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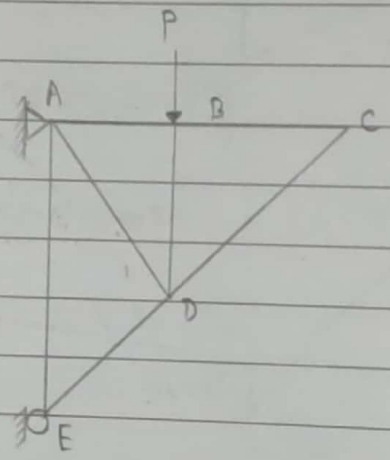
Truss

1. Prepare a note on zero force member of a truss with suitable example of trusses which should involve different cases.

⇒ The member is zero force member if;

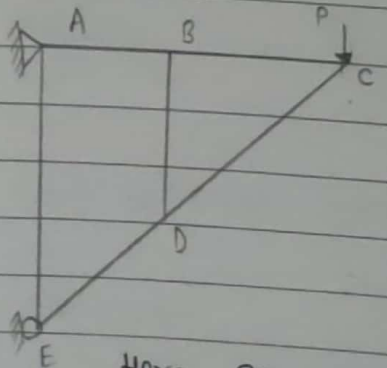
a) only two members form a non collinear joint and no external load or support reaction is applied to the joint.

for example;



Here,
CD and BC are zero force member

b) when three members form a truss joint for which two of the members are collinear and the third forms an angle with the first two, then the non-collinear member is zero force member.



Here, BD and AD are zero frame members.

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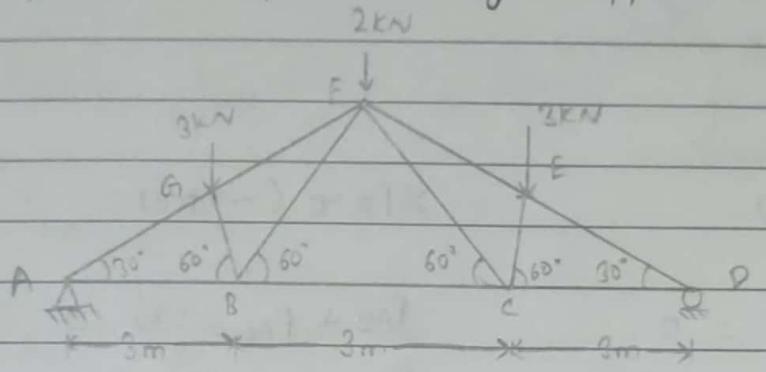
2. Determine the force in each member of the roof truss as shown in the figure and state if the members are in tension or compression. (Support A hinge, Support D roller)



Solⁿ: Calculating reactions,

$\Sigma F_x = 0 \quad (\rightarrow +ve)$

$A_x = 0$

$\Sigma F_y = 0 \quad (\uparrow +ve)$

$A_y + D_y - 3 - 2 - 3 = 0$

or $A_y + D_y = 8 \quad -①$

$\Sigma M_A = 0 \quad (\circlearrowleft +ve)$

$3 \times 2.25 + 2 \times (3+1.5) + (6+0.75)3 - D_y \times 9 = 0$

or, $6.75 + 9 + 20.25 = 9D_y$

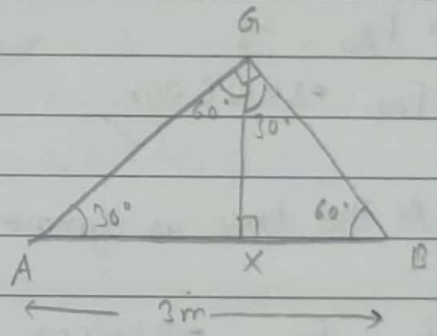
$\therefore D_y = 4kN \ (\uparrow)$

So,

$A_y + D_y = 8$

$A_y + 4 = 8$

$\therefore A_y = 4kN \ (\uparrow)$



In ΔAGB

$\cos 30° = \frac{AG}{3}$

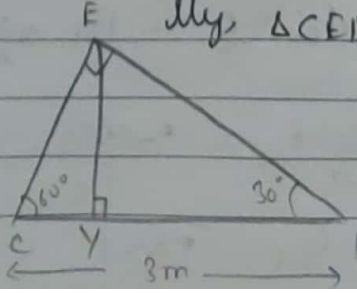
$\therefore AG = \frac{3\sqrt{3}}{2}$

In ΔAGX

$\cos 30° = \frac{AX}{AG}$

$\frac{\sqrt{3}}{2} = \frac{AX \times 2}{3\sqrt{3}}$

$\therefore AX = 2.25$



My ΔCED

$\sin 30° = \frac{EC}{CD}$

$\therefore EC = 1.5$

ΔEYC

$\cos$

$EY = EC \cos 60° = 0.75$

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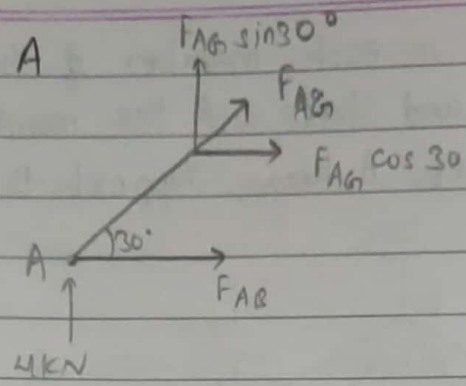
Taking joint A



$\Sigma F_y = 0$ (↑ +ve)

$4 + F_{AG}\sin 30° = 0$

or $F_{AG}\frac{1}{2} = -4$

or $F_{AG} = -8$

$\therefore F_{AG} = -8$ kN (C)

$\Sigma F_x = 0$ (→ +ve)

$F_{AB} + F_{AG}\cos 30° = 0$

$F_{AB} - 8\cos 30° = 0$

or $F_{AB} = 8 \times \frac{\sqrt{3}}{2}$

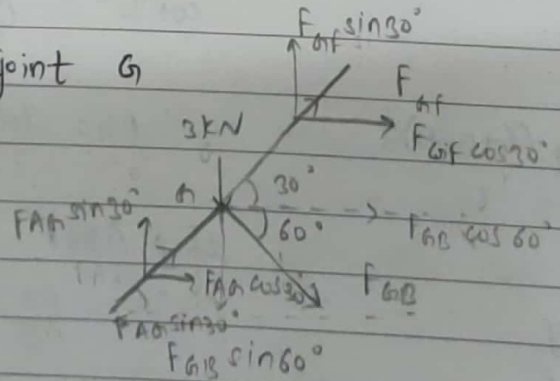
$\therefore F_{AB} = 4\sqrt{3}$ (T)

As the truss is symmetric

$F_{ED} = F_{AG} = -8$ kN (C)

$F_{AB} = F_{CD} = 4\sqrt{3}$ kN (T)

Taking joint G



$\Sigma F_n = 0$ (→ +ve)

$-F_{AG}\cos 30° + F_{GB}\cos 60° + F_{GF}\cos 30° = 0$

$8\cos 30° + F_{GB} \times \frac{1}{2} + F_{GF}\frac{\sqrt{3}}{2} = 0$

or $\frac{1}{2}F_{GB} + \frac{\sqrt{3}}{2}F_{GF} = -4\sqrt{3}$

or $F_{GB} + \sqrt{3}F_{GF} = -8\sqrt{3}$ — (1)

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$\Sigma F_y = 0$ (↑ +ve)

$-3 + F_{AG}\sin 30^\circ - F_{GB}\sin 60^\circ + F_{GF}\sin 30^\circ = 0$

or $-3 + 8\sin 30^\circ - F_{GB}\frac{\sqrt{3}}{2} + F_{GF}\times\frac{1}{2} = 0$

or $-\frac{\sqrt{3}}{2}F_{GB} + \frac{1}{2}F_{GF} = 1$ —(i)

or $-\sqrt{3}F_{GB} + F_{GF} = 2$ —(ii)

Solving (i) and (ii)

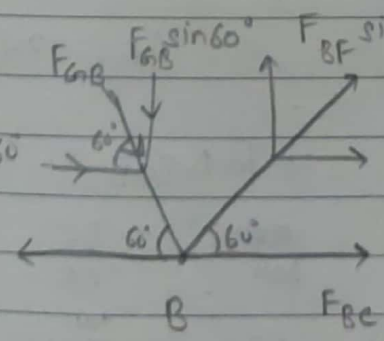
$F_{GB} = -2.598$ kN (C)
$= 2.598$ kN (C)

$F_{GF} = -6.5$ kN (C)
$= 6.5$ kN (C)

As the truss is symmetrical

$F_{GB} = F_{EC} = 2.598$ kN (C)
$F_{GF} = F_{EF} = 6.5$ kN (C)

Taking joint B



$\Sigma F_y = 0$ (↑ +ve)

or $F_{BF}\sin 60^\circ - F_{GB}\sin 60^\circ = 0$

or $F_{BF}\sin 60^\circ - 2.598\sin 60^\circ = 0$

or $F_{BF}\sin 60^\circ = 2.598\sin 60^\circ$

$\therefore F_{BF} = 2.598$ kN (T)

$\Sigma F_x = 0$ (→ +ve)

$F_{BF}\cos 60^\circ + F_{BC} + F_{GB}\cos 60^\circ - F_{AB} = 0$

or $F_{BC} + 2.598\cos 60^\circ + 2.598\cos 60^\circ - 4\sqrt{3} = 0$

or $F_{BC} + 2.598 - 4\sqrt{3} = 0$

$\therefore F_{BC} = 4.33$ kN (T)

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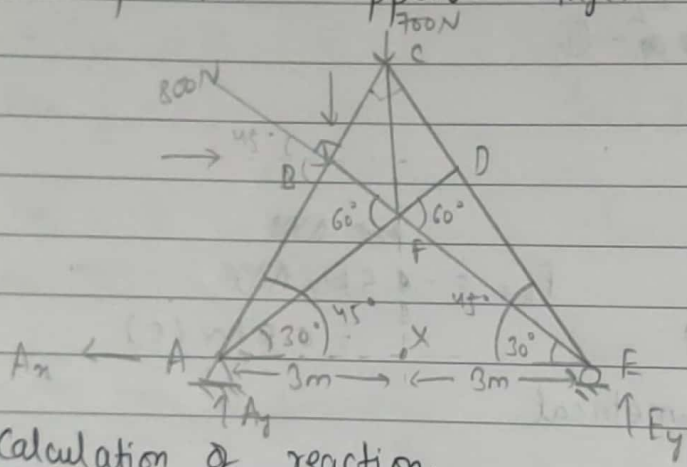
As the truss is symmetric.

