Truss

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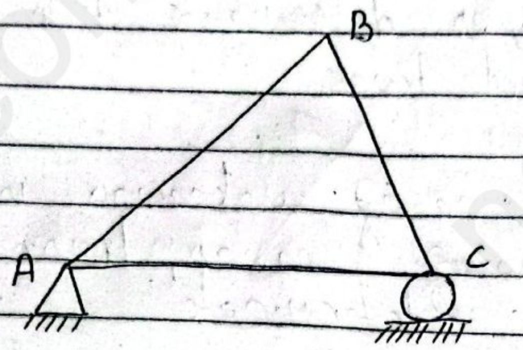
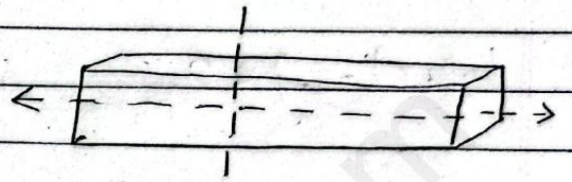


⇒ always axial forces only (✓)



Axial force
- tensile (+ve)
- compression (-ve)

m = no. of member force
r = no. of reactions

No. of unknowns = (m+r)

⇒ At every joint, we have two equilibrium equation ie. $\Sigma F_x = 0$ & $\Sigma F_y = 0$ which can give our knowns.

j = no. of joints

No. of knowns = 2j

⇒ Total indeterminacy = No. of unknown − no. of known
$= (m+r) - 2j$

⇒ External indeterminacy $= r - 3$
⇒ Internal indeterminacy $= [(m+r) - 2j] - (r-3)$

⇒ we don't analyze shear & B.M forces because force is expected to act on joint of a truss and forces are concurrent.

(i) $(m+r) - 2j = 0$; Truss is determinate & is termed as prefect truss.

(ii) $(m+r) - 2j > 0$; Since no. of unknowns is greater than no. of knowns, truss is indeterminate.

(iii) $(m+r) - 2j < 0$; ~~Since~~ Truss is imperfect & unstable.

Analysis of truss.

Two methods are available:

1. Method of joint
2. Method of sections.

➡ If Qstn is saying, find forces in each section, then use method of joint.

➡ If Qstn asking to find forces in certain or particular member only, use method of section.

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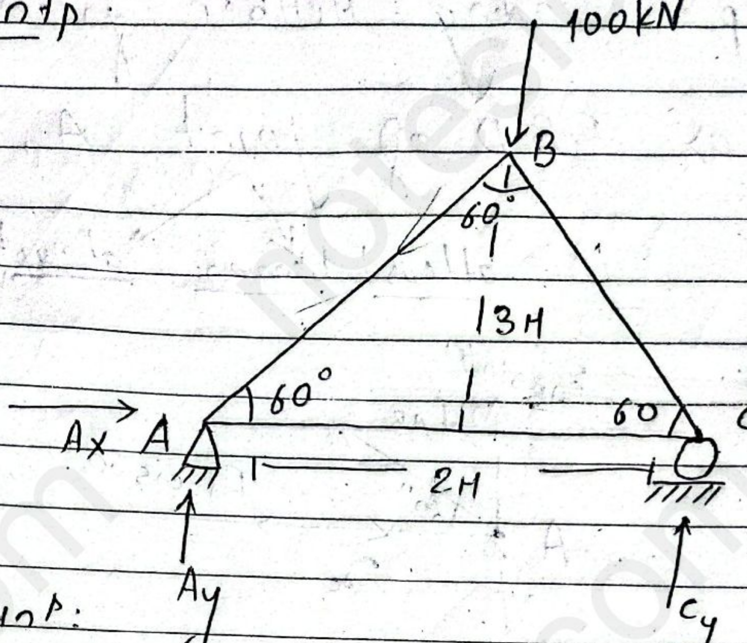
① # Method of joints:



① Step 1: finding rxns:

$(\xrightarrow{+})$: $\Sigma F_x = 0$ or, $A_x = 0$

$\Sigma M_A = 0$ (↺+)

$(\uparrow^{+})$: $\Sigma F_y = 0$; $A_y - 100 + C_y = 0$

or, $- C_y \times 2 + 100 \times 1 = 0$

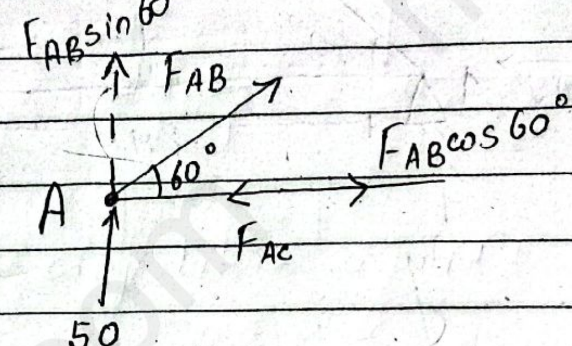
$\therefore C_y = 50\,kN$ (↑)

