\sqrt{40}} BE + BC - AB = 0$

$BC = AB - \frac{2}{\sqrt{40}} BE$

$BC = 6.93 - \frac{2}{\sqrt{40}} \cdot 6.786$

$BC = 4.7967 kN$

C



$\Sigma F_y : \frac{6}{\sqrt{40}} CE - 8kN = 0$

$CE = \frac{8\sqrt{40}}{6}$

$CE = 8.433 kN$

$\Sigma F_x : CD - 4.8 - \frac{2}{\sqrt{40}} CE = 0$

$CD = 4.8 + \frac{2}{\sqrt{40}} \cdot 8.43$

$CD = 7.467 kN$

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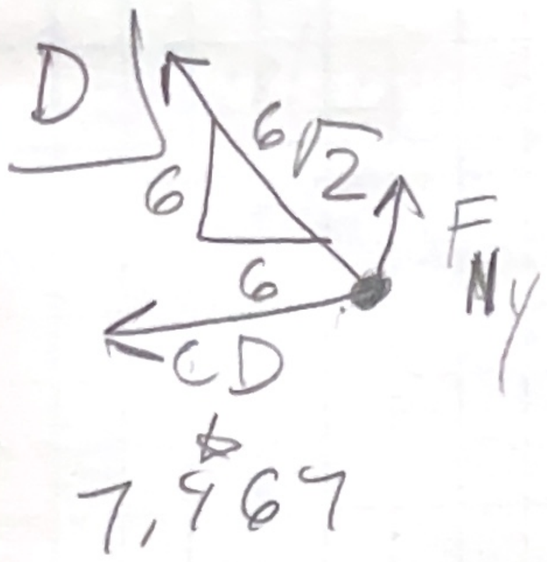

$$\Sigma F_x: \quad 7{,}469 = \frac{-6}{6\sqrt{2}} F_{ED}$$

$$7{,}469 \cdot \sqrt{2} = -F_{ED}$$

$$F_{ED} = -10{,}56 \text{ kN}$$

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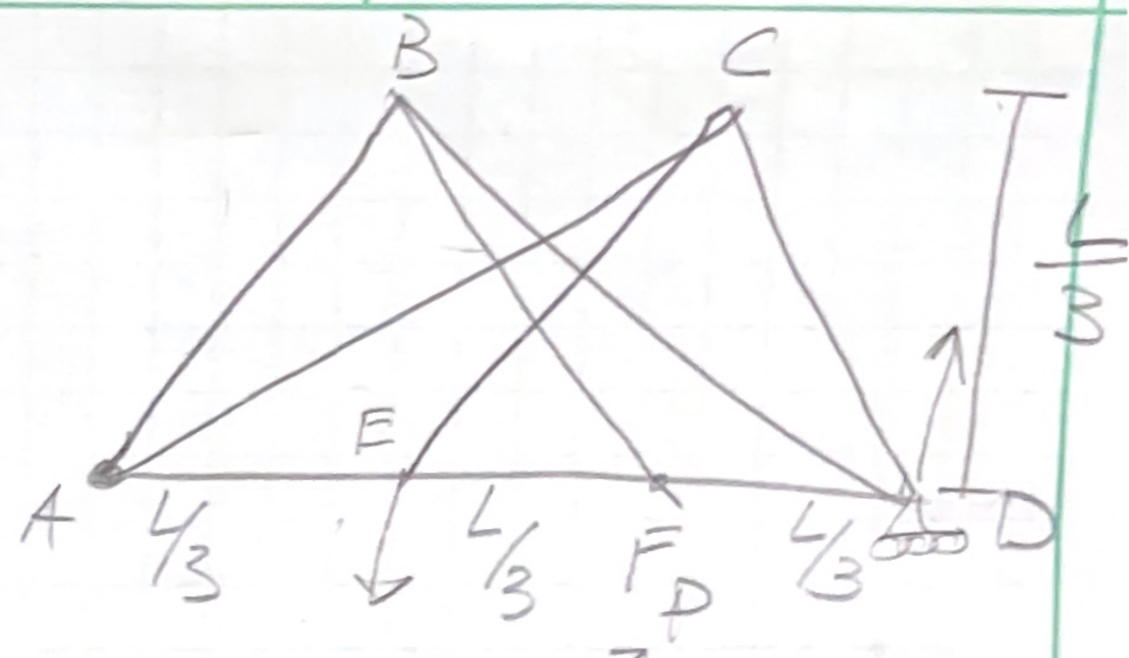
given diagram
find forces in
terms of P

Method of joints.



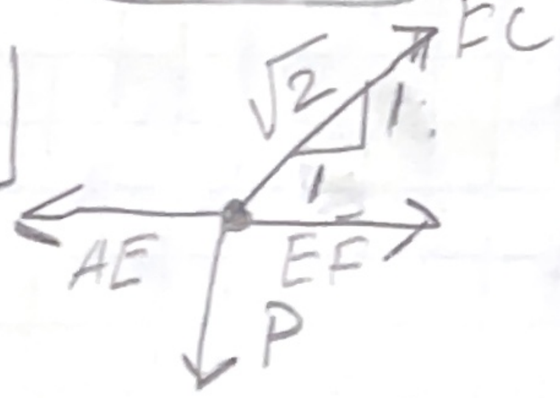
$\boxed{\Sigma M_A}$

$-P\frac{L}{3} - P\frac{2L}{3} + F_D \cdot L = 0$, $\Sigma F_y: A_y + D_y - P - P = 0$

$P \cdot \cancel{L} = F_D \cdot \cancel{L}$ $\boxed{A_y = P}$

$\boxed{F_D = P}$ $\boxed{\frac{2L^2}{9}}$

$\boxed{E}$

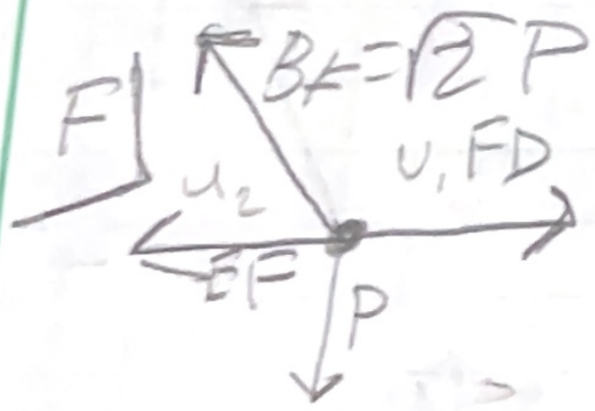


$\Sigma F_y: \frac{1}{\sqrt{2}} E_C - P = 0$

$\boxed{E_C = \sqrt{2}P}$ ✓ = $\boxed{BF}$

$\Sigma F_x: \frac{1}{\sqrt{2}} E_C + EF - AE = 0$

$\boxed{F}$



$\Sigma F_x: FD - EF - P = 0$

$P + EF - FD = 0$

$FD = EF + P$

→ from pg 3,
$AE = FD = \frac{5}{3}P$

$EF = \frac{5}{3}P - P$

$EF = \frac{2}{3}P = .67P$ ✓

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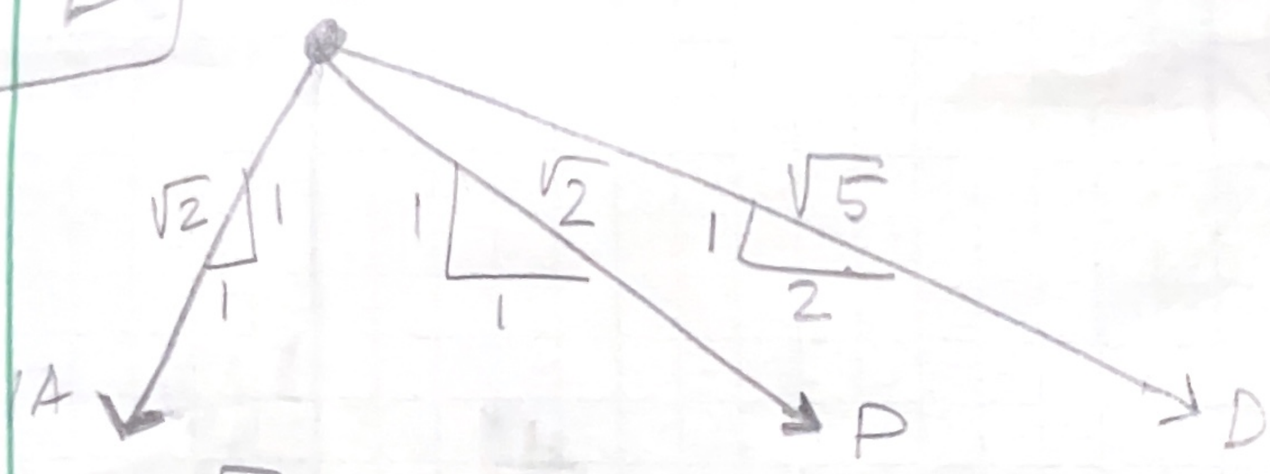
49/e