$F_{BF} = F_{FC} = 2.598\ kN\ (T)$

3. Determine the force in each member of the roof truss shown in the figure and state if the members are in ten or compression. (Support A hinge, support E roller)



Solⁿ. Calculation of reaction.

$\Sigma F_x = 0$ ($\rightarrow$ +ve)

$800\cos45° - A_x = 0$

$\therefore A_x = 565.68\ kN$

$\Sigma F_y = 0$ ($\uparrow$ +ve)

$A_y + F_y - 800\sin45 - 700 = 0$

or, $A_y + F_y = 1265.68\ kN$

$\Sigma M_A = 0$ (↺ +ve)

$800\cos45 \times 2.196 + 800\sin45 \times 2.196 + 700 \times 3 - F_y \times 6 = 0$

or, $6F_y = 4584.49$

$\therefore F_y = \frac{769.17}{4.08}\ kN$

So,

$A_y = 501.59$

In ΔAXC

$\cos45° = \frac{AX}{AC}$

$\therefore AC = 3\sqrt{2}\ m$

In ΔBCE

$\tan15° = \frac{BC}{CE}$

$BC = 3\sqrt{2}\tan15°$

Now,

$AB = AC - BC$

or, $AB = 3.19405$

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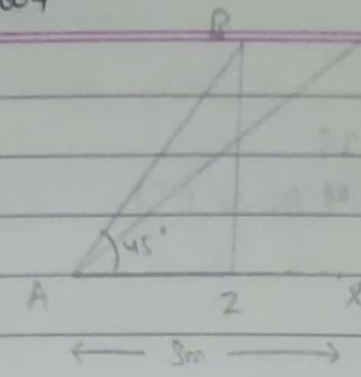
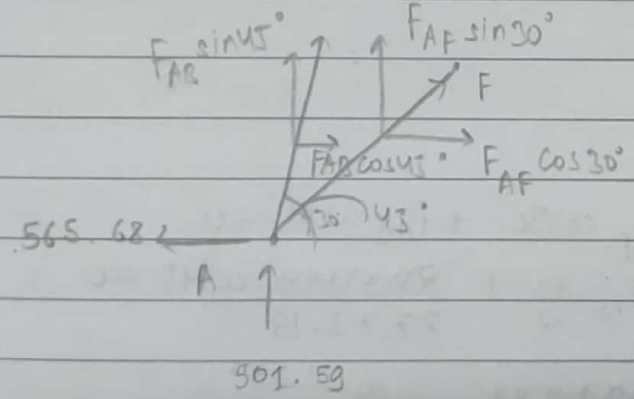


$\sin 45° = \frac{BZ}{AB}$ $\cos 45° = \frac{AZ}{AB}$

or, $BZ = 3.144 \sin 45°$ or, $AZ = 3.144 \cos 45°$

$\therefore BZ = \frac{2.\blacksquare\blacksquare\blacksquare m}{196}$ $\therefore AZ = \frac{2.\blacksquare\blacksquare\blacksquare m}{196}$

Taking joint A.



$\Sigma F_x = 0$ ($\rightarrow$ +ve)

$F_{AB}\cos45 + F_{AF}\cos30 - 800\cos45 = 0$

or, $\frac{F_{AB}}{\sqrt{2}} + \frac{F_{AF} \times \sqrt{3}}{2} = 800 \times \frac{1}{\sqrt{2}}$

or, $\frac{2F_{AB} + \sqrt{6}F_{AF}}{2\sqrt{2}} = \frac{800}{\sqrt{2}}$

or, $2F_{AB} + \sqrt{6}F_{AF} = 1600$ — ①

$\Sigma F_y = 0$ (↑ +ve) -501.59

$F_{AB}\sin45 + F_{AF}\sin30 = +496.51$

or, $\frac{F_{AB}}{\sqrt{2}} + \frac{F_{AF}}{2} = \frac{+496.51}{-501.59}$ or, $2F_{AB} + \sqrt{2}F_{AF} = -1409.73$ — ②

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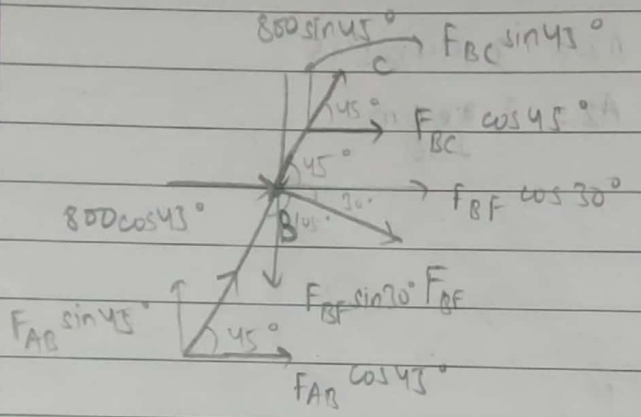
solving (I) and (II)

$F_{AB} = -2771.19\ N$

$F_{AB} = 2771.19\ (C)$

$F_{AF} = 2991.86\ N\ (T)$

Taking joint B



$\Sigma F_x = 0$ ($\rightarrow$ +ve)

or, $F_{BC}\cos45° + 800\cos45° + F_{BF}\cos30° + F_{AB}\cos45° = 0$

or, $\frac{F_{BC}}{\sqrt{2}} + 800\cos45° + F_{BF}\frac{\sqrt{3}}{2} + 2771.19\cos45° = 0$

or, $\frac{F_{BC}}{\sqrt{2}} + F_{BF}\frac{\sqrt{3}}{2} = -2525.21$ — (III)

$\Sigma F_y = 0$ ($\uparrow$ +ve)

or, $F_{AB}\sin45 - F_{BF}\sin30° - 800\sin45 + F_{BC}\sin45° = 0$

or, $2771.19\sin45 - 800\sin45 + \frac{F_{BC}}{\sqrt{2}} - \frac{1}{2}F_{BF} = 0$

or, $\frac{F_{BC}}{\sqrt{2}} - \frac{1}{2}F_{BF} = -1381.804$ — (IV)

solving (III) and (IV),

$F_{BC} = -2518.80\ N$

$= 2518.80\ N\ (C)$

$F_{BF} = -828.22\ N$

$= 828.22\ N\ (C)$

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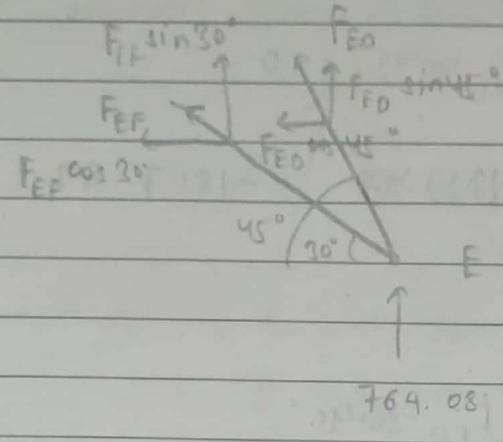
Taking joint E



$\Sigma F_x = 0$ (→ +ve)

$-F_{EF}\cos 30° - F_{ED}\cos 45° = 0$

or, $F_{EF}\cos 30° + F_{ED}\cos 45° = 0$ — (V)

$\Sigma F_y = 0$ (↑ +ve)

$764.171 + F_{EF}\sin 30° + F_{ED}\sin 45° = 0$

or, $F_{EF}\sin 30° + F_{ED}\sin 45° = -764.08$ — (VI)

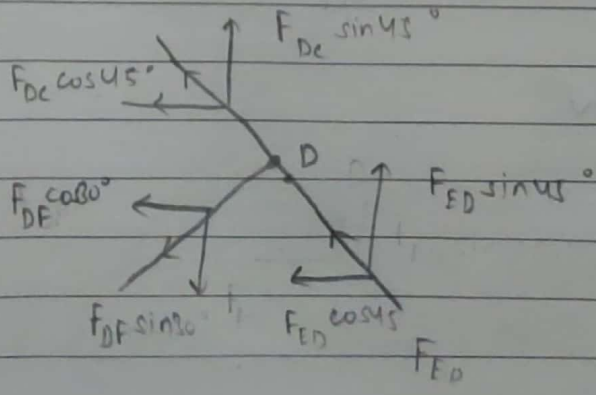
Solving (V) and (VI)

$F_{EF} = 2087.50\ N$ (T)

$F_{FD} = -2556.66\ N$

$= 2556.66\ N$ (C)

Taking joint D



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$\Sigma F_x = 0$ (→ +ve)

or, $-F_{DC}\cos45° - F_{DF}\cos30° + F_{ED}\cos45° = 0$

or, $F_{DC}\cos45° + F_{DF}\cos30° = [illegible] = -1807.83$

$\Sigma F_y = 0$

$F_{DC}\sin45° - F_{DF}\sin30° = -F_{ED}\sin45°$

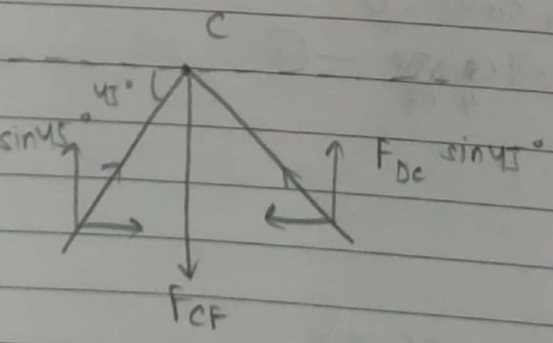
or $F_{DC}\sin45° - F_{DF}\sin30° = [illegible] = -1807.83$