Thus, $A_y = 100 - 50 = 50\,kN$ (↑)

Step 2: Finding member forces:

a) F.B.D of joint A,

atleast 1 known — at most two unknowns



Using equilibrium equation,

$\Sigma F_x = 0 \ (\longrightarrow +)$

$-F_{AC} \cancel{=0} + F_{AB} \cos 60° = 0$

$\therefore F_{AC} \cancel{=0} = F_{AB} \cos 60° = 0$ — (1)

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

or, $F_{AB} \sin 60° + 50 = 0$

or, $F_{AB} = \dfrac{-50 \times 2}{\sqrt{3}}$

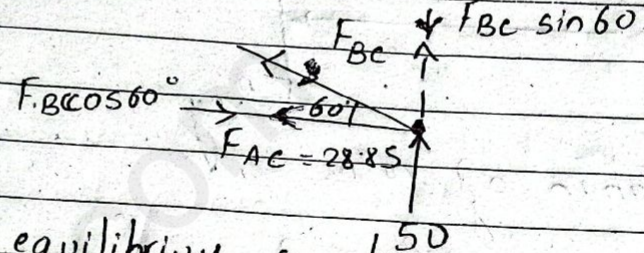
$\therefore F_{AB} = -100/\sqrt{3} = -57.73 kN \ (\downarrow)$

Here, negative sign indicates our assumed nature of axial force is wrong
∴ Force coming at AB is of compression.

