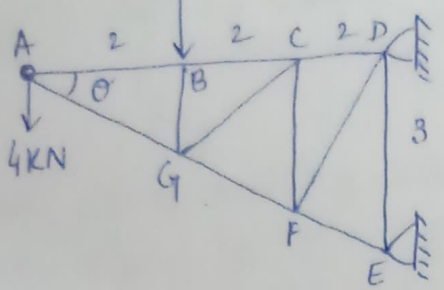
PROBLEM SHEET 3.1

(JOINT METHOD).

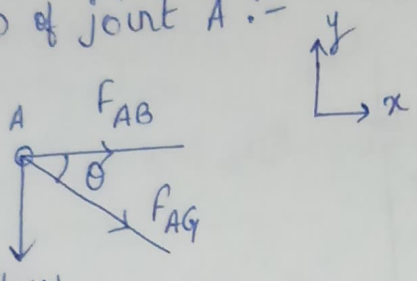
① 

(i) $f_{CG}, f_{CF} = ?$

(ii) If 2KN is removed, members in which $F = 0$.

(iii) If 2KN is applied at G, where is $f = 0$?

⇒ (i) FBD of joint A :-



$$\tan\theta = \frac{3}{6} = \frac{1}{2}$$

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

$$= 26.56^\circ \approx 26.57^\circ$$

$$\Sigma F_x = 0 \Rightarrow f_{AB} + f_{AG}\cos\theta = 0$$

$$f_{AB} + f_{AG}\cos(26.57^\circ) = 0$$

$$\Sigma F_y = 0 \Rightarrow f_{AG}\sin(26.57^\circ) + 4000 = 0$$

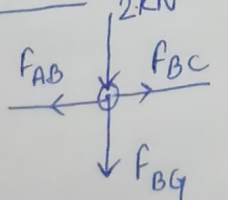
$$f_{AG} = \frac{-4000}{\sin(26.57)} = -8948 = -8.94\,KN.$$

$\therefore f_{AG} = -8.94\,KN$

$$f_{AB} = -f_{AG}\cos(26.57^\circ)$$

$$= -(-7995\ldots) \approx 8\,KN.$$

FBD of joint B :-



$\Sigma F_x = 0,$

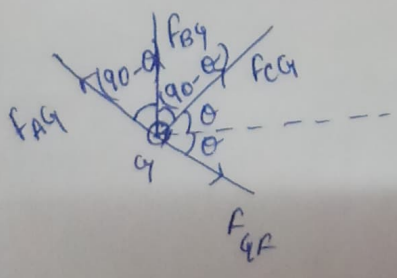
$f_{BC} - f_{AB} = 0$

$f_{BC} = 8\,KN$

$\Sigma F_y = 0 \Rightarrow f_{BG} + 2000 = 0$

$f_{BG} = -2\,KN$ //.

FBD of G :-



$\Sigma F_x = 0 \Rightarrow$

$f_{CG}\cos\theta + f_{GF}\cos\theta - f_{AG}\cos\theta = 0.$

$f_{CG} + f_{GF} - f_{AG} = 0 \rightarrow (2)$

$\Sigma F_y = 0 \Rightarrow$

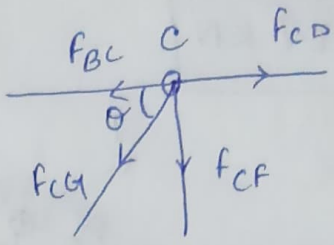
$f_{AG}\cos(90-\theta) + f_{CG}\cos(90-\theta) + f_{BG} - f_{GF}\sin\theta = 0.$

$F_{AG}\sin\theta + F_{CG}\sin\theta + F_{BG} - F_{GF}\sin\theta = 0 \rightarrow (b)$

Solving (a) & (b), we get

$$\boxed{F_{CG} = 2.235\ KN}$$

FBD of C :-



$\Sigma F_y = 0,$

$F_{CF} + F_{CG}\sin\theta = 0$

$$\boxed{F_{CF} = -1KN}$$

(ii) If 2KN force is removed from B, $\boxed{F_{BG}}$ will become zero. And hence,

$$F_{AG}\sin\theta + F_{GC}\sin\theta - F_{GF}\sin\theta = 0.$$

or $F_{AG} + F_{CG} - F_{GF} = 0 \rightarrow$ from (b)

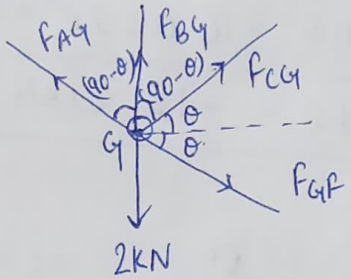
& $F_{GC} + F_{GF} - F_{AG} = 0 \rightarrow$ from (a),

$2F_{GC} = 0$

$$\boxed{F_{GC} = 0\ N}$$

Similarly, F_{CF} & F_{DF} will also be zero.