Solving

$F_{DC} = -2556.68\,N$ $\qquad F_{DF} = 0\,N$

$= 2556.68\,N$ (CC)

Taking joint C



$\Sigma F_y = 0$ (↑ +ve)

$F_{BC}\sin45° + F_{DC}\sin45° - F_{CF} = 0$

or $F_{CF} = 3615.77\,N$

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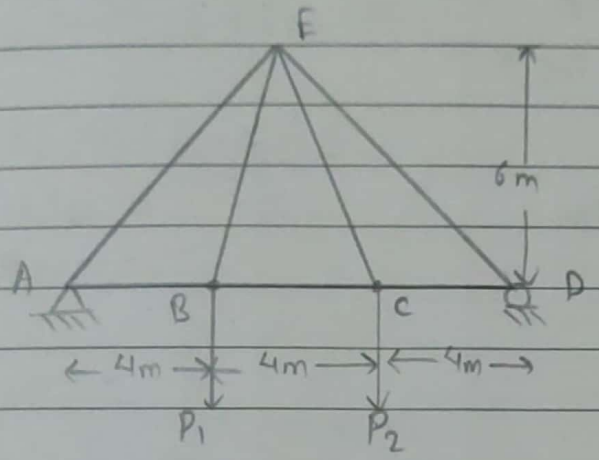
4. Determine the force in each member of the truss and state if the members are in tension or compression. Set $P_1 = 3kN$, $P_2 = 6kN$



Solv': Calculating the reactions

$\Sigma F_x = 0 \quad (\rightarrow +ve)$

$A_x = 0$

$\Sigma M_A = 0 \quad (\circlearrowleft +ve)$

$P_1 \times 4 + P_2 \times 8 - D_y \times 12 = 0$

or, $12 + 48 = 12 D_y$

or, $D_y = 5 kN (\uparrow)$

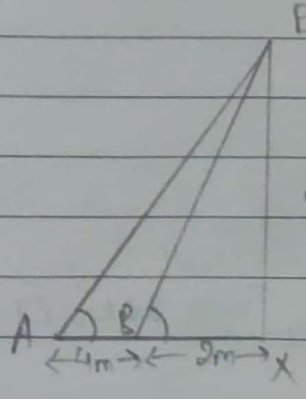
$\Sigma F_y = 0 \quad (\uparrow +ve)$

$A_y + D_y - P_1 - P_2 = 0$

or, $A_y + 5 - 3 - 6 = 0$

$\therefore A_y = 4 kN$

Now, finding the angles



In ΔAXE

$\tan A = \frac{6}{6} \quad \therefore A = 45^\circ$

Hy, $D = 45^\circ$

In ΔBXE

$\tan B = \frac{6}{2} \quad \therefore B = 71.56^\circ$

Hy, $C = 71.56^\circ$

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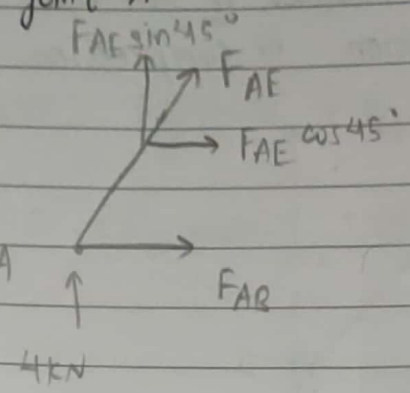
Taking joint A



$\Sigma F_y = 0$ (↑ +ve)

or $4 + F_{AE} \sin 45^\circ = 0$

or $F_{AE} = -4\sqrt{2}$ kN

$\therefore F_{AE} = 4\sqrt{2}$ kN (C)

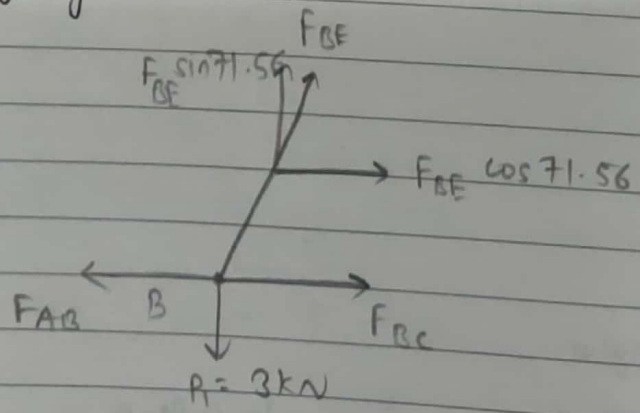
$\Sigma F_x = 0$ (→ +ve)

or $F_{AB} + F_{AE} \cos 45^\circ = 0$

or $F_{AB} + (-4\sqrt{2}) \cos 45^\circ = 0$

or $F_{AB} = 4$ kN (T)

Taking joint B



$\Sigma F_y = 0$ (↑ +ve)

$-3 + F_{BE} \sin(71.56) = 0$

or $F_{BE} \sin(71.56) = 3$

or $F_{BE} = \dfrac{3}{\sin(71.56)}$ $\therefore F_{BE} = 3.16$ kN (T)

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$\Sigma F_x = 0$ ($\rightarrow$ +ve)

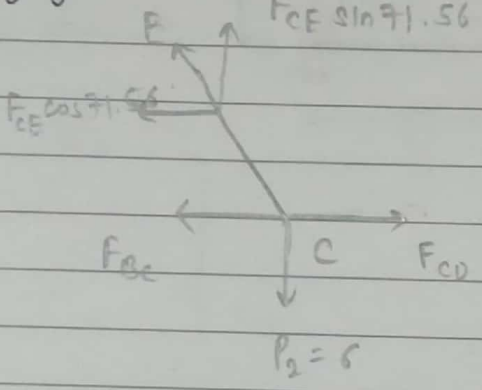
$-4 + F_{BE}\cos 71.56 + F_{BC} = 0$

$-4 + 3.16\cos 71.56 + F_{BC} = 0$

$-4 - 3 + F_{BC} = 0$

$F_{BC} = 3$ KN (T)

Taking joint C



$\Sigma F_y = 0$ ($\uparrow$ +ve)

$-6 + F_{CE}\sin 71.56 = 0$

$F_{CE} = \dfrac{6}{\sin 71.56}$

$\therefore F_{CE} = 6.32$ KN (T)

$\Sigma F_x = 0$ ($\rightarrow$ +ve)

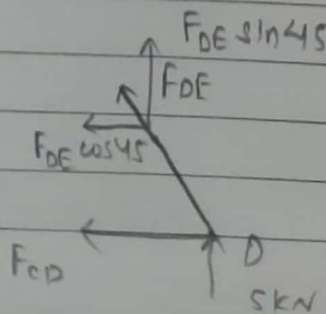
$-F_{BC} + F_{CD} - F_{CE}\cos 71.56 = 0$

$F_{CD} = 3 + 6.32\cos 71.56$

$F_{CD} = 3 + 2$

$\therefore F_{CD} = 5$ kN (T)

Taking joint D



$\Sigma F_y = 0$

$5 + F_{DE}\sin 45 = 0$

$F_{DE} = -5/\sin 45$

$\therefore F_{DE} = 7.07$ (C)

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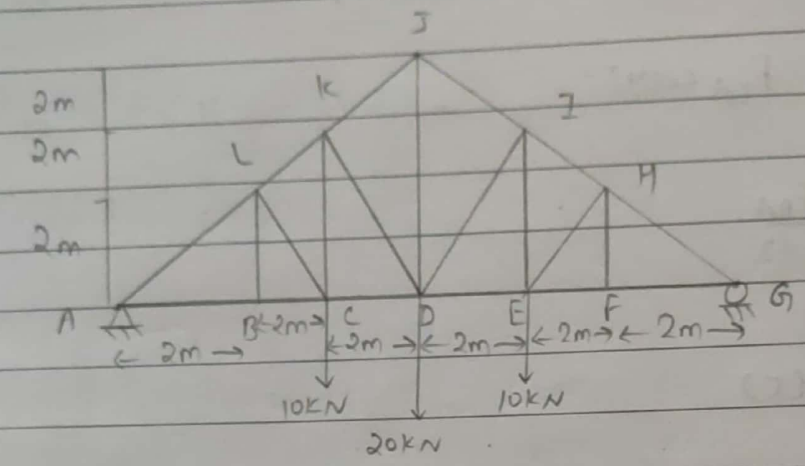
5. Determine the force in each member of the Pratt truss, and state if the members are in tension or compression



Soln: Calculating the reaction

$\Sigma F_x = 0 \quad (\rightarrow +ve)$

$A_x = 0$

$\Sigma F_y = 0 \quad (\uparrow +ve)$

$A_y + G_y - 10 - 20 - 10 = 0$

$A_y + G_y = 40 \quad \text{---} ①$

$\Sigma M_A = 0 \quad (\circlearrowleft +ve)$

$10 \times 4 + 20 \times 6 + 10 \times 8 - G_y \times 12 = 0$

or $12 G_y = 240$

$\therefore G_y = 20 \text{ kN} (\uparrow)$

$\therefore A_y = 20 \text{kN} (\uparrow)$

Thus, the truss is symmetrical

Using trigonometry

$\angle LAB = 45^\circ = \angle HGF$

$\angle LCB = 45^\circ = \angle HEF$

$\angle KDC = \tan^{-1}\left(\frac{4}{2}\right) = 63.43^\circ = \angle KDE$

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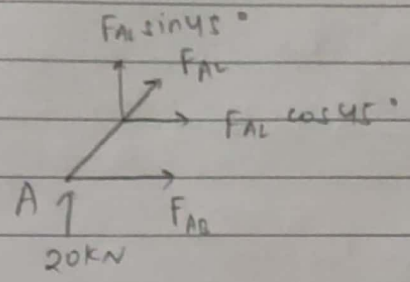
Taking joint A