eqⁿ ① becomes,

$\therefore F_{AC} = -28.85\,kN \; (\longrightarrow)$

by F.B.D of joint C,



Using equilibrium equation,

$\sum F_x = 0 \; (\xrightarrow{+})$

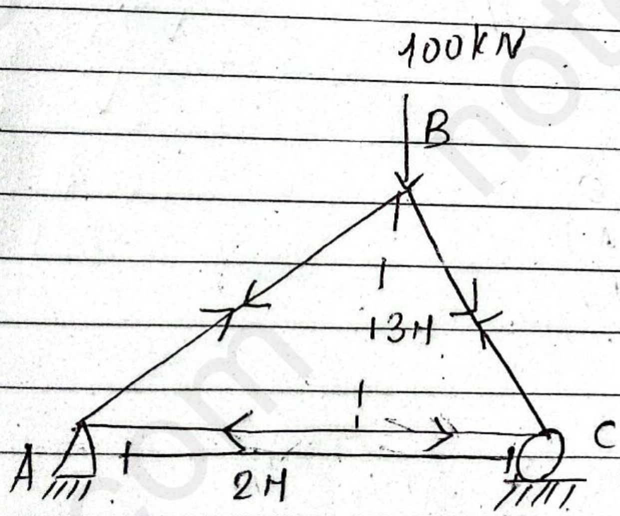
or, $F_{BC} \cos 60° - 28.85 = 0$

$\therefore F_{BC} =$

$\sum F_y = 0 \; (\uparrow^{+})$

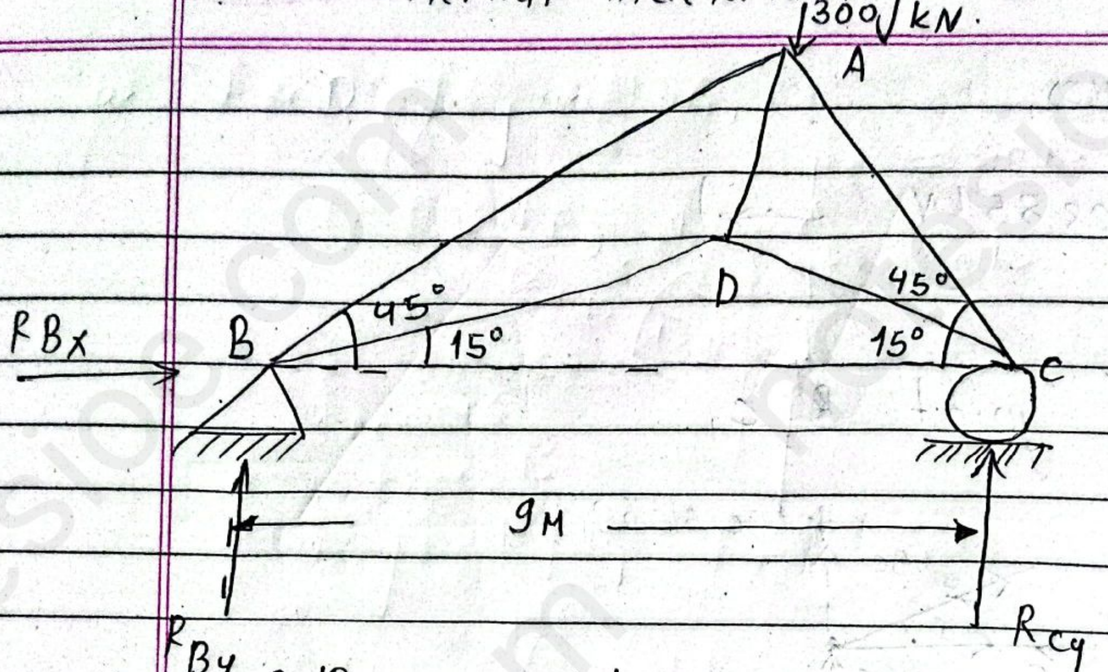
or, $50 + F_{BC} \sin 60° = 0$

$\therefore F_{BC} = -57.7 \; (\downarrow)$



Member	Force	Nature (T/C)
AB	57.7	C
AC	28.86	T
BC	57.7	C

Q) Find reaction forces in each member & determine total degree of external & internal indeterminacy.



Soln: Computation of rxn:

$(\xrightarrow{+}) \sum F_x = 0$

$\therefore R_{Bx} = 0 \text{ kN}$

$(\circlearrowleft +) M_B = 0$

or, $-300 \times 4.5 + R_{cy} \times 9 = 0$

$\therefore R_{cy} = 150 \text{ kN} (\uparrow)$

$(\uparrow^{+}) \sum F_y = 0$

or, $R_{By} + 150 - 300 = 0$

$\therefore R_{By} = 150 \text{ kN} (\uparrow)$

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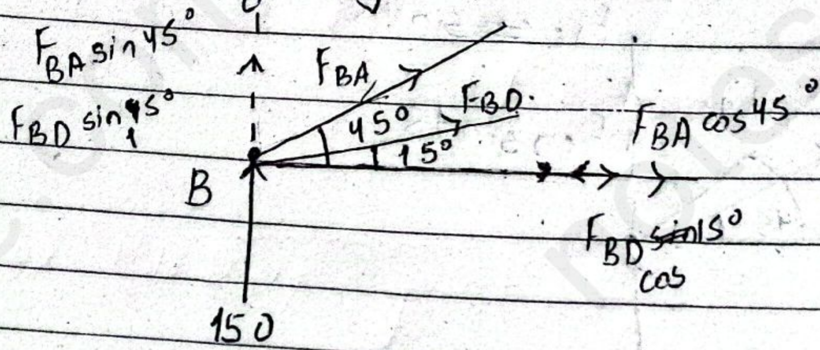
9) F.B.D of joint B.



$\sum F_x = 0 \ (\longrightarrow^{+})$

$\therefore F_{BA} \underset{(0.71)}{\cos 45°} + F_{BD} \underset{(0.966)}{\overset{\cos 15}{\cancel{\sin 45}}}° = 0 \quad -(1)$

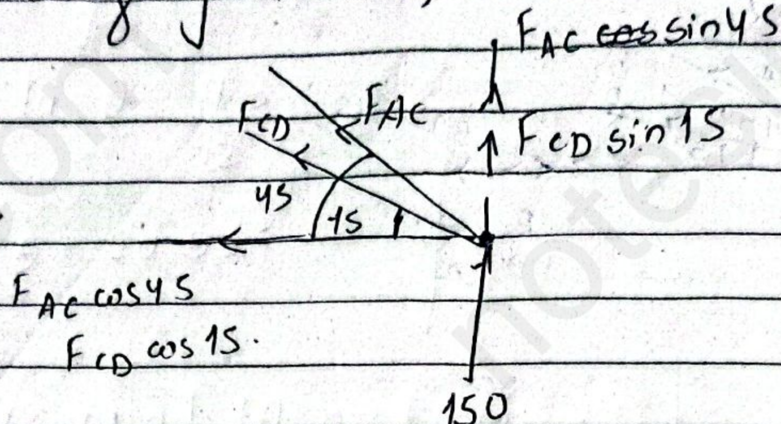
$\sum F_y = 0 \ (\uparrow^{+})$

$\therefore F_{BA} \underset{(0.71)}{\sin 45°} + F_{BD} \underset{(0.2588)}{\sin 15} + 150 = 0 \quad (11)$