(iii) If 2KN is applied at G instead of B, F_{BG} will ~~remain same~~ become zero. $\boxed{F_{BG} = 0}$



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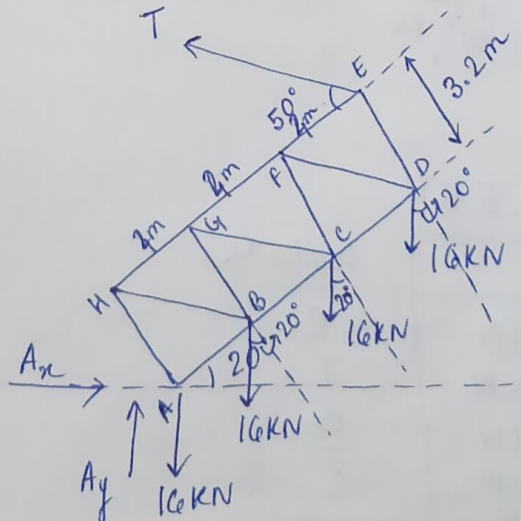
(2) Find value of EF, DE, DF, CD & FG forces



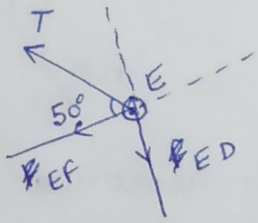
Taking moment about joint A, considering ↺ +ve

$\sum M_A = 0$;

$T\cos(50^\circ) \times 3.2 + T\sin 50^\circ \times (12) - 16\cos 20^\circ (4+8+12) = 0$.

$$\boxed{T = 32.07\ KN}$$

FBD of E :-



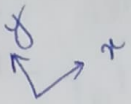
$\sum F_x = 0$,

$T\cos 50^\circ + EF = 0$

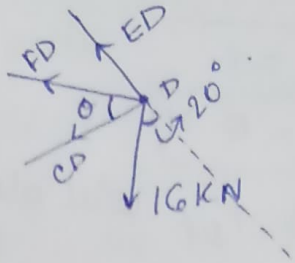
$$\boxed{EF = -20.6\ KN} \rightarrow (\#)$$

$\sum F_y = 0$, $T\sin 50^\circ - ED = 0$

$ED = 24.6\ KN$.



FBD of D :-



$\angle FDC \Rightarrow \tan\theta = \frac{3.2}{4}$

$\theta = \tan^{-1}\left(\frac{3.2}{4}\right)$

$= 38.66^\circ$.

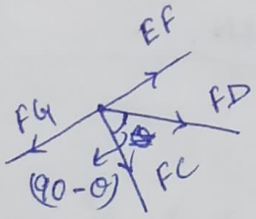
$\sum F_x = 0 \Rightarrow CD + FD\cos\theta + 16\sin 20^\circ = 0$.

$\sum F_y = 0 \Rightarrow ED + FD\sin\theta - 16\cos 20^\circ = 0$.

$\therefore$ $$\boxed{FD = -15.31\ KN}$$

$$\boxed{CD = 6.48\ KN}$$

FBD of F :-



$\sum F_x = 0$,

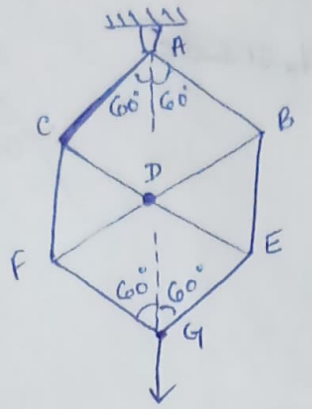
~~$EF - FG = 0$~~

$EF + FD\cos\theta - FG = 0$

$\therefore$ $FG = 32.5\ KN$.

Member	Force	Nature
EF	20.6 KN	C
ED	24.6 KN	T
DF	15.31 KN	C
CD	6.48 KN	T
FG	32.5 KN	T

(3)

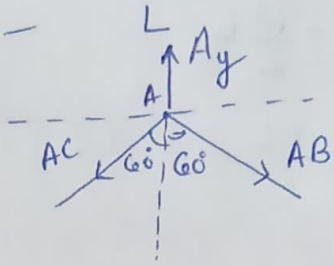


Find BE & BD.