$\Sigma F_y = 0$ (↑ +ve)

$20 + F_{AL}\sin 45° = 0$

$F_{AL} \times \frac{1}{\sqrt{2}} = -20$

$F_{AL} = -20\sqrt{2}$ kN

$F_{AL} = 20\sqrt{2}$ kN (C)

$\Sigma F_x = 0$ (→ +ve)

$F_{AB} + F_{AL}\cos 45° = 0$

$F_{AB} - 20\sqrt{2} \times \frac{1}{\sqrt{2}} = 0$

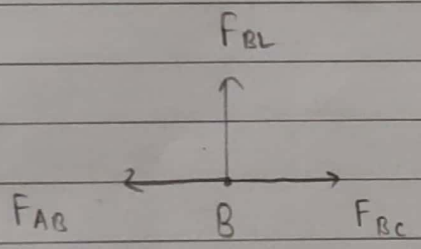
$F_{AB} = 20$ KN (T)

Similarly,

$F_{FHG} = 20\sqrt{2}$ KN (C)

$F_{FG} = 20$ KN (T)

Taking joint B



$\Sigma F_y = 0$ (↑ +ve)

$F_{BL} = 0$

Similarly

$F_{FH} = 0$

$\Sigma F_x = 0$ (→ +ve)

$-F_{AB} + F_{BC} = 0$

$F_{BC} = 20$ KN (T)

Similarly

$F_{FE} = 20$ KN (T)

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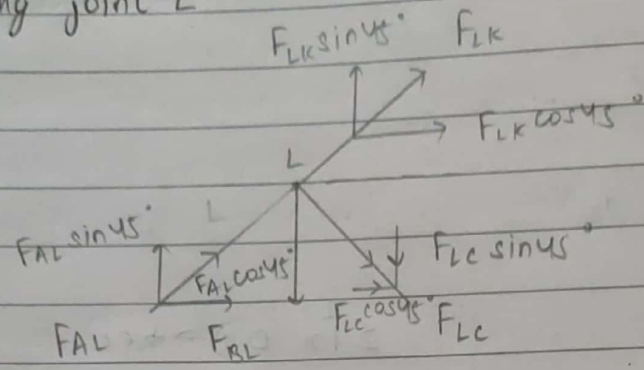
Taking joint L



$\Sigma F_x = 0 \ (\rightarrow +ve)$

$F_{AL}\cos45° + F_{LC}\cos45° + F_{LK}\cos45° = 0$

or, $20\sqrt{2}\cos45 + F_{LC}\cos45° + F_{LK}\cos45° = 0$

$F_{LK}\cos45° + F_{LC}\cos45° = -20 \quad -①$

$\Sigma F_y = 0 \ (\uparrow +ve)$

$F_{LK}\sin45° - F_{LC}\sin45° - F_{BL} + F_{AL}\sin45° = 0$

or, $F_{LK}\sin45° - F_{LC}\sin45° = -20 \quad -②$

Solving ① & ②

$2F_{LK}\cos45° = -40$

or, $F_{LK} = -20\sqrt{2}$ kN

$\therefore F_{LK} = 20\sqrt{2}$ kN (C)

Then,

$-20\sqrt{2}\cos45° + F_{LC}\cos45° = -20$

$-20 + F_{LC}\frac{1}{\sqrt{2}} = -20$

$\therefore F_{LC} = 0$

Similarly,

$F_{HI} = 20\sqrt{2}$ kN (C)

$F_{HE} = 0$

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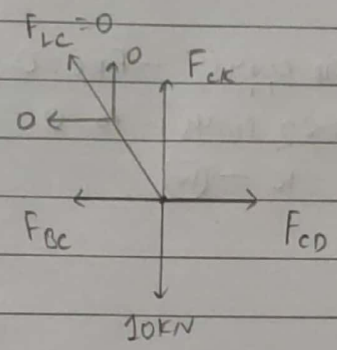
Taking joint C



$\Sigma F_y = 0$ (↑ +ve)

$F_{CK} - 10 = 0$

$\therefore F_{CK} = 10KN$ (T) Similarly

$F_{EJ} = 10KN$ (T)

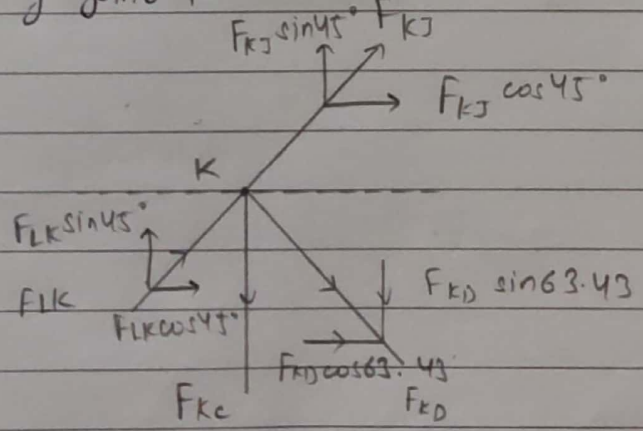
$\Sigma F_x = 0$ (→ +ve)

$-F_{BC} + F_{CD} = 0$

or, $F_{CD} = 20KN$ (T) Similarly,

$F_{ED} = 20KN$ (T)

Taking joint K



$\Sigma F_x = 0$ (→ +ve)

or, $F_{LK}\cos45° + F_{KD}\cos63.43 + F_{KJ}\cos45° = 0$

or, $20\sqrt{2}\cos45° + F_{KJ}\cos45° + F_{KD}\cos63.43° = 0$

or $F_{KJ}\cos45° + F_{KD}\cos63.43° = -20$ — (iii)

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$\Sigma F_y = 0$ (↑ve)

$F_{KJ}\sin 45^\circ - F_{KD}\sin 63.43^\circ + F_{IK}\cos 45^\circ - F_{KC} = 0$

or $F_{KJ}\sin 45^\circ - F_{KD}\sin 63.43^\circ + 20\sqrt{2}\sin 45^\circ - 10 = 0$

or $F_{KJ}\sin 45^\circ - F_{KD}\sin 63.43 = -10 \quad (IV)$

Solving (III) and (IV)

$F_{KJ}\sin 45^\circ + F_{KJ}\cos 45^\circ = -30$

or $F_{KJ}\left(\frac{1}{\sqrt{2}} + \frac{1}{\sqrt{2}}\right) = -30$

or $F_{KJ}\left(\frac{2}{\sqrt{2}}\right) = -30$

or $F_{KJ} = -15\sqrt{2}\ KN$

$\therefore F_{KJ} = 15\sqrt{2}\ KN\ (C)$

Then,

$-15\sqrt{2}\cos 45^\circ + F_{KD}\cos 63.43^\circ = -20$

or $-15 F_{KD}\cos 63.43^\circ = -5$

or $F_{KD} = -11.18\ kN$

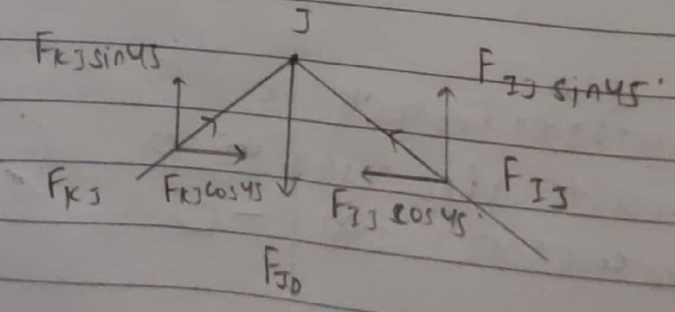
or $F_{KD} = 11.18\ KN\ (C)$

Similarly,

$F_{IJ} = 15\sqrt{2}\ KN\ (C)$

$F_{ID} = 11.18\ KN\ (C)$

Taking joint J



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$\Sigma F_y = 0$ (↑ +ve)

$F_{IJ} \sin 45^\circ - F_{JD} + F_{IJ} \sin 45^\circ = 0$

$F_{JD} = 15 + 15$

$\therefore F_{JD} = 30\,kN$ (T)

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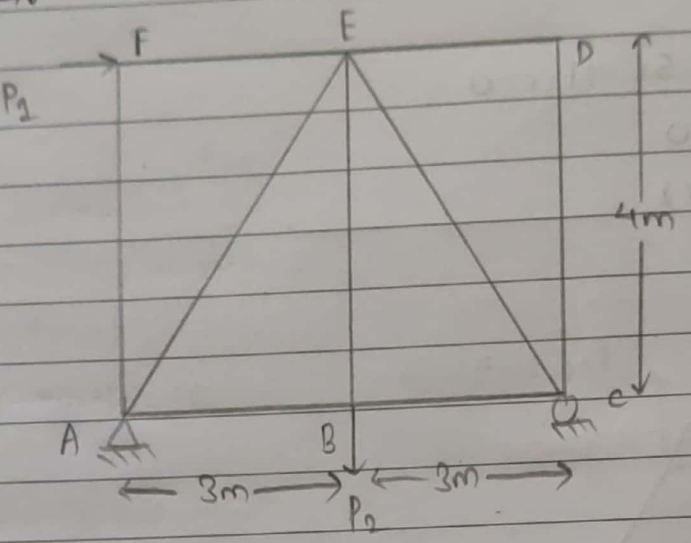
8. Determine the force in each member of the truss and sta
if the members are in tension or compression. Set $P_1 = 9kN$,
$P_2 = 15kN$



Solⁿ: Calculating the reactions.