$\therefore BA = -289.\cancel{kN}\ 8\ kN\ (C)$

$\therefore BD = 212.13\,kN\ (T)$

b> F.B.D of joint C,



$\Sigma F_x = 0 \ (\xrightarrow{+})$

or, $F_{AC}\cos 45 + F_{CD}\cos 15 = 0$ — (I)

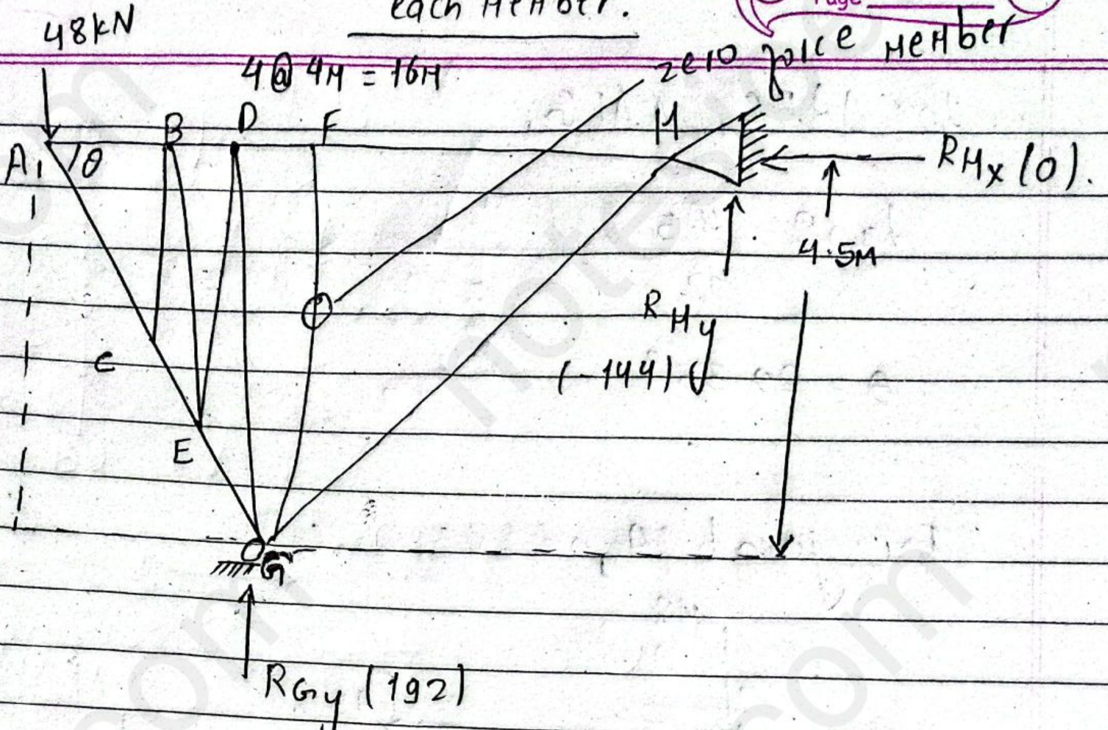
$\Sigma F_y = 0 \ (\uparrow^{+})$

or, $F_{AC}\sin 45 + F_{CD}\sin 15 + 150 = 0$ — (II)

$\therefore AC = -289.8 N (C)$

$\therefore CD = 212.13 kN (T)$

Find forces in each member.



Soln

$(\xrightarrow{+})\ \Sigma F_x = 0$

$\therefore R_{Hx} = 0$

$(\uparrow^{+})\ \Sigma F_y = 0$

or, $R_{Gy} + R_{Hy} - 48 = 0$

$\therefore R_{Hy} = -192 + 48$

$= -144\,kN\ (\downarrow)$

$(\curvearrowright^{+})\ \Sigma M_H = 0$

or, $R_{Gy} \times 4 - 48 \times 16 = 0$

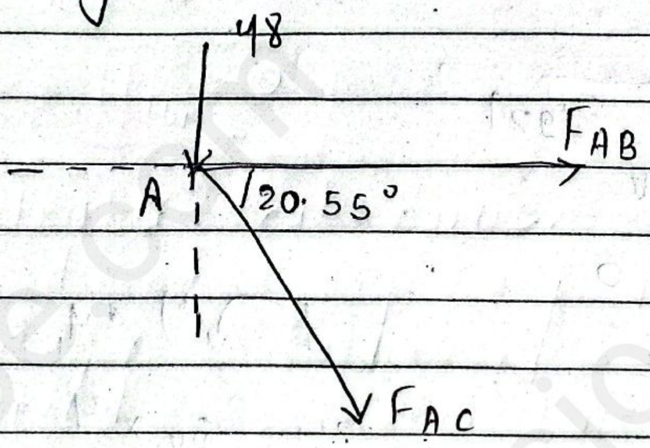
$\therefore R_{Gy} = 192\,kN\ (\uparrow)$

In ΔABC, ΔAFG,

$$\tan\theta = \frac{4.5}{12}$$

$$\theta = 20.55°$$

For joint A,



$\Sigma F_x = 0 \ (\longrightarrow +)$

$F_{AB} + F_{AC}\cos 20.55 = 0$ — ①.