For complete truss, force A_y is acting at joint A.

$A_y - L = 0 \Rightarrow A_y = L$

FBD of A :-



$\Sigma F_x = 0 \Rightarrow AB \sin 60^\circ - AC \sin 60^\circ = 0$

$AB = AC$

$\Sigma F_y = 0,$

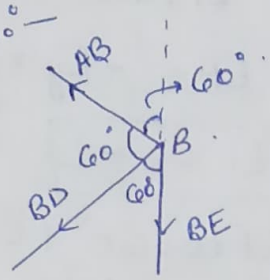
$A_y - AB\cos 60^\circ - AC\cos 60^\circ = 0$

$2AB\cos 60^\circ = L$

$2AB \times \frac{1}{2} = L$

$\boxed{AB = L}$ // & $AC = L$

FBD of B :-



$\Sigma F_y = 0 \Rightarrow AB\cos 60^\circ - BD\cos 60^\circ - BE = 0 \rightarrow (i)$

$\Sigma F_x = 0 \Rightarrow BD \sin 60^\circ + AB \sin 60^\circ = 0 \rightarrow (ii)$

$BD = -AB$

$\underline{BD = -L}$

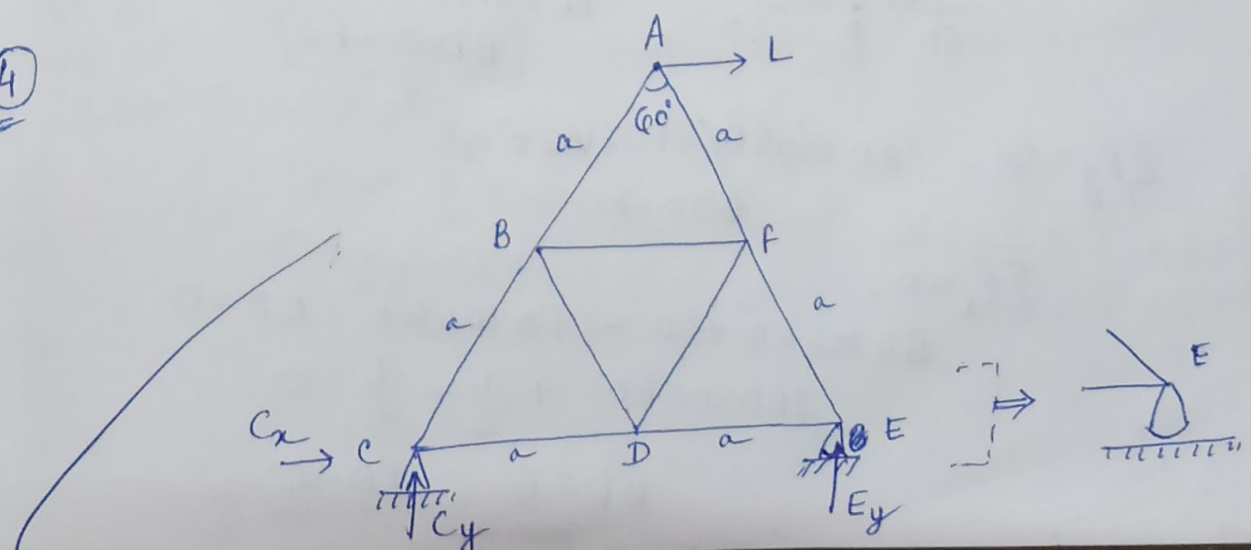
from (i), $\frac{L}{2} + \frac{L}{2} - BE = 0$

$\underline{BE = L}$

$\therefore$ $BD = L$ (C)

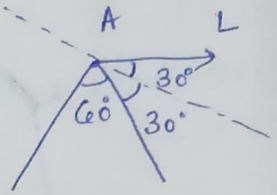
$BE = L$ (T)

(4)



Taking moment about joint C,

+ve ↻ $\Sigma M_C = 0$; ~~$E_y \times 2a - L\cos 30$~~



$E_y \times 2a - L\cos 30^\circ \times 2a = 0$

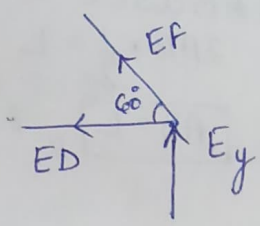
$E_y - L\frac{\sqrt{3}}{2} = 0$

$E_y = \frac{\sqrt{3}}{2} L$

$\Sigma F_y = 0 \Rightarrow C_y + E_y = 0 \Rightarrow C_y = -\frac{\sqrt{3}}{2} L$