$\Sigma F_x = 0$ ($\rightarrow$ +ve)

$-A_x + P_1 = 0$

$\therefore A_x = P_1$

$\therefore A_x = 9kN$ ($\leftarrow$)

$\Sigma M_A = 0$ (↻ +ve)

$P_1 \times 4 + P_2 \times 3 - C_y \times 6 = 0$

$36 + 45 - 6C_y = 0$

$6C_y = 81$

$\therefore C_y = 13.5kN$ ($\uparrow$)

$\Sigma F_y = 0$ ($\uparrow$ +ve)

$A_y + C_y - 15 = 0$

$A_y = 15 - 13.5$

$\therefore A_y = 1.5kN$ ($\uparrow$)

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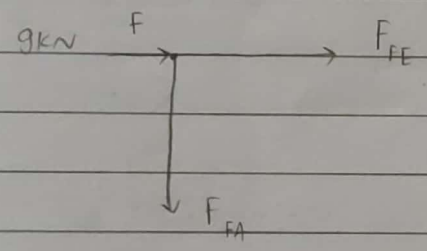
From ΔEBA

$\tan(\angle EAB) = \frac{4}{3}$

$\therefore \angle EAB = 53.10^\circ$

Similarly,
$\angle ECB = \angle EAB = 53.10^\circ$ [Symmetrical]

Taking joint F



$\Sigma F_x = 0$ ($\rightarrow$ +ve)

$9 + F_{FE} = 0$

$\therefore F_{FE} = -9\,kN$

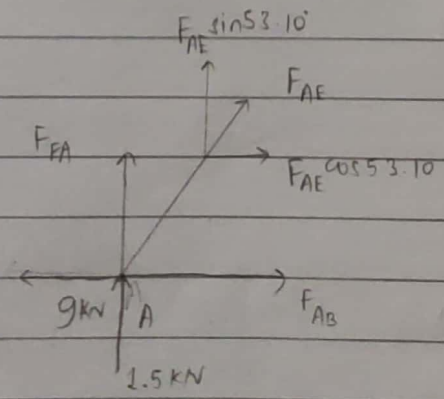
$\therefore F_{FE} = 9\,kN\,(C)$

$\Sigma F_y = 0$ ($\uparrow$ +ve)

$-F_{FA} = 0$

$\therefore F_{FA} = 0\,kN$

Taking joint A



$\Sigma F_y = 0$ ($\uparrow$ +ve)

$1.5 + F_{FA} + F_{AE}\sin 53.10^\circ$

or, $F_{AE} \times \frac{4}{5} + 1.5 + 0 = 0$

or, $F_{AE} \times \frac{4}{5} = -1.5$

or, $F_{AE} = \frac{-7.5}{4}$

or, $F_{AE} = -1.875$

$\therefore F_{AE} = 1.875\ kN\ (C)$

$\Sigma F_x = 0\ (\rightarrow +ve)$

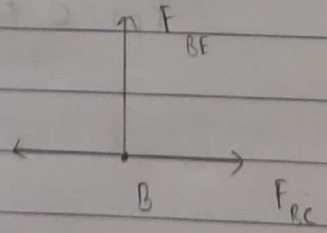
$-9 + F_{AB} + F_{AE} \cos 53.10' = 0$

or $-9 + F_{AB} - 1.875 \times \frac{3}{5} = 0$

or, $F_{AB} = 9 + 1.125$

$\therefore F_{AB} = 10.125\ kN\ (T)$

Taking joint B



$\Sigma F_y = 0\ (\uparrow +ve)$

or $F_{BF} = 0$

$\Sigma F_x = 0\ (\rightarrow +ve)$

or, $-F_{AB} + F_{BC} = 0$

or, $F_{BC} = 10.125\ kN\ (T)$

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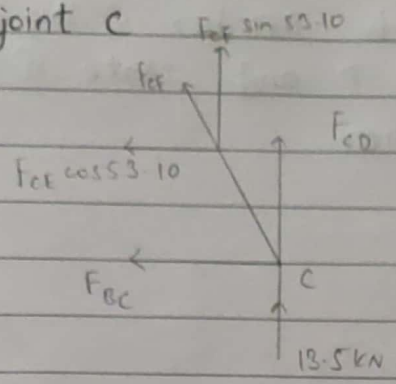
Taking joint C



$\Sigma F_y = 0$ (↑ +ve)

or, $F_{CE} \sin 53.10 + 13.5 + F_{CD} = 0$

or, $F_{CE} \times \frac{4}{5} + 13.5 + F_{CD} = 0$ — (i)

$\Sigma F_x = 0$ (→ +ve)

$-F_{BC} - F_{CE} \cos 53.10 = 0$

or, $F_{CE} \times \frac{3}{5} = -10.125$

or, $F_{CE} = -16.875$ KN

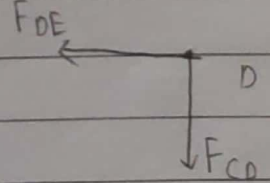
∴ $F_{CE} = 16.875$ KN (C)

Then,

$-16.875 \times \frac{4}{5} + 13.5 + F_{CD} = 0$

or, $F_{CD} = 0$

Taking joint D



$\Sigma F_x = 0$ (→ +ve)

$-F_{DE} = 0$ ∴ $F_{DE} = 0$ KN

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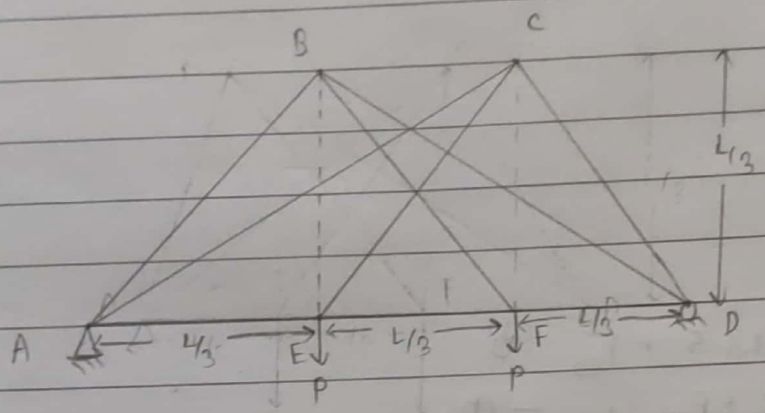
9 Determine the force in each member of the double scissor truss in terms of the load P and state if the member are in tension or compression



Sol^n: Calculation of reaction

$\Sigma F_x = 0 \quad (\rightarrow +ve)$

$A_x = 0$

$\Sigma F_y = 0$

$A_y + D_y - P - P = 0$

or $A_y + D_y = 2P \quad -①$

$\Sigma M_A = 0 \quad (\circlearrowleft +ve)$

or $P \times \frac{L}{3} + \frac{2L}{3} \times P - D_y \times L = 0$

or $D_y \times L = P\left(\frac{L}{3} + \frac{2L}{3}\right)$

or $D_y \times L = P \times L$

$\therefore D_y = P$

So,

$A_y = P$

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In ΔAFC

$$\tan(\angle CAF) = \frac{4/3}{2\sqrt{2}/3}$$

$\therefore \angle CAF = 26.56^\circ$ similarly $\angle BDE = 26.56^\circ$

In ΔABE

$$\tan\angle BAE = \frac{4/3}{4/3}$$

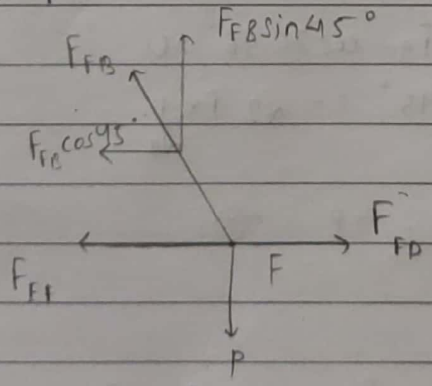
$\therefore \angle BAF = 45^\circ$ Similarly $\angle CDF = 45^\circ$

In ΔEFC

$$\tan\angle CEF = \frac{4/3}{4/3}$$

$\therefore \angle CEF = 45^\circ$ similarly $\angle BFP = 45^\circ$

Taking joint F



$\Sigma F_y = 0$ (↑ve)

$$F_{FB}\sin 45^\circ - P = 0$$

$$F_{FB} \times \frac{1}{\sqrt{2}} = P$$

$\therefore F_{FB} = \sqrt{2}\,P$ (T) Similarly due to symmetry $F_{FC} = \sqrt{2}\,P$ (T)

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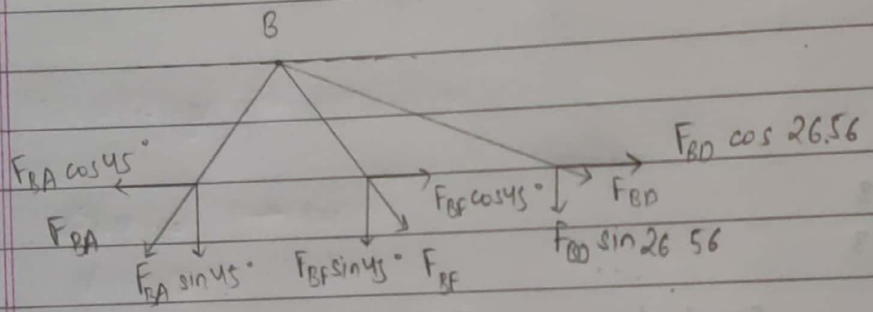
$\Sigma F_x = 0 \ (\rightarrow +ve)$

or, $F_{FD} - F_{FE} - F_{FB}\cos 45^\circ = 0$

or, $F_{FD} - F_{FE} - \sqrt{2}P \times \frac{1}{\sqrt{2}} = 0$

$\therefore F_{FD} - F_{FE} = P \quad -(i)$

Taking joint B



$\Sigma F_x = 0 \ (\rightarrow +ve)$

$-F_{BA}\cos 45^\circ + F_{BF}\cos 45^\circ + F_{BD}\cos 26.56^\circ = 0$

or, $F_{BD}\cos 26.56^\circ - F_{BA}\cos 45^\circ = -\sqrt{2}P \times \frac{1}{\sqrt{2}}$

or, $F_{BD}\cos 26.56^\circ - F_{BA}\cos 45^\circ = -P \quad -(ii)$

$\Sigma F_y = 0 \ (\uparrow +ve)$

$-F_{BA}\sin 45^\circ - F_{BF}\sin 45^\circ - F_{BD}\sin 26.56^\circ = 0$

$F_{BD}\sin 26.56^\circ + F_{BA}\sin 45^\circ = -P \quad -(iii)$

Solving (ii) and (iii)