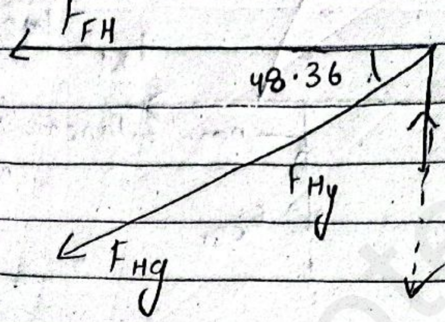
$\Sigma F_y = 0 \ (\uparrow +)$

$-48 - F_{AC}\sin 20.55 = 0$

or, $F_{AC} = -136.74$ kN (Compression).

$F_{AB} = 128.038$ kN (Tensile)

For joint H,



In Δ FGH,

$\tan\theta = \frac{4.5}{4}$

$\theta = 48.36°$.

$\sum F_x = 0 \; (\xrightarrow{+})$

or, $-F_{FH} - F_{HG}\cos 48.36 = 0$ — (1)

$\sum F_y = 0 \; (\uparrow^{+})$

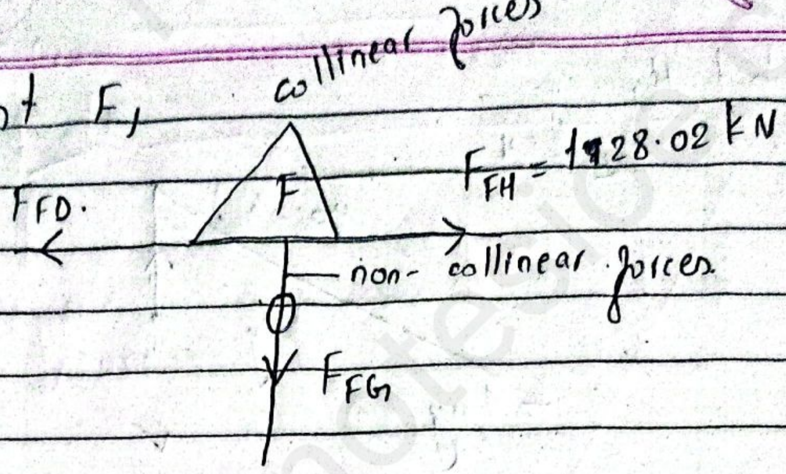
or, $-F_{HG}\sin 48.36 + (-144) = 0$

$\therefore F_{HG} = -192.68$ kN

$= 192.68$ kN (compression)

$\therefore F_{FH} = 128.03$ kN (Tensile)

For joint F,

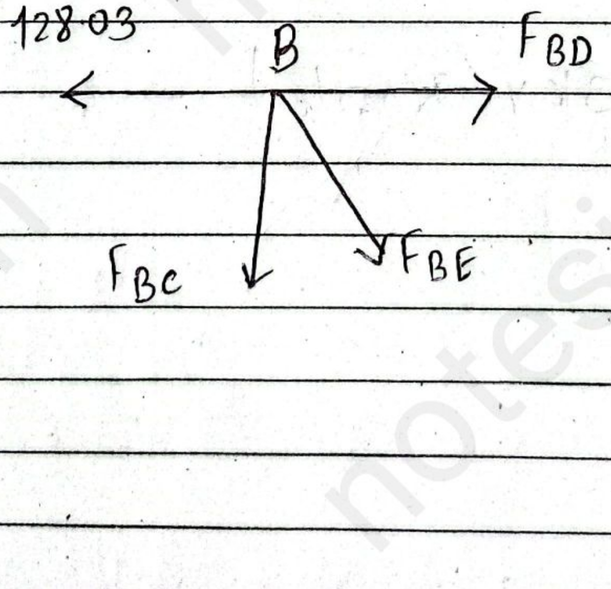


$\therefore$ ~~$F_{FD} = 128.02$ kN (Tensile)~~

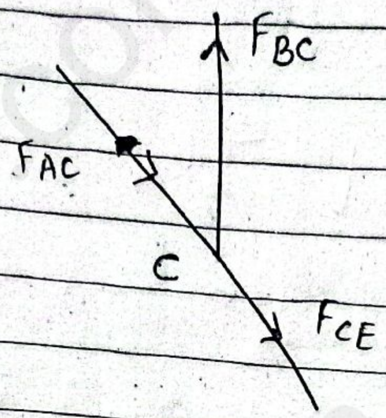
$\boxed{F_{FG} = 0}$

Member that carries zero load / that doesn't play any role in load transfer mechanism. Such member is termed as zero force member.