B



F_y $AB\frac{\sqrt{2}}{2} + P + BD\frac{1}{\sqrt{5}} = 0$, $AC = BD$

F_x $-AB\frac{\sqrt{2}}{2} + P + \frac{2}{\sqrt{5}}BD = 0$

$AB\frac{\sqrt{2}}{2} = P + \frac{2}{\sqrt{5}}BD$

sub

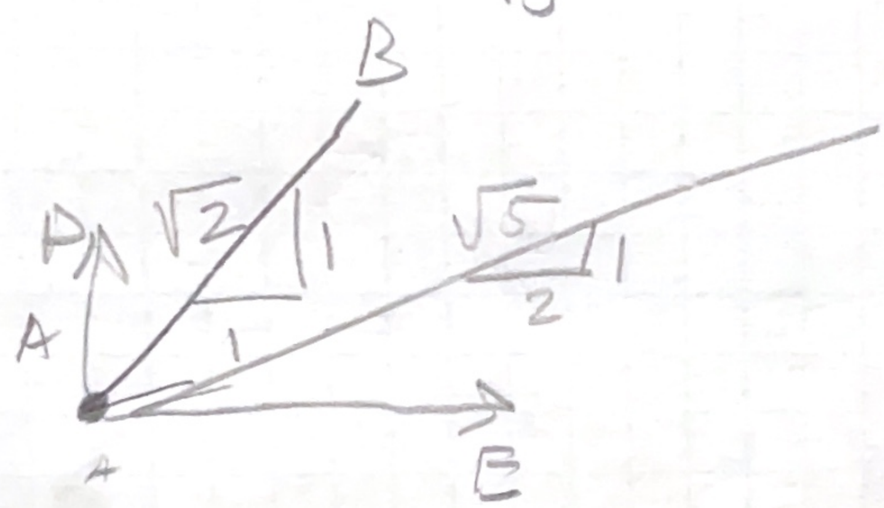
$2P + \frac{2}{\sqrt{5}}BD + BD\frac{1}{\sqrt{5}} = 0$

$\frac{3}{\sqrt{5}}BD = -2P$

$$\boxed{BD = -\frac{2\sqrt{5}}{3}P}$$

$\approx 1.49P$

A



F_y $P + AB\frac{\sqrt{2}}{2} + \frac{1}{\sqrt{5}}BD = 0$

$AB\frac{\sqrt{2}}{2} = -\frac{1}{\sqrt{5}} \cdot \frac{-2\sqrt{5}}{3}P - P$

$AB = \frac{2}{\sqrt{2}}\left(-1 + \frac{2}{3}\right)$

$$\boxed{AB = \frac{-2}{3\sqrt{2}} = -.4714P}$$

F_x $\frac{2}{\sqrt{5}}BD + \frac{\sqrt{2}}{2}AB + AE = 0$

$\frac{-4}{3}P - \frac{1}{3}P + AE = 0$, $\boxed{AE = \frac{5}{3}P = 1.67P}$

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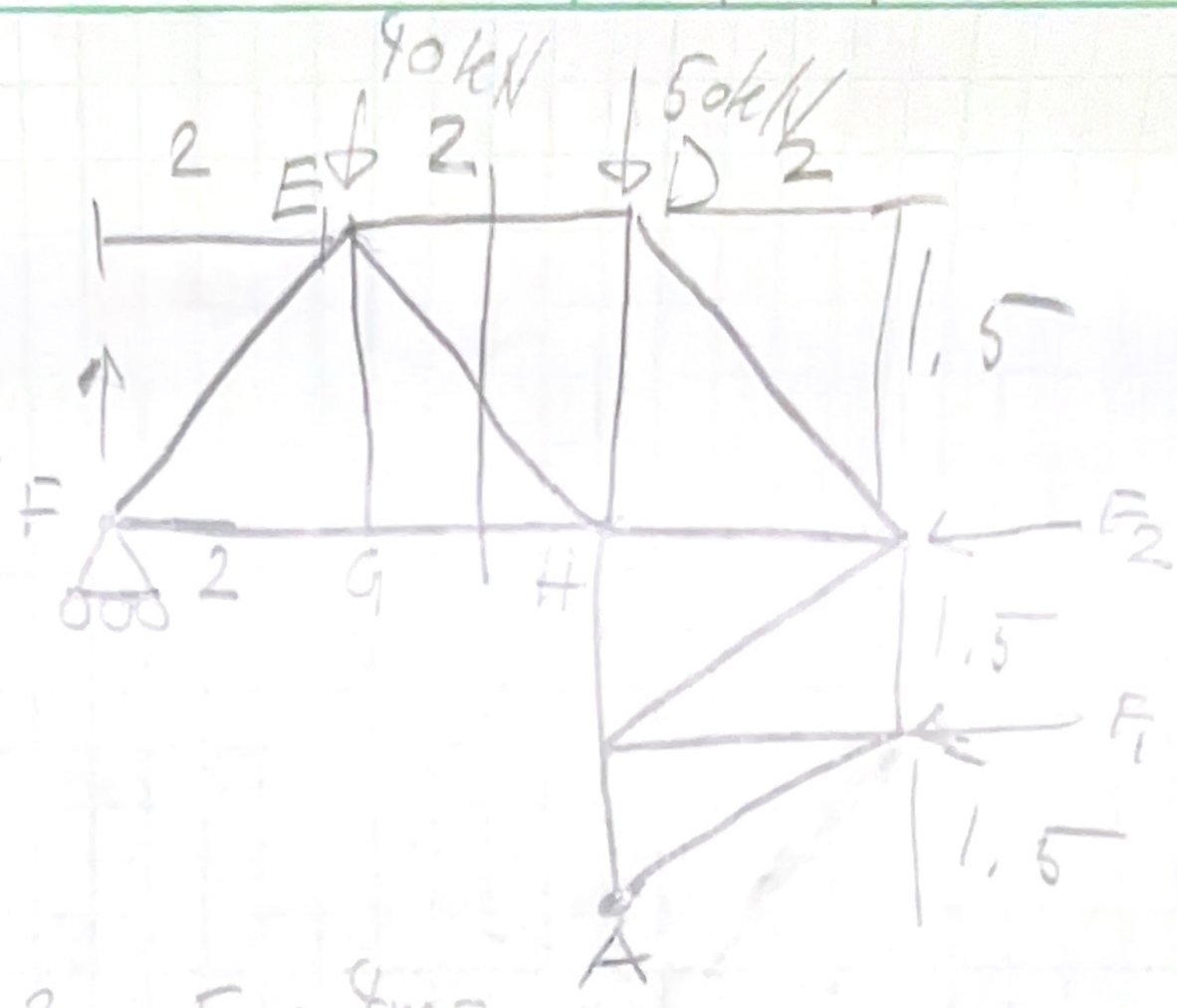
given:

$F_1 = 45\ kN$

$F_2 = 30\ kN$

find: ED, EH, GH

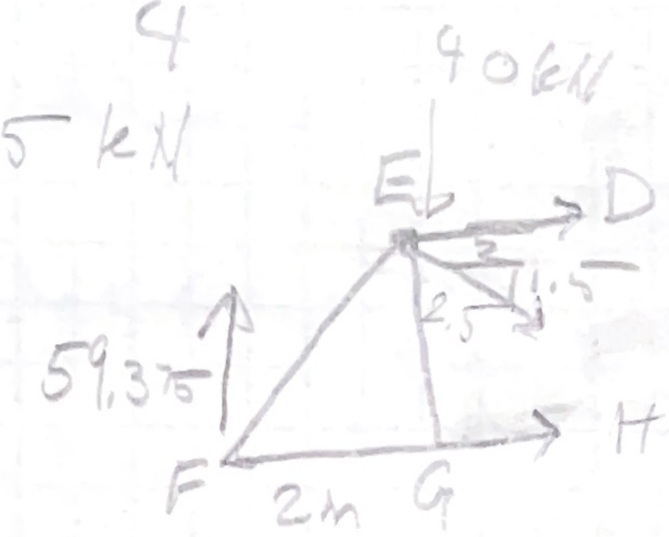


ΣM_A:

$1.5 \cdot F_1 + 3F_2 + 40kN \cdot 2m - F_F \cdot 4m = 0$

$F_F = \dfrac{(1.5)(45) + (3)(30) + (40)(2)}{4}$

$F_F = 59.375\ kN$



ΣM_E:

$-(2m \cdot 59.375kN) + 1.5m \cdot GH = 0$

$GH = \dfrac{118.75}{1.5}$, $\boxed{GH = 79.167\ kN}$

ΣF_y: $-\dfrac{1.5\ EH}{2.5} + 59.375\ kN - 40\ kN = 0$

$EH = \dfrac{2.5(19.375)}{1.5}$, $EH = \boxed{32.29\ kN}$

ΣF_x: $ED + GH + \dfrac{2}{2.5} EH = 0$

$ED = -25.83 - 79.167$

$\boxed{ED = -105\ kN}$

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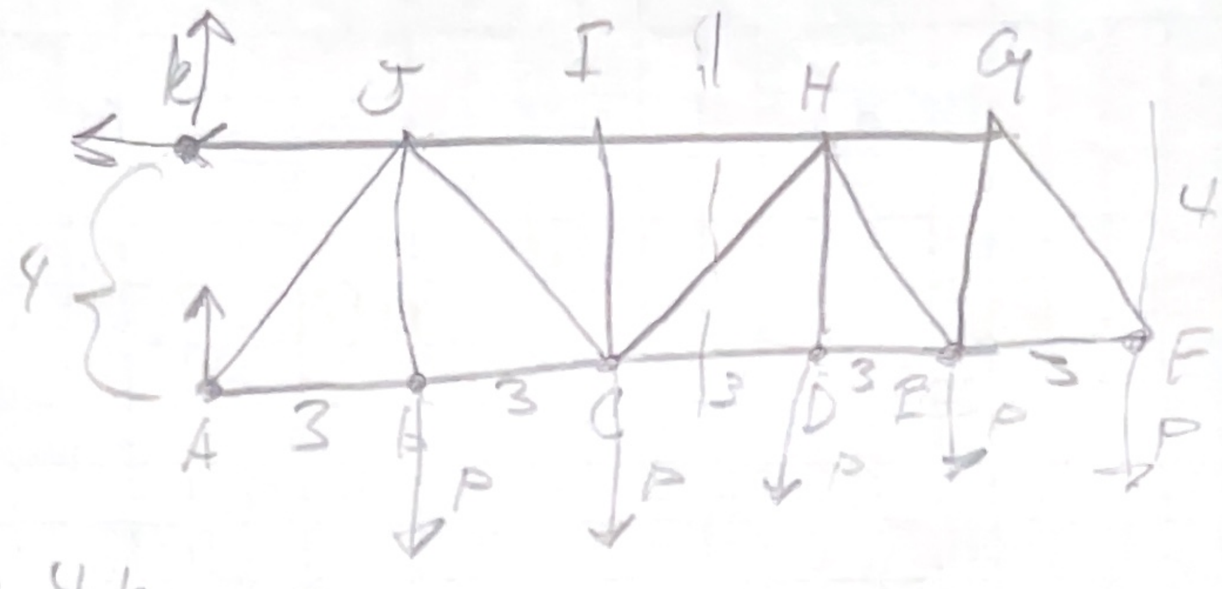
given:-
P = 1795 lb
find: CD, HI, CH



$$\Sigma M_A = -P\left(\sum_{n=1}^{k=5} 3n\right) + 4k_x = 0$$

$$= -1795(3+6+9+12+15) + 4k_x = 0$$

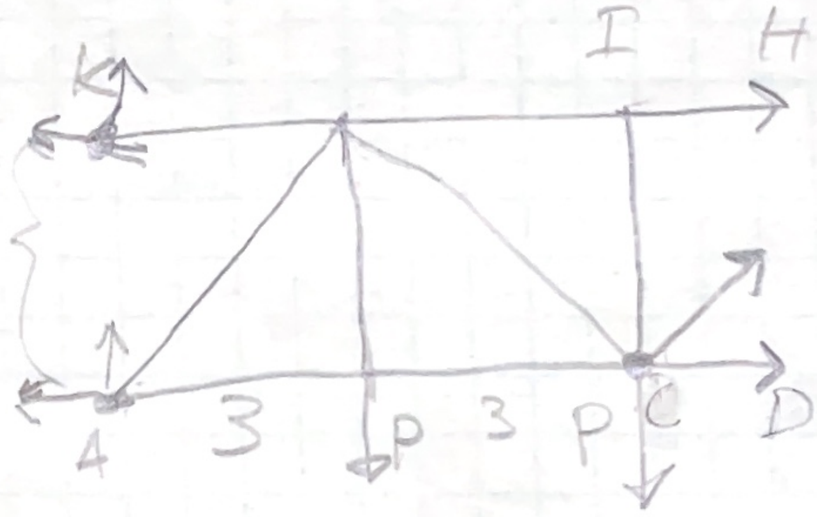
$$k_x = \frac{80775}{4} = 20193.75\ lb$$

ΣF_x: $k_x + A_x = 0$, $A_x = -20193.75\ lb$

ΣM_F: $(20193.75 \cdot 4) + 1795(3+6+9+12) + (-A_y - k_y)15 = 0$

ΣF_y: $5P = A_y + k_y$

$A_y + k_y = 8975$



ΣM_D:

$$-Ih \cdot 4ft + (4 \cdot 20193.75) + 3P - 6(8975) = 0$$

$$Ih = \frac{(4 \cdot 20193.75) + 3(1795) - 6(8975)}{4}$$

$$\boxed{Ih = 8077.5\ lb}$$

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$$\sum F_x: -(k_x + A_x) + HI + \frac{3}{5} CH + CD = 0$$