$F_{BD}\cos 26.56^\circ + F_{BD}\sin 26.56^\circ = -2P$

or, $F_{BD}(\cos 26.56^\circ + \sin 26.56) = -2P$

or, $F_{BD} = \frac{-2P}{1.34}$

or, $F_{BD} = -1.49P$

$\therefore F_{BD} = 1.49P \ (C)$

similarly $F_{CA} = 1.49P \ (C)$

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Then,

$F_{BD}\cos 26.56 - F_{BA}\cos 45 = -P$

or, $-1.49P\cos 26.56 - F_{BA}\cos 45 = -P$

or, $-1.332P + P = F_{BA}\cos 45$

or, $-0.332P = \frac{F_{BA}}{\sqrt{2}}$

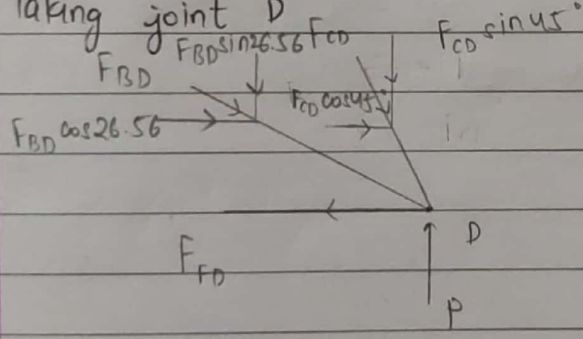
or, $F_{BA} = -0.47P$

$\therefore F_{BA} = 0.47P$ (C)

Similarly,

$F_{CD} = 0.47P$ (C)

Taking joint D



$\Sigma F_x = 0$ ($\rightarrow$ +ve)

$-F_{FD} + F_{BD}\cos 26.56 + F_{CD}\cos 45 = 0$

or, $F_{FD} = 1.49P\cos 26.56 + 0.47P\cos 45$

$\therefore F_{FD} = 1.66P$ (T) Similarly,

$F_{AF} = 1.66P$ (T)

Then eq^n (1),

$1.66P - F_{FE} = P$

or, $1.66P - P = F_{FE}$

$\therefore F_{FE} = 0.66P$ (T).

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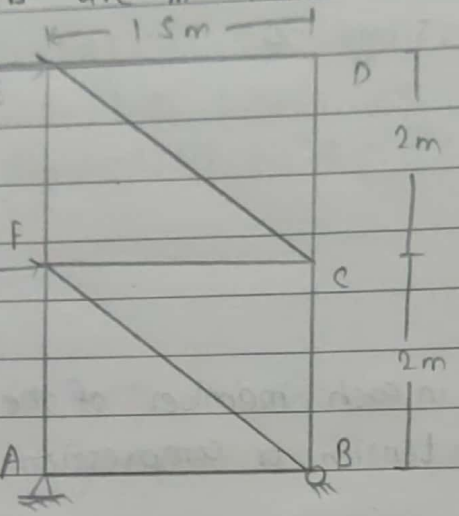
10. Determine the force in members AF, BF and BC and state if the members are in tension or compression.



Solⁿ: Calculating reaction,

$\Sigma F_x = 0$ ($\rightarrow$ +ve)

$4 + 8 - A_x = 0$

$\therefore A_x = 12\,kN$ ($\leftarrow$)

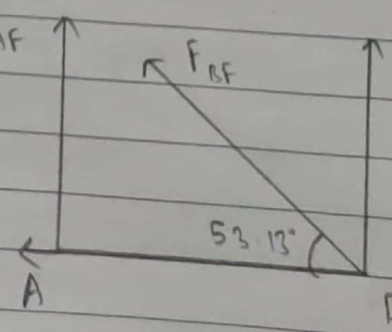
$\Sigma F_y = 0$ ($\uparrow$ +ve)

$A_y + B_y = 0$

As, no vertical force is applied,

$A_y = 0$ and $B_y = 0$

Taking the desired section



$\theta = \tan^{-1}\left(\frac{2}{1.5}\right) = 53.13°$

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$\Sigma F_x = 0 \quad (\rightarrow +ve)$

$-12 - F_{BF} \cos 53.13^\circ = 0$

$F_{BF} \cos 53.13^\circ = -12$

$\therefore F_{BF} = 20\ KN\ (C)$

$\Sigma F_y = 0 \quad (\uparrow +ve)$

$F_{AF} + F_{BF} \sin 53.13 + F_{BC} = 0$

$F_{AF} + F_{BC} - 20 \sin 53.13 = 0$

$F_{AF} + F_{BC} = 16\ KN \quad \text{—①}$

$\Sigma M_B = 0 \quad (\circlearrowleft +ve)$

$1.5 \times F_{AF} = 0$

$\therefore F_{AF} = 0.$

So,

$F_{BC} = 16\ KN\ (T)$ //

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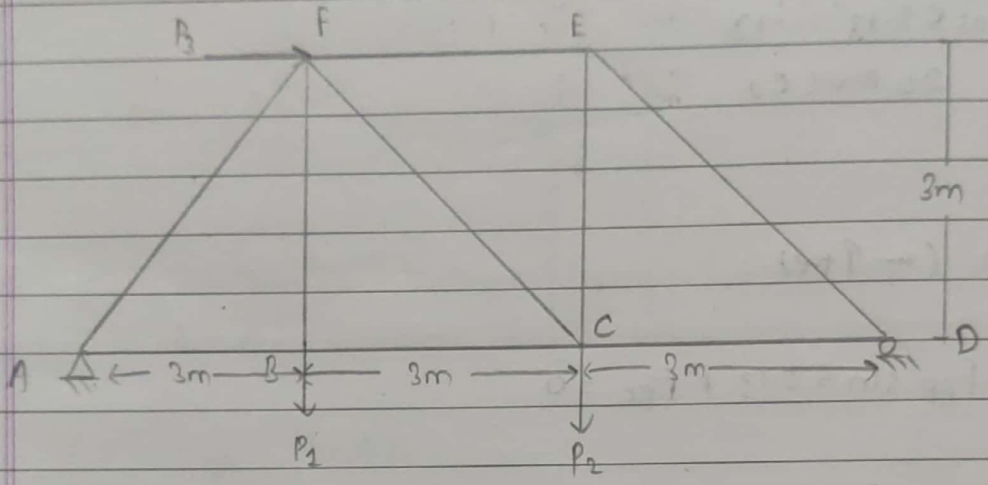
11. Determine the force in members FF, BF, BC and BF of the truss and state if these members are in tension or compression. Set $P_1 = 9kN$, $P_2 = 12kN$, $P3 = 6kN$



Solv^n: Calculating the reaction

$\Sigma F_x = 0$ ($\rightarrow$ +ve)

$-A_x + P_3 = 0$

or $A_x = 6kN (\leftarrow)$

$\Sigma F_y = 0$

$A_y + D_y - P_1 - P_2 = 0$

or $A_y + D_y - 9 - 12 = 0$

or $A_y + D_y = 21\ kN$

$\Sigma M_A = 0$ (2 +ve)

$P_3 \times 3 + P_1 \times 3 + P_2 \times 6 - D_y \times 9 = 0$

or $6 \times 3 + 9 \times 3 + 12 \times 6 = 9D_y$

or $18 + 27 + 72 = 9D_y$

$\therefore D_y = 13kN (\uparrow)$

$\therefore A_y = 8kN (\uparrow)$

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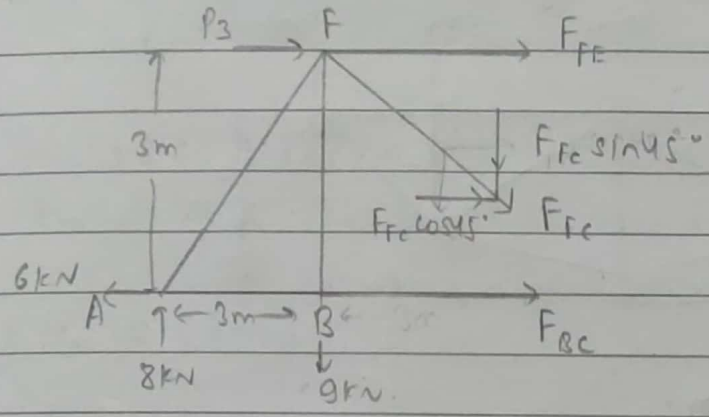
Taking the desired section



Now,

$\Sigma F_x = 0$ (→ +ve)

$P_3 + F_{FE} + F_{Fc}\cos 45^\circ + F_{BC} - 6kN = 0$

or, $F_{FE} + F_{Fc}\cos 45^\circ + F_{BC} = 0$

$\Sigma F_y = 0$ (↑ +ve)

$8 - 9 - F_{Fc}\sin 45^\circ = 0$

or, $F_{Fc} = -\sqrt{2}\ kN$

or, $F_{Fc} = \sqrt{2}\ kN$ (C)

$\Sigma M_B = 0$ (↻ +ve)

$8 \times 3 + 6 \times 3 + F_{FE} \times 3 - F_{Fc}\cos 45^\circ \times 3 = 0$

or, $24 + 18 + 3F_{FE} - 3 = 0$

or, $3F_{FE} = -39$

or, $F_{FE} = -13\ kN$

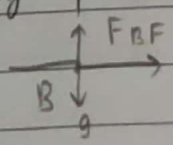
$\therefore F_{FE} = 13\ kN$ (C)

So,

$-B + (-\sqrt{2})\cos 45^\circ + F_{BC} = 0$

or, $F_{BC} = 14kN$ (T)

Taking point B



$F_{BF} - 9 = 0$

$\therefore F_{BF} = 9kN$ (T)