For joint B,



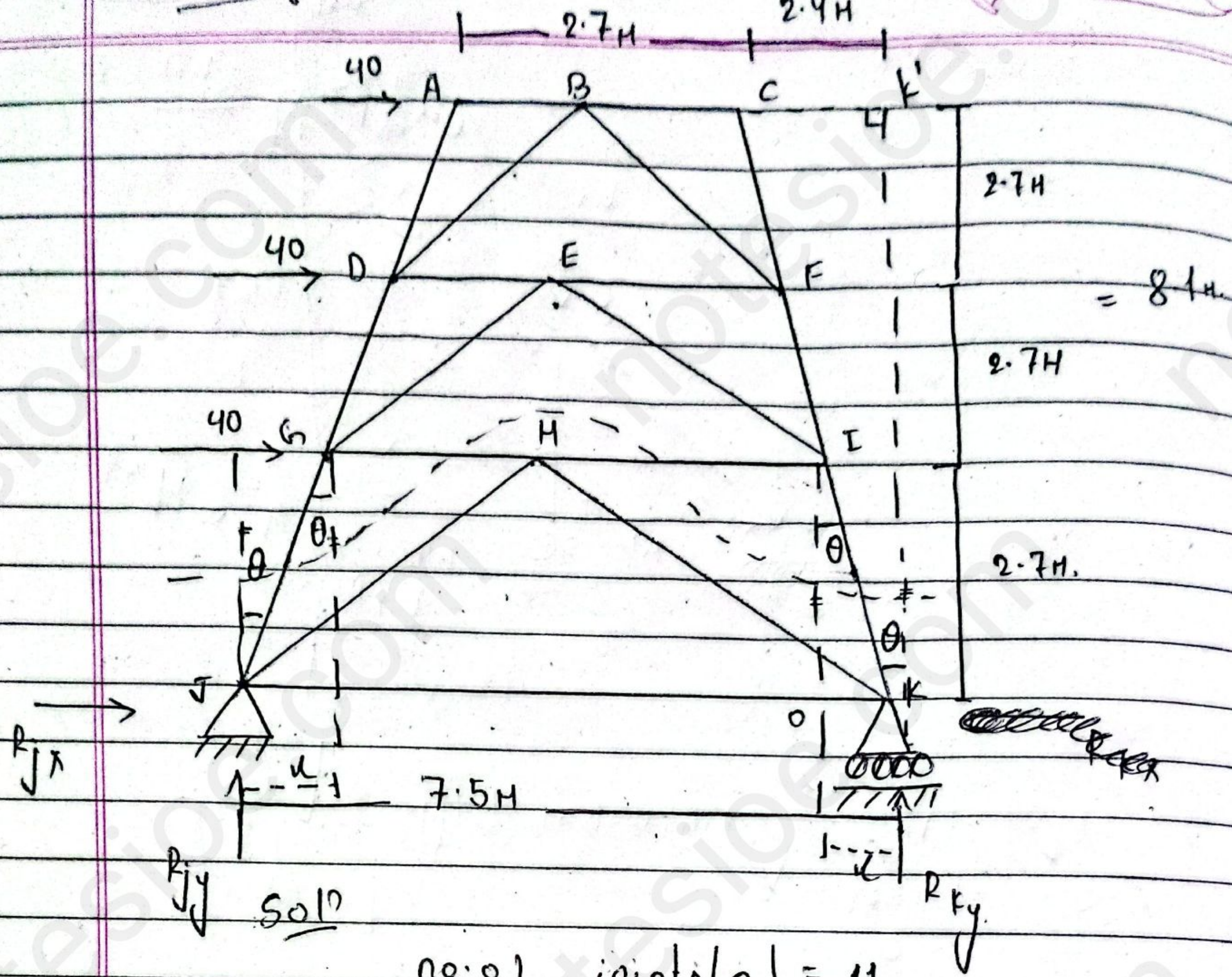
For joint C,



Here, F_{AC} & F_{CE} are collinear forces & F_{BC} is non-collinear force so, ~~F_{BC} is~~ member BC is zero force member.

Thus, $F_{AC} = F_{CE} = 136.74\,kN$.