$$k_x + A_x = 0$$

$$\sum F_y: 5P - 2P + \frac{4}{5} CH = 0$$

$$CH = \frac{(3P)5}{4}$$

$$\boxed{CH = -6731.25 \text{ lb}}$$

$$8077.5 - \frac{(6731.25)3}{5} = -CD$$

$$\boxed{CD = -4038.75 \text{ lb}}$$

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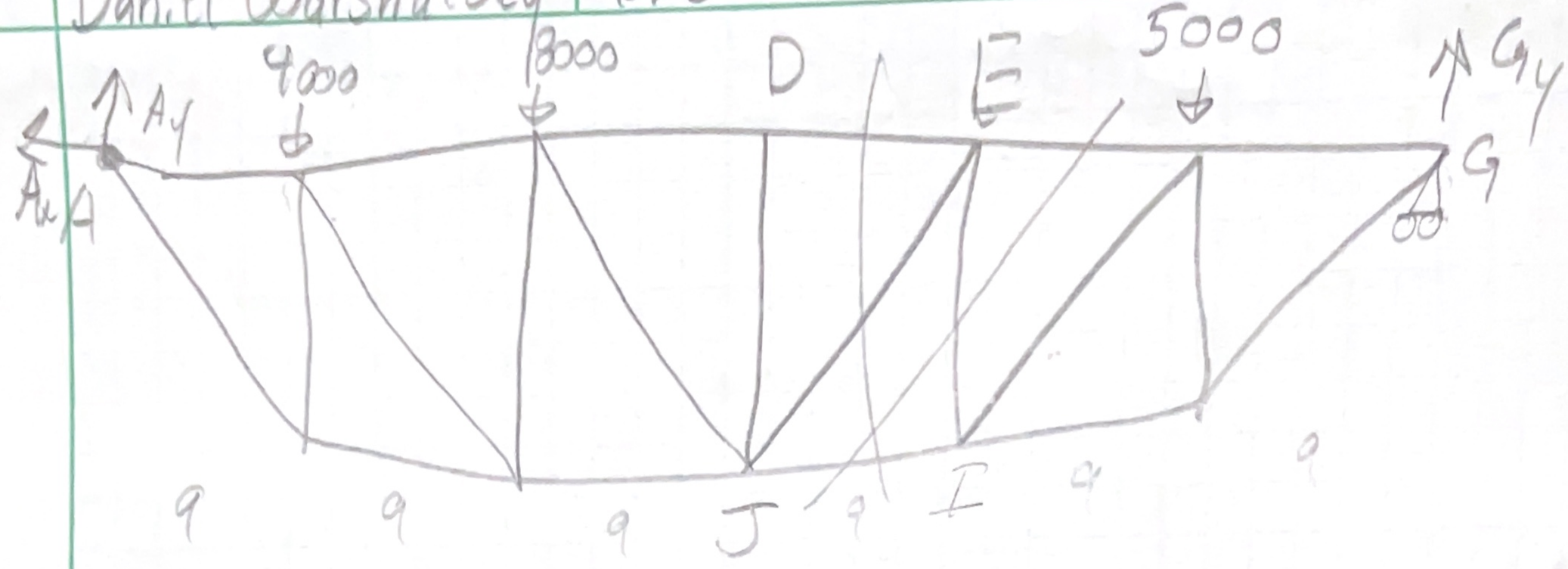


given: diagram,
find: EI, JI

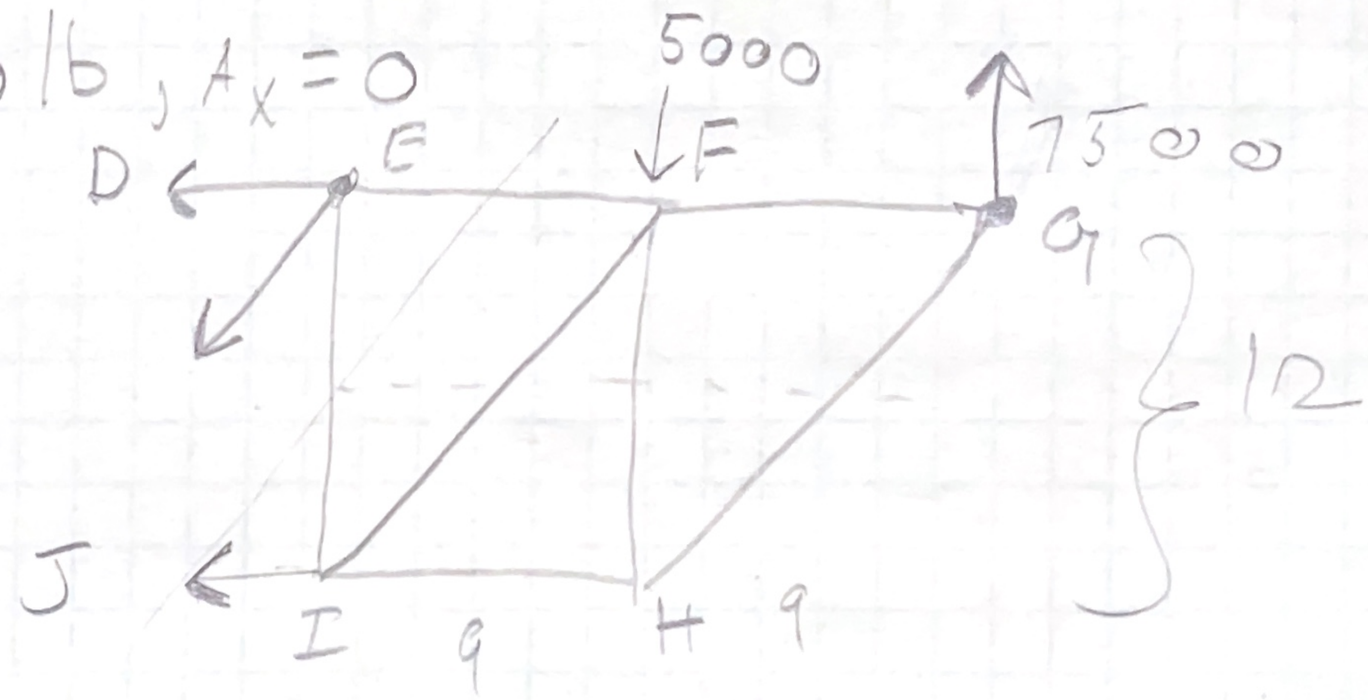
$$\Sigma M_A: (9 \cdot 4000) - (18 \cdot 8000) - 5000 \cdot 45 + G_y \cdot 54 = 0$$

$$G_y = \frac{405000}{54}$$

$$G_y = 7500$$

$$\Sigma F_y: G_y + A_y - 4000 - 8000 - 5000 = 0$$

$$A_y = 9500\,lb, \quad A_x = 0$$



$$\Sigma M_E: (5000 \cdot 9ft) + (-I_J \cdot 12) + (7500 \cdot 18) = 0$$

$$I_J = \frac{(7500 \cdot 18) - (5000 \cdot 9)}{12}$$

$$\boxed{I_J = 7500\,lb}$$ ✓

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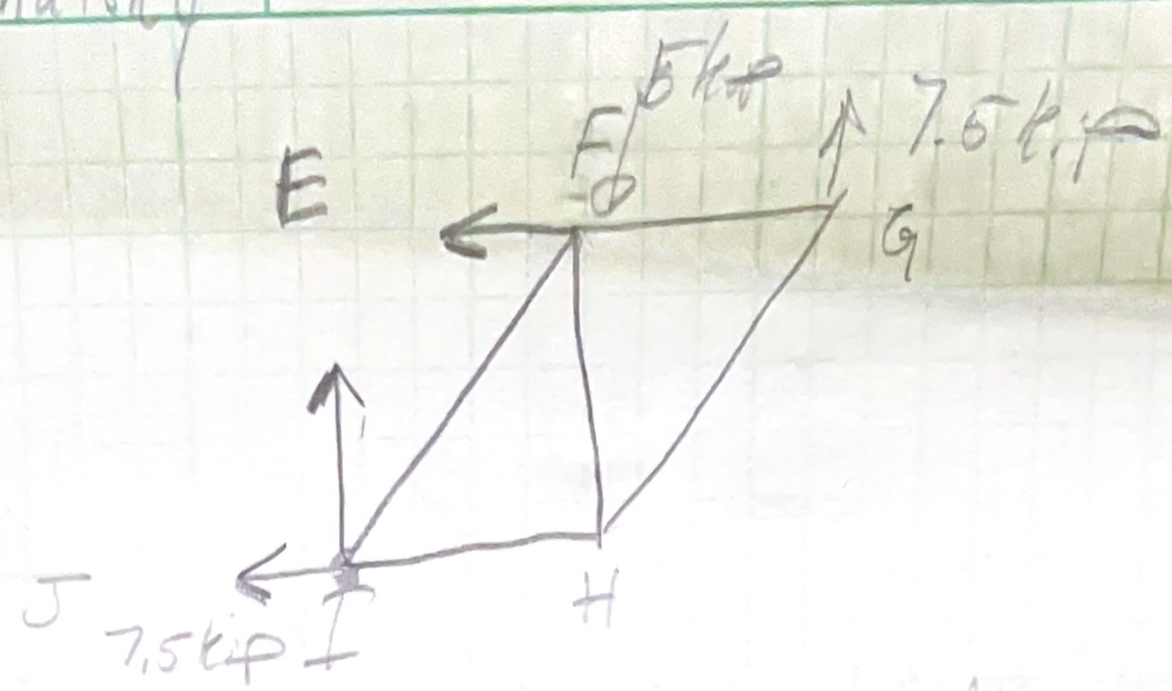
ΣF_x:



ΣF_x: $EF + I_J = 0$, $EF = -7500\,lb$

ΣF_y: $\cancel{-5kip + 7.5kip} + IE = 0$

$\boxed{IE = -2.5\,kip}$

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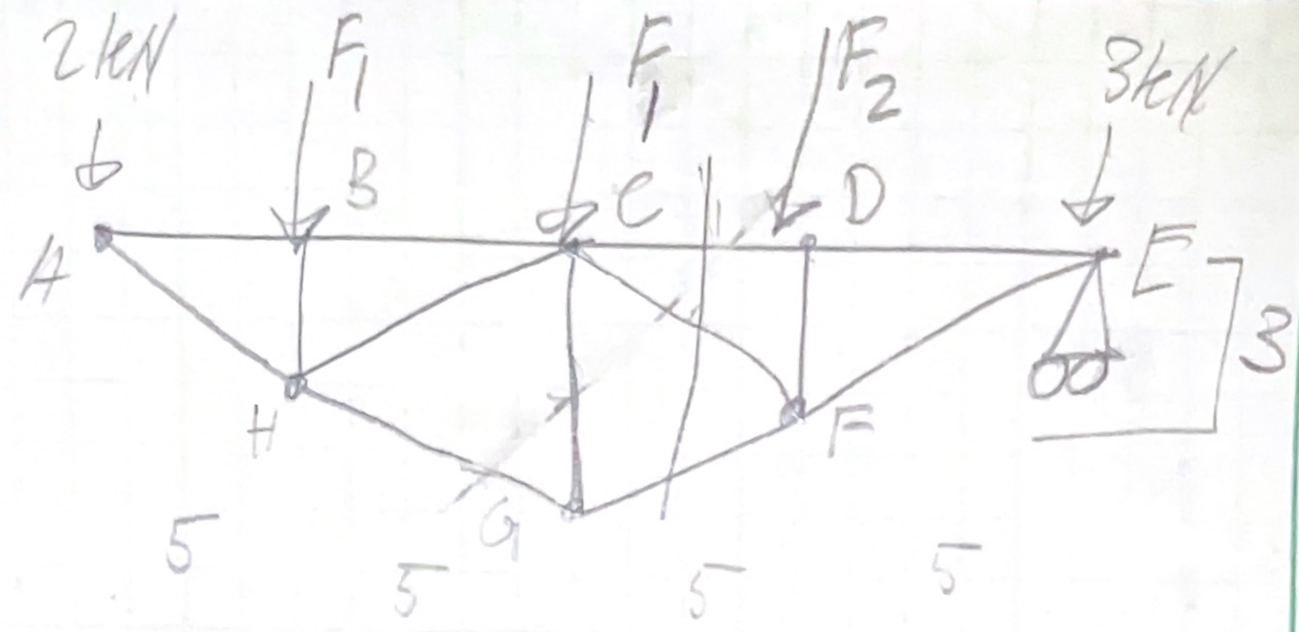
given:

$F_1 = 3.5\,kN$

$F_2 = 7\,kN$

find:

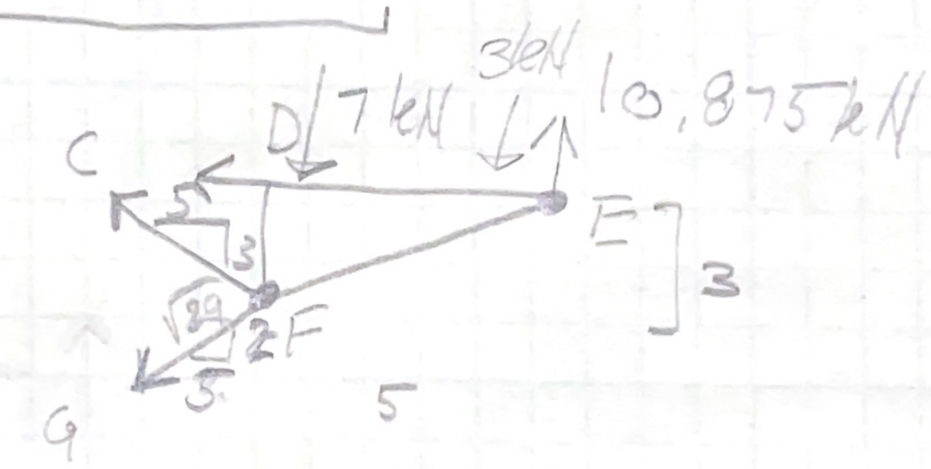
CD, CF, CG



$$\Sigma M_A: -F_1(5+10) - F_2(15) - 3kN \cdot 20 + F_E \cdot 20 = 0$$

$$F_E = \frac{15F_1 + 15F_2}{20} + 3$$

$$F_E = 10.875\,kN$$



$$\Sigma M_F: (5 \cdot 10.875) + CD \cdot 3 - 3 \cdot 5$$

$$CD = \frac{-5 \cdot 10.875 + 15}{3} \qquad \boxed{CD = -13.125\,kN}$$

$$\Sigma F_x: 13.125\,kN - \frac{5}{\sqrt{34}} CF - \frac{5}{\sqrt{29}} FG = 0$$

$$\Sigma F_y: (10.875 - 3 - 7) + \frac{3}{\sqrt{34}} CF - \frac{2}{\sqrt{29}} FG = 0$$

$$FG = \frac{\left(.875 + \frac{3}{\sqrt{34}} CF\right)\sqrt{29}}{2}$$

$$13.125 - \frac{5}{\sqrt{34}} CF - \frac{5}{2}\left(.875 + \frac{3}{\sqrt{34}} CF\right) = 0$$

$$CF = \frac{10.9375}{\frac{12.5}{\sqrt{34}}} = 5.102\,kN$$

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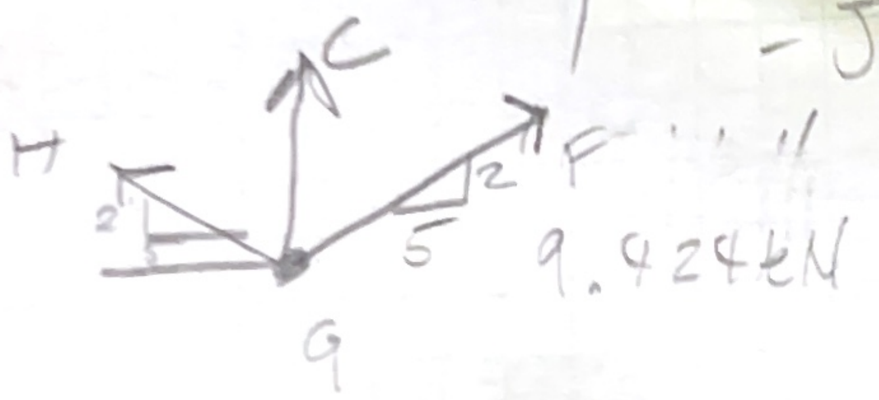
- Joint G