$\Sigma F_x = 0 \Rightarrow C_x + L = 0 \Rightarrow C_x = -L$

FBD of joint E :-



$\Sigma F_y = 0 \Rightarrow EF\sin 60^\circ + E_y = 0$

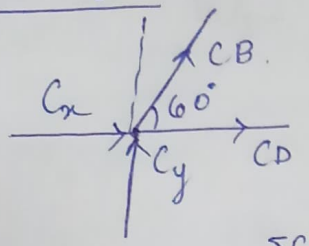
$EF = -E_y \times \frac{2}{\sqrt{3}}$

$\boxed{EF = -L}$

$\Sigma F_x = 0$; $EF\cos 60^\circ + ED = 0$.

$\boxed{ED = \frac{L}{2}}$

FBD of C :-



$\Sigma F_y = 0$, $CB\sin 60^\circ + C_y = 0$

$CB = -C_y \times \frac{2}{\sqrt{3}}$

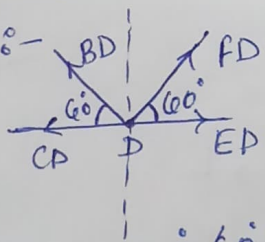
$\boxed{CB = +L}$

$\Sigma F_x = 0$,

$CD + C_x + CB\cos 60^\circ = 0$.

$\boxed{CD = L - \frac{L}{2} = \frac{L}{2}}$ //

FBD of D :-



$\Sigma F_{xy} = 0$,

$FD\sin 60^\circ + BD\sin 60^\circ = 0$.

$\boxed{BD = -FD}$

$\Sigma F_y = 0$, $BD\sin 60^\circ + FD\sin 60^\circ = 0$.

$BD = -FD$.

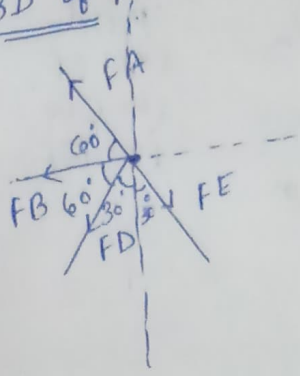
$\Sigma F_x = 0$,

$BD\cos 60^\circ + CD - FD\cos 60^\circ - ED = 0$.

$2BD\cos 60^\circ + \frac{L}{2} - \frac{L}{2} = 0$

$BD = 0$, $FD = 0$.

FBD of f :-



$\Sigma f_y = 0$;

$FA \sin 60^\circ - EF \cos 30^\circ = 0$

$FA = EF \times \frac{\sqrt{3}}{2} \times \frac{2}{\sqrt{3}}$

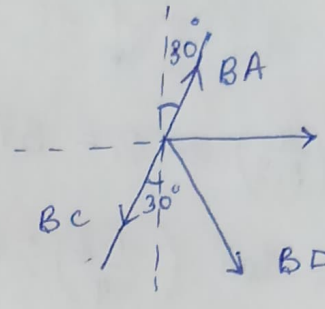
$\boxed{FA = -L}$

$\Sigma F_x = 0$; $FA \cos 60^\circ + FB - FE \sin 30^\circ = 0$

$-\frac{L}{2} + FB + \frac{L}{2} = 0$

$\boxed{FB = 0}$

FBD of B :-



$\Sigma f_y = 0$

$BA \cos 30^\circ - BC \cos 30^\circ = 0$.

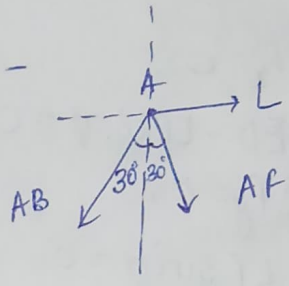
$BA = BC$.