Find force in member IK.



Soln

no. of joints(n) = 11
no. of members(m) = 19
r = 3

Total indeterminacy = (m+r) − 2j
= (19+3) − 2 × 11
= 0

External indeterminacy = r − 3
= 0

Internal = Total − External = 0 − 0 = 0.

In $\Delta CK'K$,

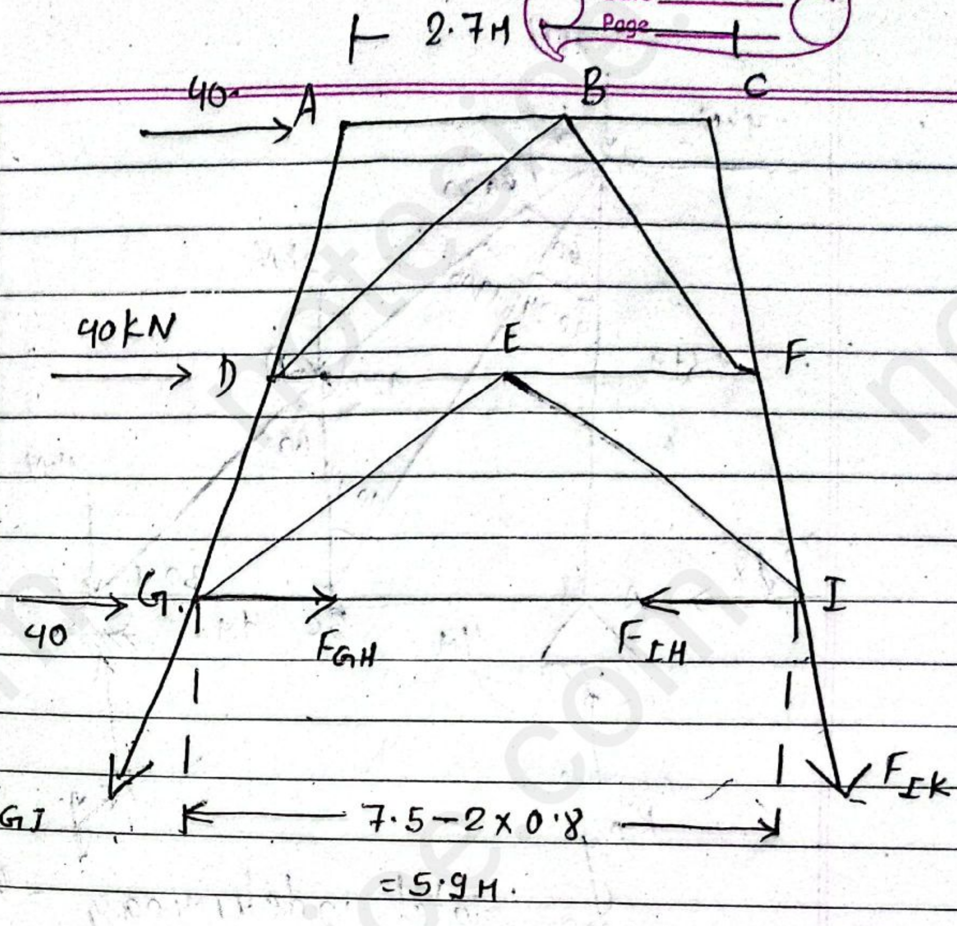
$\tan\theta = \frac{2.4}{8.1}$

$\theta = 16.5^\circ$

In ΔIOK,

$\tan\theta = \frac{x}{2.7}$

$x = 0.8\,m$.