$CF = 5.1\ kN$

$$FG = \left(13.125 - \frac{5}{\sqrt{34}} CF\right)\frac{\sqrt{29}}{5}$$

$$FG = 9.424\ kN$$

$$\Sigma F_x : \frac{5}{\sqrt{29}} FG - \frac{5}{\sqrt{29}} HG = 0$$

$$\boxed{FG = HG}$$

$$\Sigma F_y : \frac{4}{\sqrt{29}} FG + CG = 0$$

$$\boxed{CG = -7\ kN}$$

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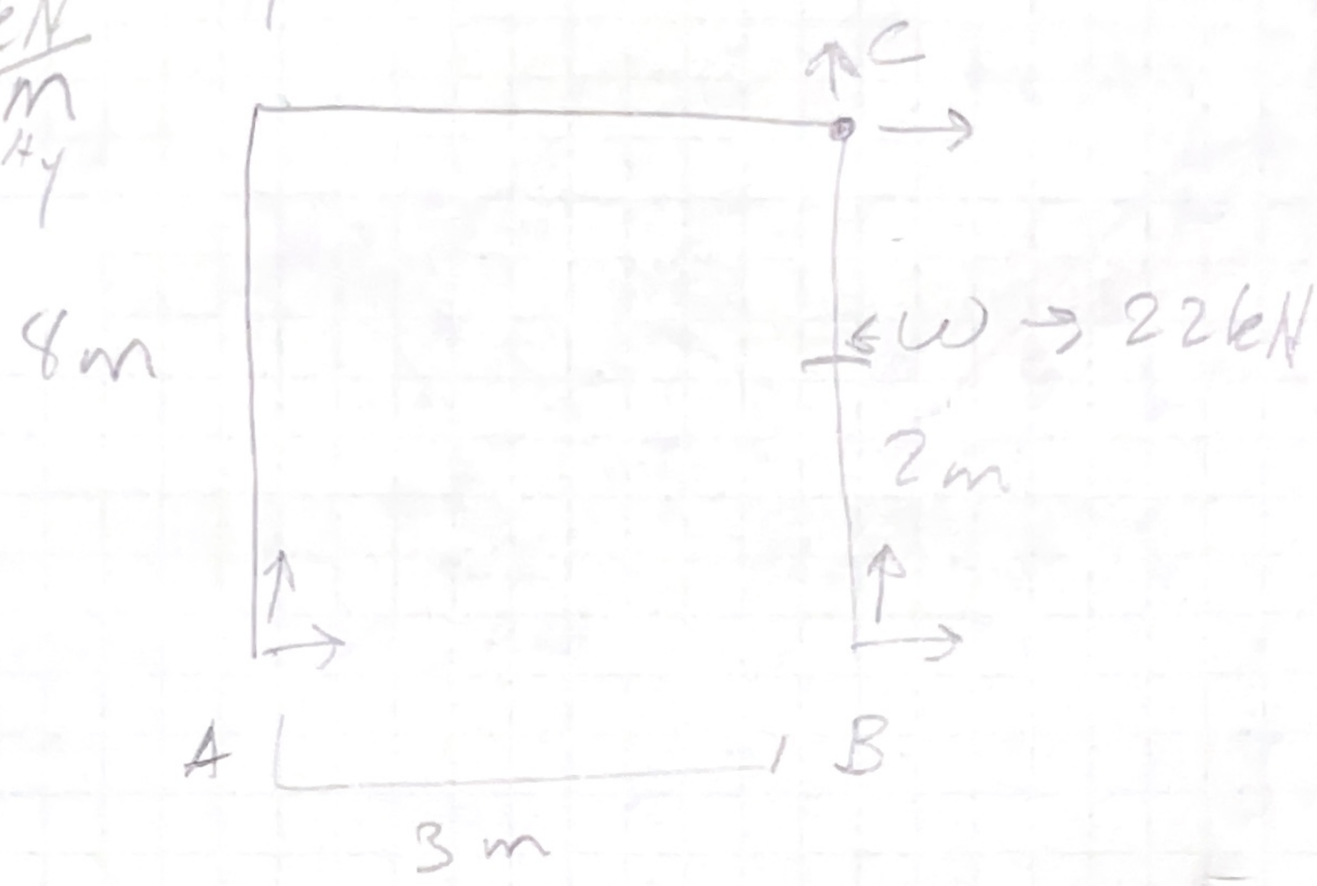
Given:
$w = 5.5 \frac{kN}{m}$
find: A_x, A_y
B_x, B_y



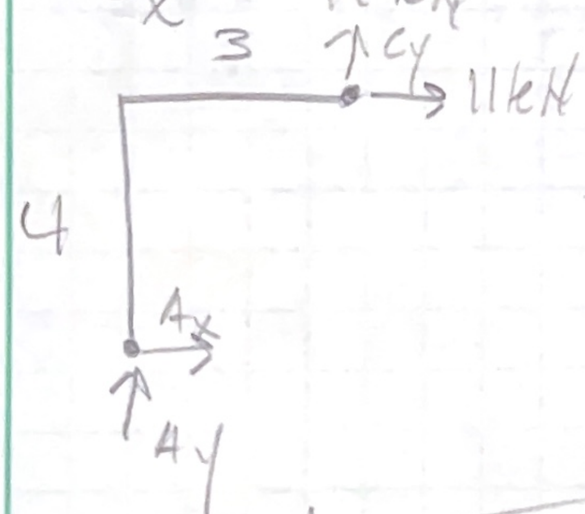
$F_w = 4m \cdot 5.5\frac{kN}{m} = 22kN$ at 2m

$\Sigma M_C: -2m \cdot 22 + B_x \cdot 4m = 0$

$B_x = \frac{44}{4} = 11kN$

$B_x + C_x = 0$
$C_x = 11kN$

$C_x = -11kN$



$\Sigma M_A: C_y \cdot 3m - C_x' \cdot 4m = 0$

$C_y = \frac{-44}{3}$

$C_y = -14.67$

$\Sigma F_x: A_x = -C_x = 11kN$

$\Sigma F_y: A_y + C_y = 0$

$A_y = -C_y$

$A_y = -14.67kN$

→ scalar notation

$B_y = -C_y$

$B_y = -14.67$

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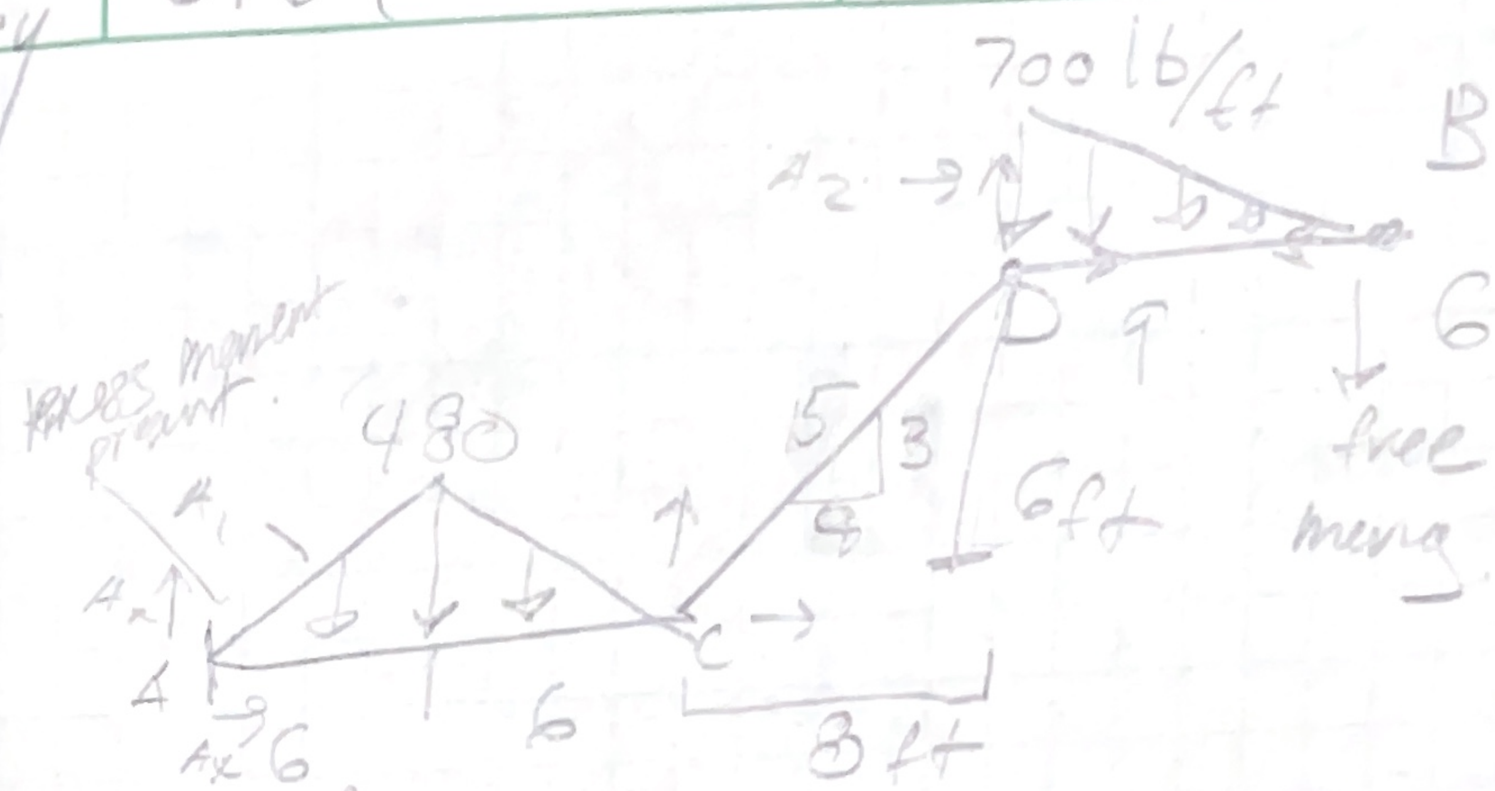
given:
$\omega = 480$ lb/ft