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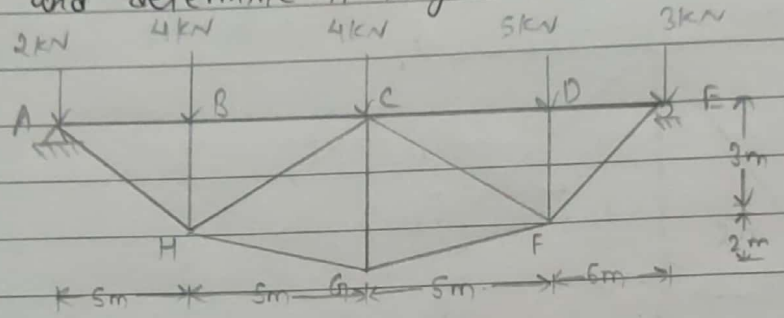
12. Determine the force in members BC, HC and HG of the truss and determine if they are in tension or compression.



solⁿ: Calculation of reaction,

$\Sigma F_x = 0$ ($\rightarrow$ +ve)

$A_x = 0$

$\Sigma F_y = 0$ ($\uparrow$ +ve)

or, $A_y + F_y - 2 - 4 - 4 - 5 - 3 = 0$

or, $A_y + E_y = 18$ —①

$\Sigma M_A = 0$

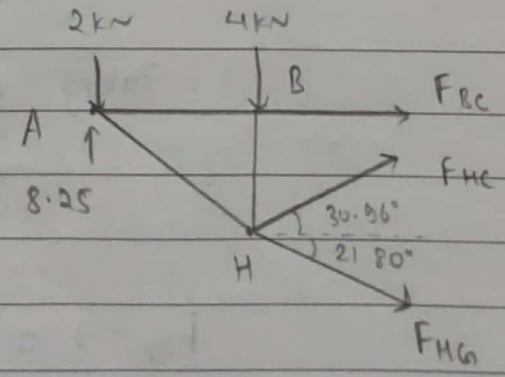
$4 \times 5 + 4 \times 10 + 5 \times 15 + 3 \times 20 - 20 \times F_y = 0$

or, $20 + 40 + 75 + 60 = 20 F_y$

$\therefore F_y = 9.75 kN (\uparrow)$

$\therefore A_y = 8.25 kN (\uparrow)$

Taking the desired section



$\Sigma F_x = 0$ ($\rightarrow$ +ve)

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$F_{BC} + F_{HC}\cos 30.96^\circ + F_{HG}\cos 21.80 = 0$ —(i)

$\Sigma F_y = 0$ (↑ +ve)

$-2 - 4 + 8.25 + F_{HC}\sin 30.96 - F_{HG}\sin 21.80 = 0$

$F_{HC}\sin 30.96 - F_{HG}\sin 21.80 = -2.25$ —(ii)

$\Sigma M_H = 0$ (↻ +ve)

$-2\times 5 + 8.25\times 5 + 3\times F_{BC} = 0$

$-10 + 41.25 + 3F_{BC} = 0$

$3F_{BC} = -31.25$

$\therefore F_{BC} = 10.41\ kN\ (C)$

Then,

$F_{HC}\cos 30.96 + F_{HG}\cos 21.80 = 10.41$ —(iii)

solving (ii) and (iii)

$F_{HC} = 5.94\ kN\ (T) = 2.23\ kN\ (T)$

$F_{HG} = 14.29\ kN\ (T) = 9.15\ kN\ (T)$

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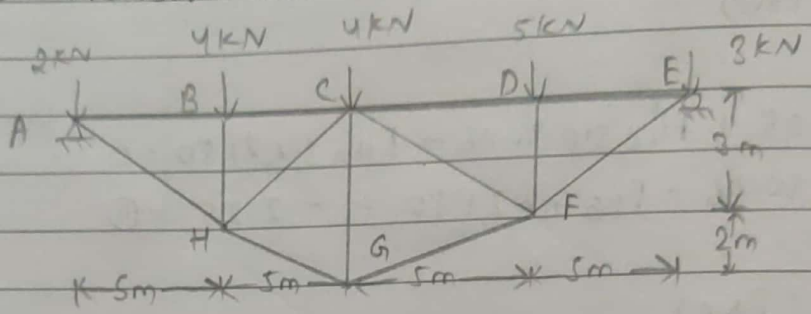
13. Determine the force in members CD, CF and CG and sta if these members are in tension or compression.

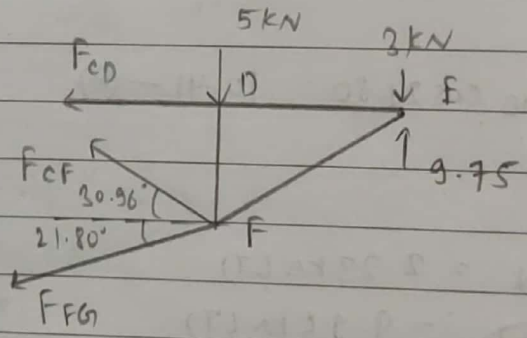


soln: From previous question

$A_y = 8.25kN(\uparrow)$

$E_y = 9.75kN(\uparrow)$

Taking the desired section



$\Sigma M_F = 0$ (⟲ tve)

$3 \times 5 \quad -F_{CD} \times 3 - 9.75 \times 5 = 0$

or, $3F_{CD} = -9.75 \times 5 + 3 \times 5$

$\therefore F_{CD} = 11.25kN$ (C)

$\Sigma F_x = 0$ ($\rightarrow$ tve)

$-F_{CD} - F_{CF} \cos 30.96 - F_{FG} \sin \cos 21.80 = 0$

or, $F_{CF} \cos 30.96 + F_{FG} \cos 21.80 = -(-11.25)$

or, $F_{CF} \cos 30.96 + F_{FG} \cos 21.80 = 11.25$ -①

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$\Sigma F_y = 0$ (↑ +ve)

$-3 - 5 + 9.75 + F_{CF} \sin 30.96 - F_{FG} \sin 21.80 = 0$

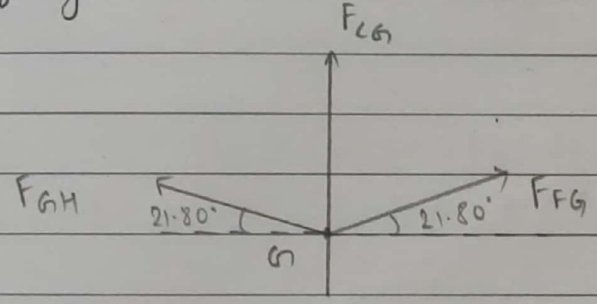
$\therefore F_{CF} \sin 30.96 - F_{FG} \sin 21.80 = -1.75$ — (ii)

Solving (i) and (ii)

$F_{CF} = 3.20$ kN (T)

$F_{FG} = 9.15$ kN (T)

Taking joint G



$\Sigma F_x = 0$ (→ +ve)

$F_{FG} \cos 21.80 = F_{GH} \cos 21.80$

$\therefore F_{FG} = F_{GH} = 9.15$ kN (T)

$\Sigma F_y = 0$ (↑ +ve)

$\therefore F_{CG} + F_{GH} \sin 21.80 + F_{FG} \sin 21.80 = 0$

$\therefore F_{CG} = 6.79$ kN (C)

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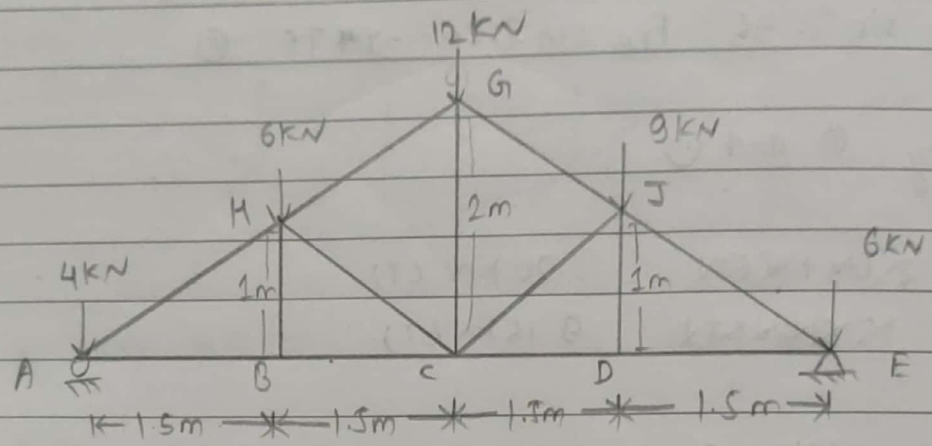
14. Determine the force in members BC, HC and HG. State if these members are in tension or compression.



solⁿ: Calculation of reaction

$\Sigma F_x = 0$ (→ +ve)

∴ As $E_x = 0$

$\Sigma F_y = 0$

or, $A_y + E_y - 4 - 6 - 12 - 9 - 6 = 0$

or $A_y + E_y = 37$ KN

$\Sigma M_E = 0$

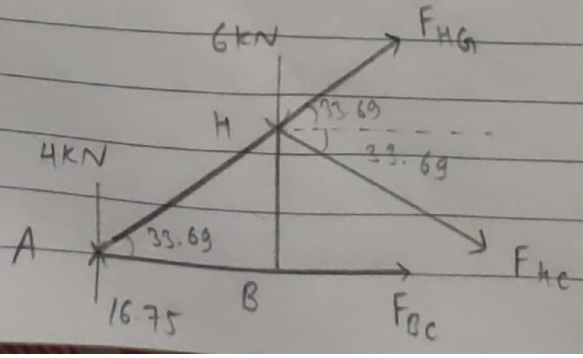
or, $A_y \times 6 - 9 \times 1.5 - 12 \times 3 - 6 \times 4.5 - 4 \times 6 = 0$

or $6A_y = 100.5$

or $A_y = 16.75$ KN (↑)

∴ $E_y = 20.25$ KN (↑)

Taking desired section.