$\Sigma f_x = 0$,

$BC \sin 30^\circ - BA \sin 30^\circ = 0$

$BA = BC$

FBD of A :-



$\Sigma f_y = 0$,

$AB \cos 30^\circ + AF \cos 30^\circ = 0$

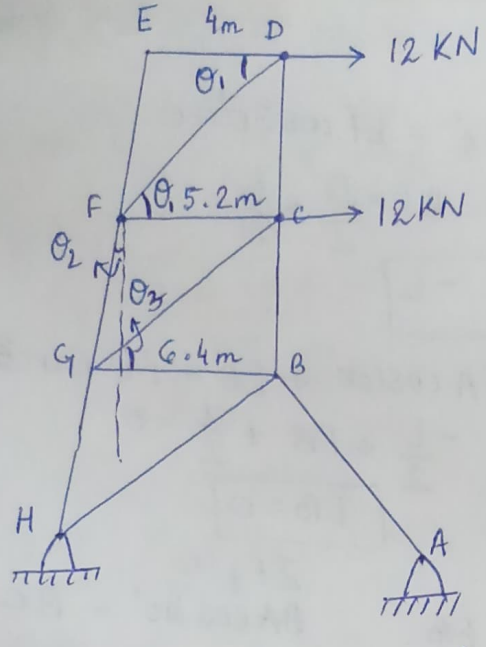
$AB = -AF = L$

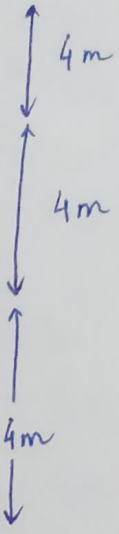
$\therefore$ $AB = BC = L$.

Members	Force	Nature
(1) AB	L	T
(2) BC	L	T
(3) AF	L	C
(4) EF	L	C
(5) DE	L/2	T
(6) CD	L/2	T
(7) BF	0	–
(8) DF	0	–
(9) BD	0	–

PTO

(5)



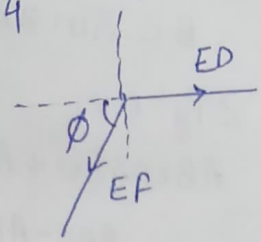


Find
(a) CF
(b) CG
(c) EF

$\tan\theta_1 = \left(\frac{4}{5.2}\right)$, $\theta_1 = \tan^{-1}\left(\frac{4}{5.2}\right) \Rightarrow \theta_1 = 37.57°$.

$\tan\theta_2 = \frac{(6.4-5.2)}{4} \Rightarrow \theta_2 = \tan^{-1}\left(\frac{1.2}{4}\right)$; $\theta_2 = 16.69°$

FBD of E :-



$\Sigma F_x = 0$,

$ED - EF\cos\phi = 0$

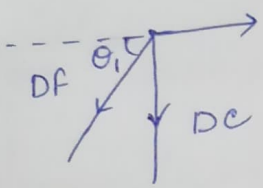
$\Sigma F_y = 0$,

$EF\sin\phi = 0$

$\therefore$ **ED = 0**

EF = 0

FBD of D :-



$\Sigma F_x = 0$,

$12 - DF\cos\theta_1 = 0$.

$DF = \frac{12}{\cos(37.57°)}$

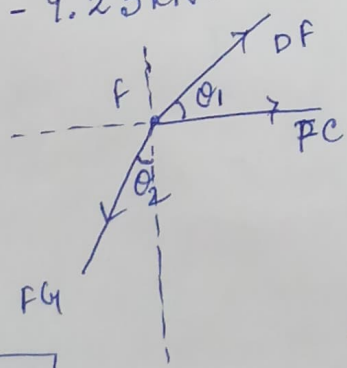
$DF = 15.15$ KN

$\Sigma F_y = 0$; $DC + DF\sin\theta_1 = 0$.

$DC = -DF\sin\theta_1$

$DC = -9.23$KN.

FBD of f :-



$\Sigma F_x = 0$;

$FC + DF\cos\theta_1 - FG\sin\theta_2 = 0$

$\Sigma F_y = 0$;

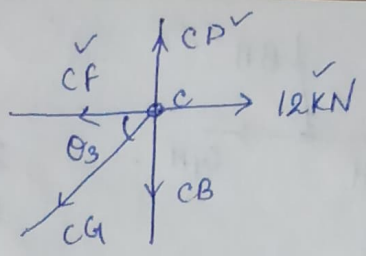
$DF\sin\theta_1 - FG\cos\theta_2 = 0$

Solving we get,

$FG = 9.64$KN

CF = -9.23KN

FBD of C :-



$\Sigma F_x = 0$;