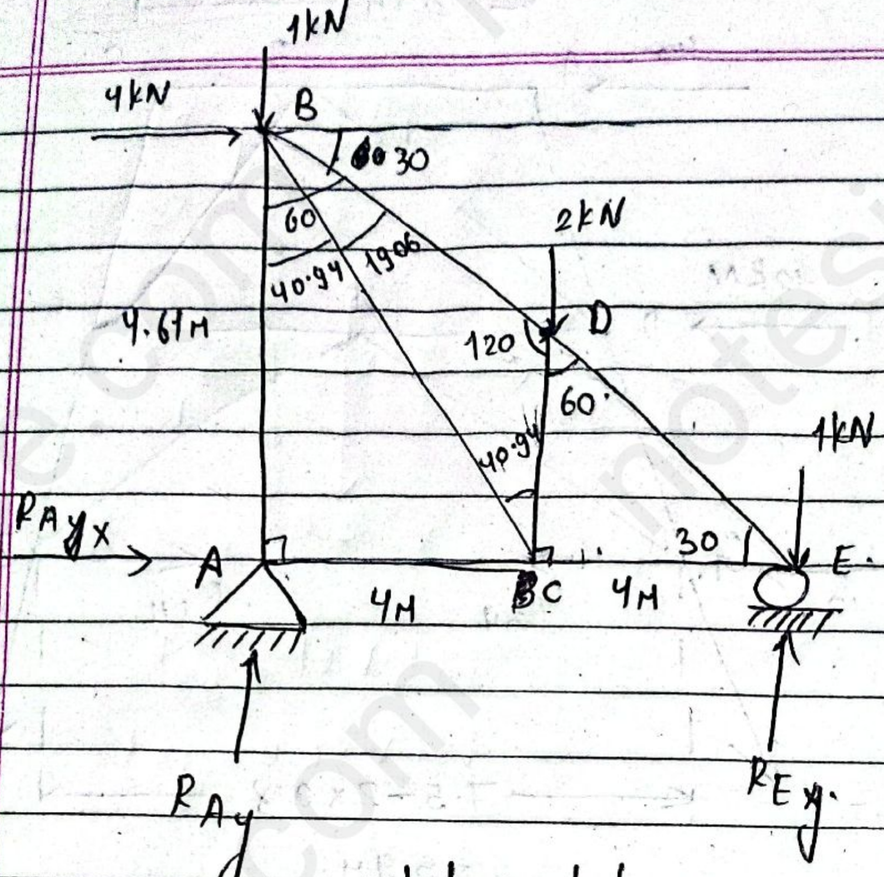
Taking moment about G,

$(\curvearrowright +)\ \Sigma M_G = 0$

or, $40 \times 5.4 + 40 \times 2.7 + F_{IK} \cos 16.5 \times 5.9 = 0$.

$$F_{IK} = -\frac{324}{5.65} = -57.27\,kN$$

$\therefore F_{IK} = 57.27\,kN$ (compression)



Total indeterminacy $= (m+r) - (2j)$

$= (7+3) - 2\times 5$

$= 0.$

Ext. indeterminacy $= r-3 = 0.$

Internal $= 0.$

$\Sigma F_x = 0 \ (\xrightarrow{+})$

or, $R_{Ax} + 4 = 0$

$\therefore R_{Ax} = -4\,kN \ (\leftarrow)$

$(\circlearrowright +)\ \Sigma M_A = 0$

or, $4 \times 4.61 + 2 \times 4 + 1 \times 8 - R_{Ey} \times 8 = 0$

or $R_{Ey} = 4.305\ kN\ (\uparrow)$

$R_{Ay} = -0.305 kN\ (\downarrow)$

In ΔBAE,

$\tan\theta = \frac{BA}{AE}$

$\tan 30 \times 8 = BA$

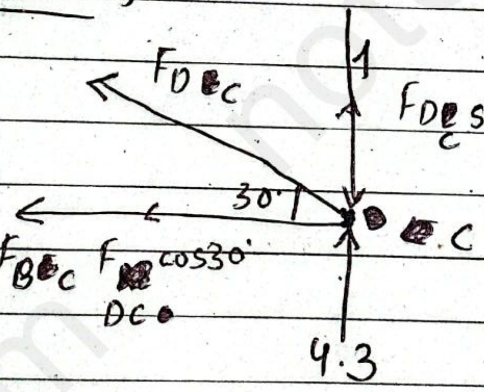
$\therefore AB = 4.61 m.$

In Δ BAC,

$\tan\theta = \frac{4}{4.61}$

$\therefore \theta = 40.94°$

In joint E,



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

or, $F_{DE} \sin 30 - 1 + 4.3 = 0$

or, $F_{DE} \frac{1}{2} = -3.3$

$\therefore F_{DE} = 6.6\ kN$ (compression)

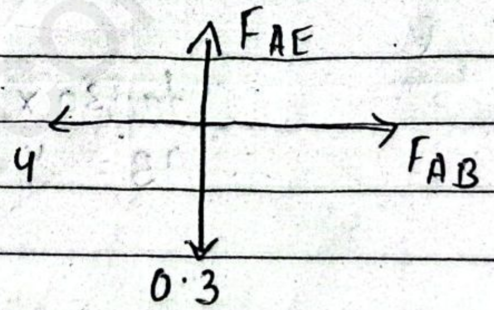
$\Sigma F_x = 0\ (\xrightarrow{+})$

or, $-F_{CE} - F_{DE} \cos 30 = 0$

or, $F_{BC} = 5.71\ kN$

(tension).

In joint A,



$F_{AB} = 4\,kN\ (T)$

$F_{AE} = 0{\cdot}3\,kN\ (T)$.

At joint E,