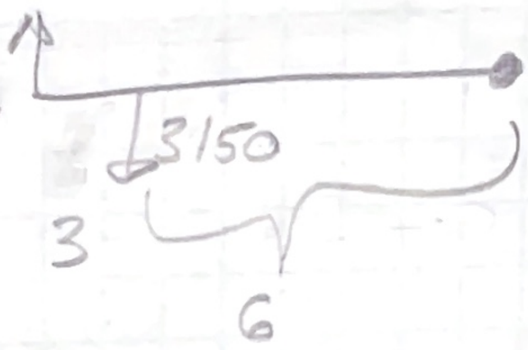


method: resolve distributed loads
→ moments at each member to find F_{cy}, F_{cx} to get to F_{By}, F_{By}

$A_1 = \frac{1}{2} \cdot 12 \cdot 480 = 2880$ lb at 6 ft

$A_2 = \frac{1}{2} \cdot 9 \cdot 700 = 3150$ lb, $x = \frac{2}{3} \cdot 9 = 6$ m from B

ΣM_B:



$-9D_y + 6 \cdot 3150 = 0$

$D_y = \frac{6 \cdot 3150}{9} = 2100$ lb, $\frac{3}{5} CD = 2100$ lb

$CD = 3500$ lb

$\Sigma F_{y\,DB} = 2100 - 3150 + B_y = 0$

$\boxed{B_y = 1050 \text{ lb}}$

$D_x = \frac{4}{5} CD$

$D_x = 2800$ lb

$\Sigma F_{x\,DB} = 2800 + B_x = 0$

$\boxed{B_x = -2800 \text{ lb}}$

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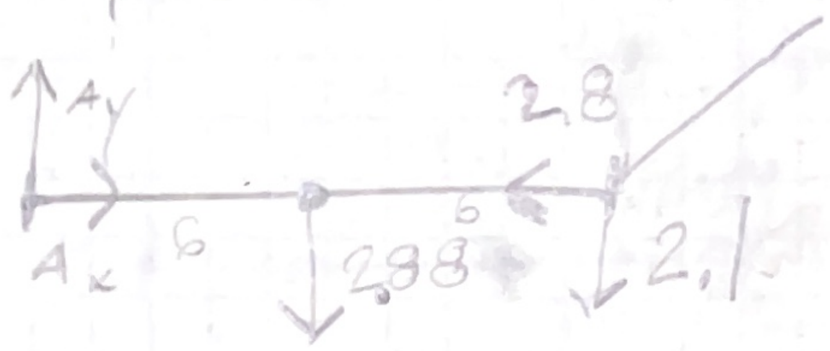
AC



ΣM_A | $-6 \cdot 2.88 - 12 \cdot 2.1 + M_A = 0$

$M_A = (6 \cdot 2.88) + (12 \cdot 2.1)$

$M_A = 92.48$ kip·ft

ΣF_x | $A_x = -(-2.8)$

$A_x = 2.8$ kip

ΣF_y | $A_y - 2.1 - 2.88 = 0$

$A_y = 4.98$ kip

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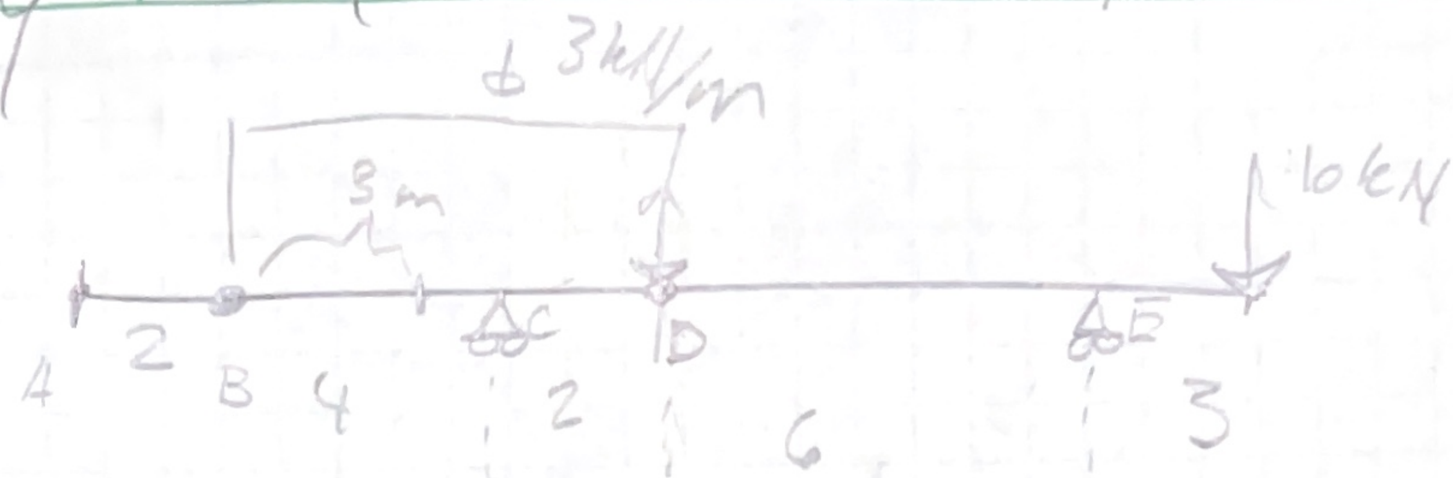
given:
$F_1 = 10kN$

find:
A_x, A_y
M_A, E_y, C_y



→ moment after breaking into components. right to left

ΣM_E | $6F_{Dy} - 3F_1 = 0$

$F_{Dy} = \frac{30}{6}$

$F_{Dy} = -5kN$

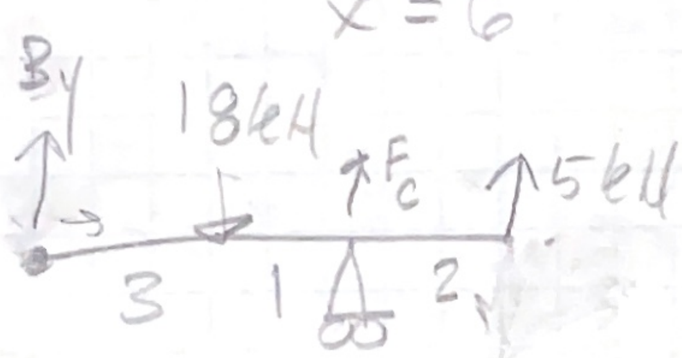
resolve distributed load:

$6m \cdot 3\frac{kN}{m} = 18kN$ at center

$x = 6$

ΣF_{Ey} | $-5 - 10 + E_y = 0$

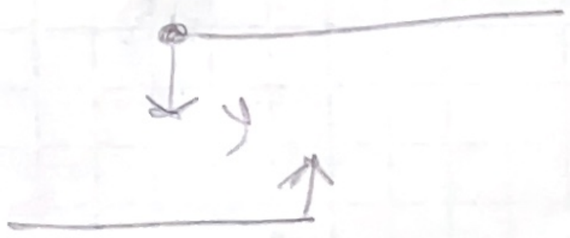
$E_y = 15kN$



→ Signs reverse because of reaction forces.