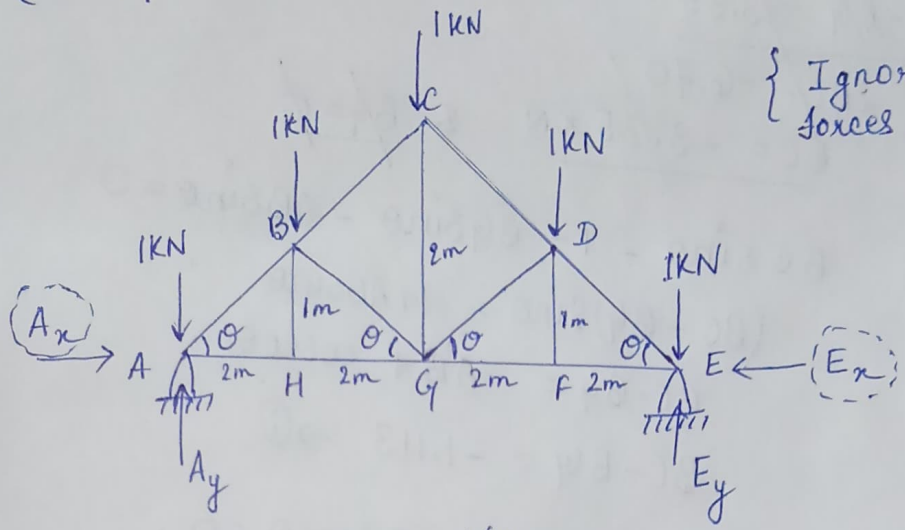
$(CG \cos\theta_3) + CF - 12 = 0$

$CG = \frac{12 - CF}{\cos\theta_3}$

$\boxed{CG = 25.03\,KN}$

Members	Forces	Nature
(i) EF	0	-
(ii) CF	9.23KN	C
(iii) CG	25.03 KN	T

(6)



{ Ignoring horizontal forces A_x & E_x }.

$\tan\theta = \left(\frac{1}{2}\right)$, $\theta = \tan^{-1}\left(\frac{1}{2}\right) = 26.57°$.

$\Sigma M_A = 0$; $E_y(8) - 1KN(8+6+4+2) = 0$

↻ +ve

$E_y = \frac{20}{8}$

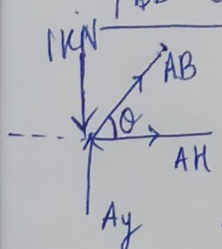
$\boxed{E_y = 2.5\,KN}$

For entire truss, $A_y + E_y - 5 = 0$ $\{\Sigma F_y = 0\}$.

$A_y = 5 - E_y$.

$\boxed{A_y = 2.5\,KN}$

FBD of A



$\Sigma F_x = 0$,

$AH + AB\cos\theta = 0$

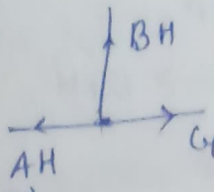
$\Sigma F_y = 0$,

$-1 + AB\sin\theta + A_y = 0$

$AB = \frac{1 - A_y}{\sin\theta} = -3.35KN$

$AH = 3KN$

FBD of H :-



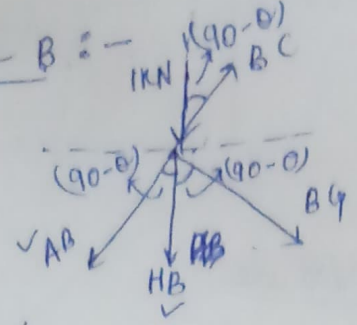
$\Sigma F_y = 0$,

$\boxed{BH = 0}$

$\Sigma F_x = 0$,

$GH = AH = 3\,KN$

FBD of B :-



$\Sigma F_y = 0$;

$BC\sin\theta - AB\sin\theta - BG\sin\theta - 1 = 0$

$BC - BG = AB = -3.35\,KN$

$\Sigma F_x = 0$,

$BC\cos\theta + BG\cos\theta - AB\cos\theta = 0$

$BC + BG = -3.35$

$BC - BG = 3.35$

$2BC = -6.70$

$BC = -3.35\,KN$ & $BG = 0$

$\Sigma F_y = 0$; $BC\sin\theta - 1 = BG\sin\theta - AB\sin\theta = 0$

$(BC - BG)\sin\theta = 1 + AB\sin\theta$

$BC - BG = AB + \operatorname{cosec}\theta$

$BC - BG = -1.113 \rightarrow (i)$

$\Sigma F_x = 0$; $BC\cos\theta + BG\cos\theta - AB\cos\theta = 0$.