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$\Sigma M_H = 0$

or, $16.75 \times 1.5 - 4 \times 1.5 + F_{BC} \times 1 = 0$

or, $F_{BC} = +19.125$ KN

$\therefore F_{BC} = 19.125$ KN (T)

$\Sigma F_x = 0$ ($\rightarrow$ +ve)

or, $-19.125 + F_{HG} \cos 33.69 + F_{HC} \cos 33.69 = 0$

or, $F_{HG} \cos 33.69 + F_{HC} \cos 33.69 = 19.125$ KN — (i)

$\Sigma F_y =$ ($\uparrow$ +ve)

$16.75 - 4 - 6 + F_{HG} \sin 33.69 - F_{HC} \sin 33.69 = 0$

or, $F_{HG} \sin 33.69 - F_{HC} \sin 33.69 = -6.75$ — (ii)

Solving (i) and (ii)

$F_{HG} = -17.57$ KN $= 17.57$ KN (C)

$F_{HC} = -5.40$ KN $= 5.4$ KN (C)

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15. Determine the force in members BC, CH, GH and CG of the truss and state if the members are in tension or compression.

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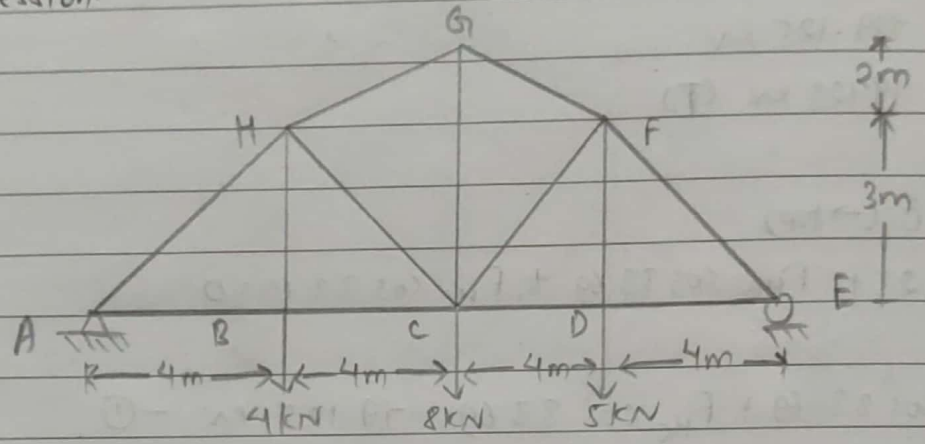


Solⁿ: Calculation of reaction

$\Sigma F_x = 0$ ($\rightarrow$ +ve)

$\therefore A_x = 0$

$\Sigma F_y = 0$ ($\uparrow$ +ve)

or, $A_y + E_y - 4 - 8 - 5 = 0$

or, $A_y + E_y = 17\ kN$ — ①

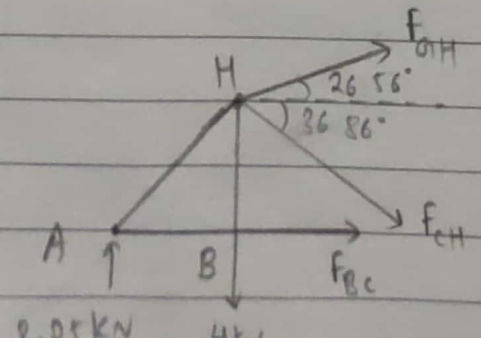
$\Sigma M_A = 0$

or, $4 \times 4 + 8 \times 8 + 5 \times 12 - E_y \times 16 = 0$

$\therefore E_y = 8.75\ kN$ ($\uparrow$)

$\therefore A_y = 8.25\ kN$ ($\uparrow$)

Taking the required section,



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$\Sigma M_H = 0$ (2+ve)

or, $8.25 \times 4 - F_{BC} \times 3 = 0$

or, $3F_{BC} = 8.25 \times 4$

or, $F_{BC} = \frac{8.25 \times 4}{3}$

$\therefore F_{BC} = 11\,kN$ (T)

$\Sigma F_x = 0$ ($\rightarrow$ +ve)

or, $F_{BC} + F_{GH} \cos 26.56 + F_{CH} \cos 36.86 = 0$

or, $F_{GH} \cos 26.56 + F_{CH} \cos 36.86 = -11\,kN$ — (i)

$\Sigma F_y = 0$ ($\uparrow$ +ve)

or, $-4 + 8.25 + F_{GH} \sin 26.56^\circ - F_{CH} \sin 36.86 = 0$

or, $F_{GH} \sin 26.56^\circ - F_{CH} \sin 36.86 = -4.25$ — (ii)

Solving (i) and (ii)

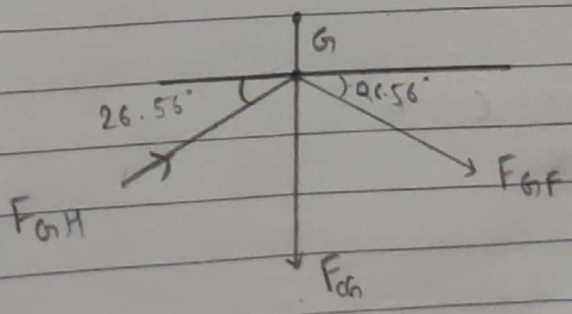
$F_{GH} = -11.18\,kN$

$= 11.18\,kN$ (C)

$F_{CH} = -1.24\,kN$

$= 1.24\,kN$ (C)

Taking joint G



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$\Sigma F_x = 0$ ($\rightarrow$ +ve)

or $F_{GH}\cos 26.56 + F_{GF}\cos 26.56 = 0$

or $F_{GF}\cos 26.56 = -F_{GH}\cos 26.56$

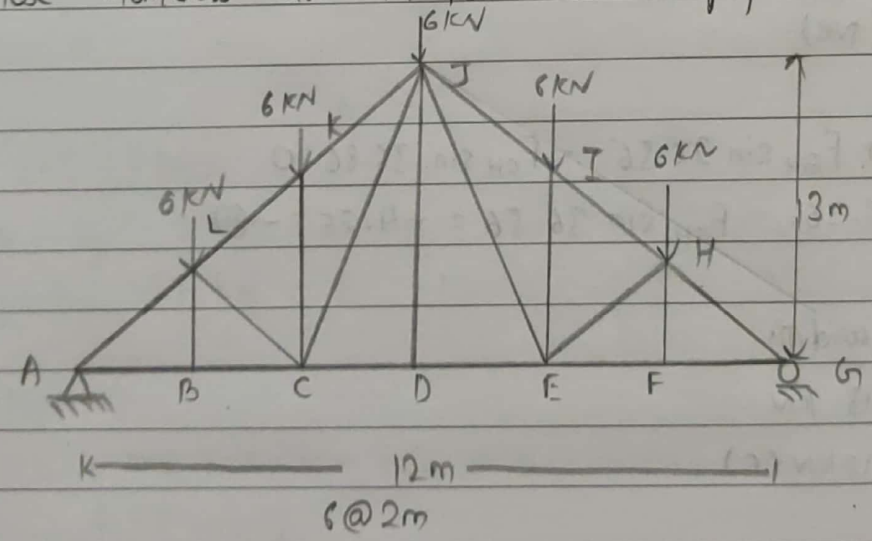
$\therefore F_{GF} = 11.18\ kN\ (C)$

$\Sigma F_y = 0$ ($\uparrow$ +ve)

$-F_{CG} + F_{GH}\sin 26.56 + F_{GF}\sin 26.56 = 0$

$\therefore F_{CG} = 9.99\ kN\ (T)$

16. Determine the force in members CD, CJ and EJ and state if these members are in tension or compression.



Solⁿ: Calculating the reactions

$\Sigma F_x = 0$ ($\rightarrow$ +ve)

$\therefore A_x = 0$

$\Sigma F_y = 0$ ($\uparrow$ +ve)

$A_y + G_y - 6 - 6 - 6 - 6 - 6 = 0$

or $A_y + G_y = 30\ kN$ —①

$\Sigma M_A = 0$

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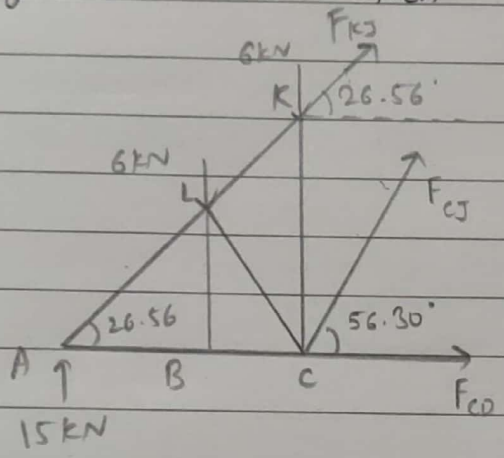
or, $6\times2 + 6\times4 + 6\times6 + 6\times8 + 6\times10 - G_y \times 12 = 0$

or, $G_y \times 12 = 180$

or, $G_y = 15\ kN(\uparrow)$

$\therefore A_y = 15\ kN(\uparrow)$

Taking the desired section



$\frac{CK}{AC} = \tan 26.56°$

$\therefore CK = 2m$

$\Sigma M_K = 0$ (2 +ve)

or, $15\times4 - 6\times2 + -F_{CD}\times2 - F_{CJ}\cos 56.30\times2 = 0$

or, $-2F_{CD} - 2F_{CJ}\cos 56.30° = -48$

or, $F_{CD} + F_{CJ}\cos 56.30° = +24$ —(i)

$\Sigma F_x = 0$ (→ +ve)

$F_{CJ}\cos 56.30° + F_{CD} + F_{KJ}\cos 26.56° = 0$ —(ii)

$\Sigma F_y = 0$ (↑ +ve)

$15 - 6 - 6 + F_{KJ}\sin 26.56 + F_{CJ}\sin 56.30° = 0$

or, $F_{CJ}\sin 56.30° + F_{KJ}\sin 26.56° = -3$ —(iii)

Solving (i), (ii) and (iii)

$F_{CD} = 18\ kN\ (T)$

$F_{CJ} = 10.81\ kN(T)$

$F_{KJ} = -26.83\ kN$

$= 26.83\ kN\ (C)$.