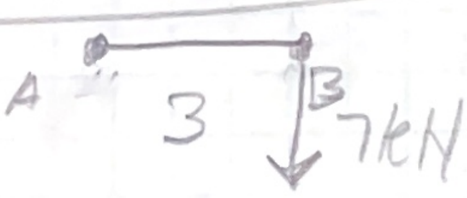
$\Sigma M_C: -4B_y + 5 \cdot 2 + 18 \cdot 1 = 0$

$B_y = \frac{28}{4} = 7kN$



$\Sigma F_y: F_{cy} + 7 - 18 + 5 = 0$

$F_{cy} = 6kN$



M_A | $M_A - 7kN \cdot 3 = 0$

$M_A = 21kN \cdot m$

$\Sigma F_y: A_y - 7kN = 0$

$A_y = 7kN$

$\Sigma F_x: A_x = 0$

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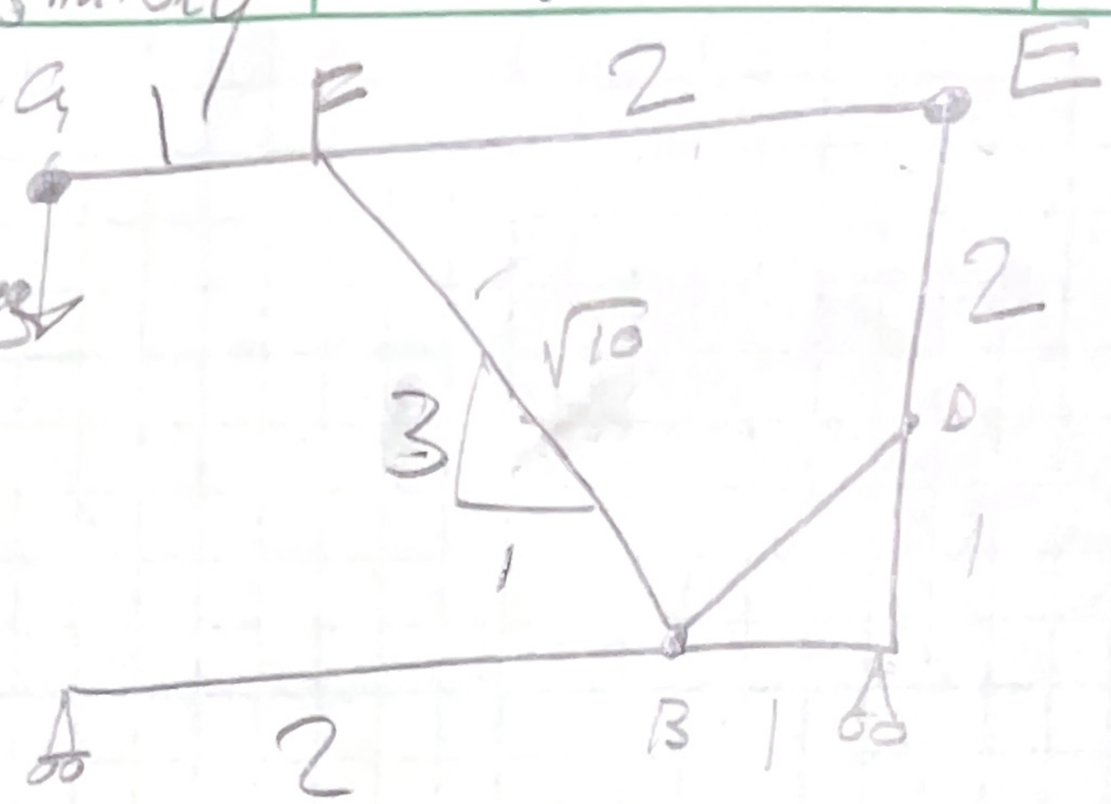
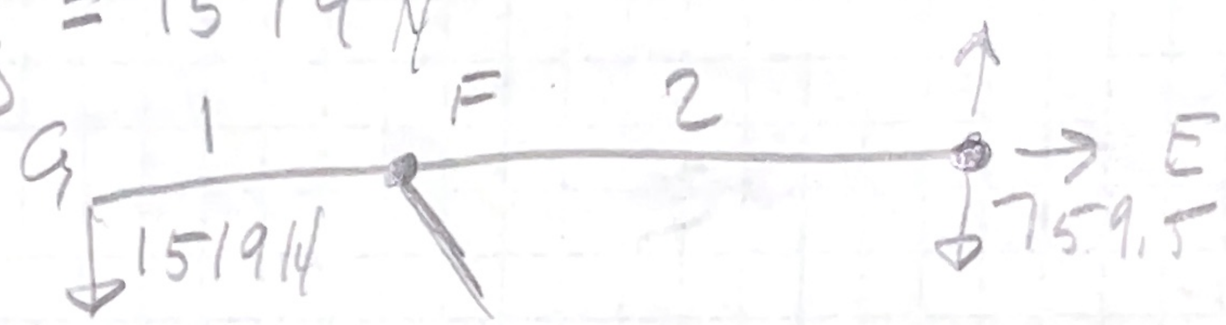
given: G

$F = 98.1\,55\,kg$



→ find FB, BD method: ΣM at point F

$F_g = 1519\,N$



ΣM_F | $1m \cdot 1519N + 2m \cdot E_y = 0$

tensile $E_y = -759.5\,N$

$\Sigma F_y: -759.5N - 1519N + F_{BFy} = 0$

$F_{BFy} = 2278.5$

$\frac{3}{\sqrt{10}} F_{BF} = 2278.5$

$F_{BF} = 2401.75\,N$

$\Sigma F_x: -\frac{1}{\sqrt{10}} BF + E_x = 0$

$E_x = \frac{2401.75}{\sqrt{10}}$

$E_x = 759.5\,kN$

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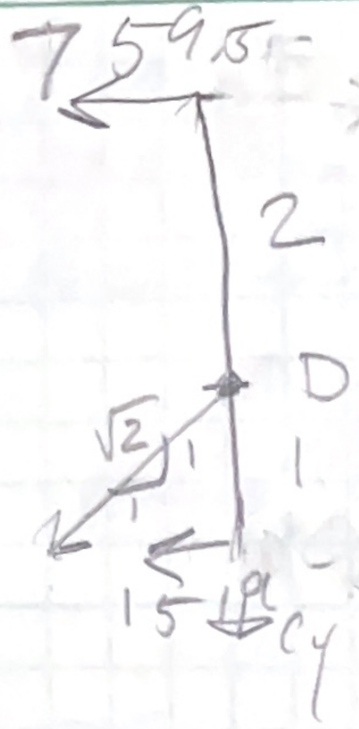

ΣM_D:

$759{,}5\,N \cdot 2m + C_x \cdot 1m = 0$

$C_x = -1519$

ΣF_x: $-1519 - 759{,}5 + DB \cdot \frac{1}{\sqrt{2}} = 0$

$DB = \underline{2278.5 \cdot \sqrt{2}}$

$DB = 3222{,}3\,N$