$BC + BG = -3.35 \rightarrow (ii)$

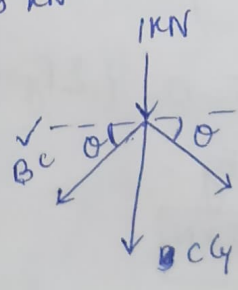
$BC - BG = -1.113$

$BC = \frac{-4.463}{2} = -2.231$

$BC = -2.232\,KN$

$\therefore BG = -1.1178\,KN$

FBD of C :-



$\Sigma F_x = 0$;

$BC\cos\theta - CD\cos\theta = 0$

$BC = CD = -2.232\,KN$

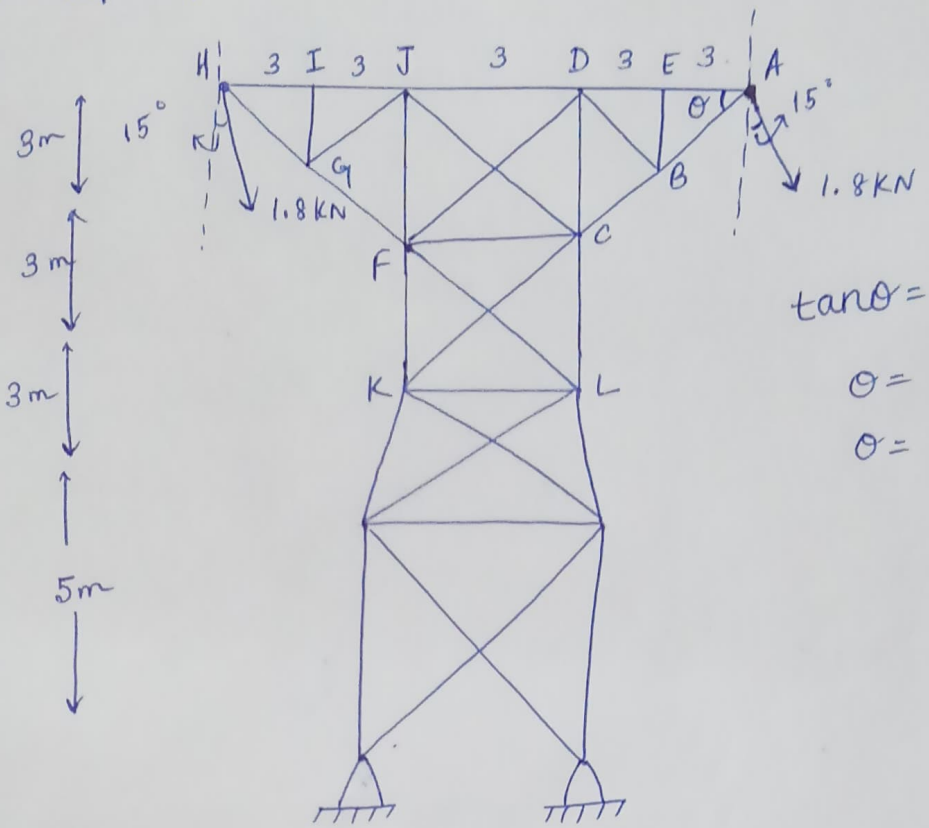
$\Sigma F_y = 0$; $1 + CG + 2BC\sin\theta = 0$

$CG = -(2BC\sin\theta + 1)$

$= -3\,KN$

Members	Force (KN)	Nature
(i) AB = DE	3.35	C
(ii) BC = CD	2.24	C
(iii) AH = EF	3 KN	T
(iv) BH = DF	0	-
(v) GH = FG	3KN	T
(vi) BG = DG	1.1KN	C.

(7)

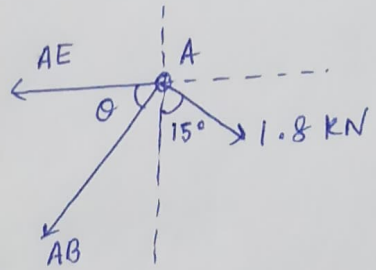


$\tan\theta = \frac{3}{6}$

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

$\theta = 26.57°$

FBD of A :-



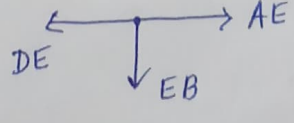
$\Sigma F_y = 0;$

$1.8\cos 15° + AB\sin\theta = 0$

$AB = \frac{-1.8\cos 15°}{\sin(26.57°)} = -3.89\ KN$

$\Sigma F_x = 0; \quad AE + AB\cos\theta - 1.8\sin 15° = 0.$

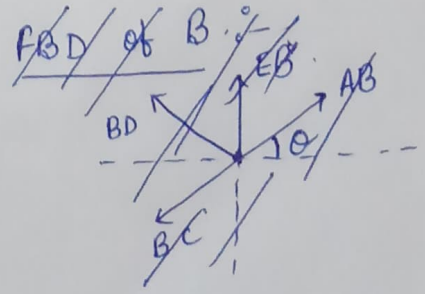
FBD of E :-



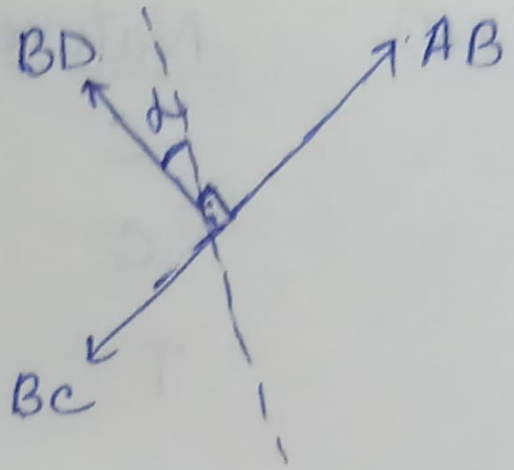
$\Sigma F_y = 0;$

$EB = 0$

FBD of B :-



FBD of B :-



$\Sigma F_y = 0$;

$BD \cos\alpha = 0$

$\boxed{BD = 0}$

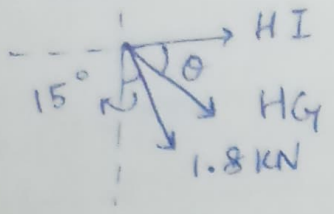
$\Sigma F_x = 0$,

$BC - AB = 0$

$\underline{\underline{BC = AB = -3.89\,kN}}$

$N_A + N_B$

FBD of H :-



$\Sigma F_{xy} = 0$;

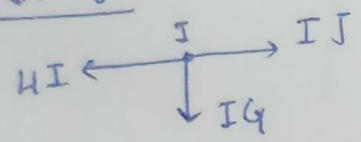
$HG \sin\theta + 1.8 \cos 15^\circ = 0$

$HG = -3.88$ KN

$\Sigma F_x = 0$; $HI + HG\cos\theta + 1.8 \sin 15^\circ = 0$

$HI = 3.00$ KN

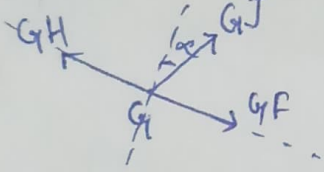
FBD of I :-



$\Sigma F_y = 0 \Rightarrow IG = 0$

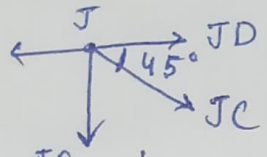
$\Sigma F_x = 0 \Rightarrow IJ = -HI = -3$ KN

FBD of G :-



$\Sigma F_y = 0 \Rightarrow GJ = 0$.

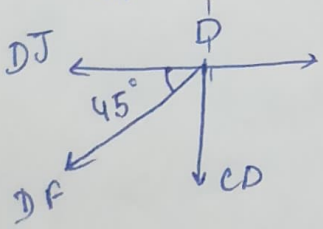
FBD of J :-



$JD + JC\cos 45^\circ = -3$ $(\Sigma F_x = 0)$

$JF + JC \sin 45^\circ = 0$ $(\Sigma F_y = 0)$

FBD of D :-



$\Sigma F_x = 0$;

$DJ + Df\cos 45^\circ = DE$

$\Sigma F_y = 0$;

$Df \sin 45^\circ + CD = 0$.

$DJ = 3.94 - Df\cos 45^\circ$

① $DJ = 3.94 - Df \sin 45^\circ$ ↙ Cross member

$DJ \leq 3.94$ KN since → $Df > 0$ (Tension only)

$DJ = 3 - CJ \sin 45^\circ$

$DJ \leq 3$ KN since $CJ > 0$ (Tension only)

Taking $DJ = 3$ KN

$Df = 1.31$ KN & hence

$\{CD = 0.93$ KN (C)$\}$