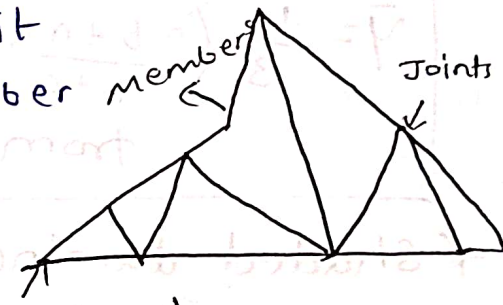
UNIT-2 Analysis of framed structure/ Trusses.

A framed structure or truss is composed of several bars joined together in a particular fashion. These bars/rods are called members of structure. A member under tension is called tie and a member under compression is called strut.

Truss:- It is rigid structure and it is made by the several number of members connected end to end together by the hinge joint or pin joint only.

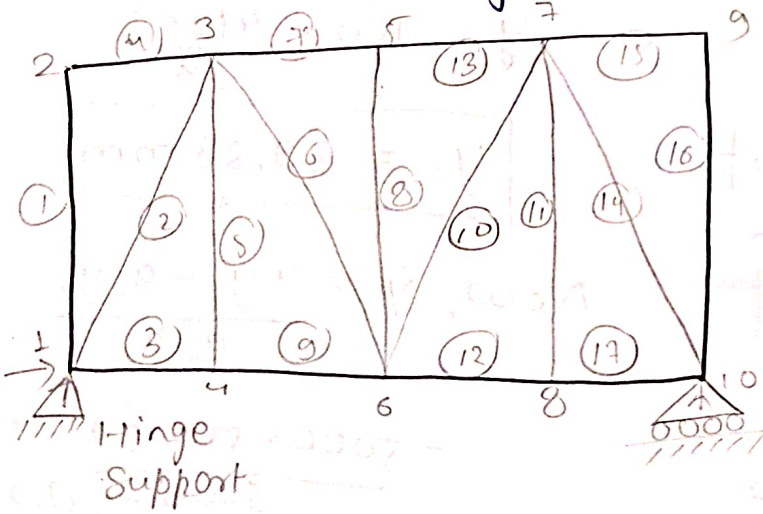


→ **Types of trusses:-**

① **Perfect Truss / Efficient Truss:-**

Condition:- $m+R=2j$ ⇒ Rigid truss

m → No. of member
R → No. of support reactions
j → No. of joints



→ j = 10
R = 3
m = 17

Here,

$$m+R=2j$$

② **Imperfect truss :-** $m+R \neq 2j$

(i). Imperfect deficient truss

$m+R<2j$

⇒ Under rigid truss

(ii). Imperfect Redundant truss.

$m+R>2j$

⇒ Over rigid truss.

Assumptions:-

(I) The frame is loaded only at the joints.
(II). All the members of structure are pin jointed.
(III). Considering the structure as a perfect structure.
(IV). The self weight of the members is neglected in truss.

METHODS:-

(1). Method of joints:- In this method, each and every joint is treated separately as a free body in equillibrium. The unknown force are then determined by equillibrium equation $\Sigma V = 0$ and $\Sigma H = 0$.

→ A joint is taken for analysis when two forces which are unknown acting at that joint. To start with, a joint is taking where there are 2 unknown forces. After calculating all the forces acting at that joint, next joint is taken up again at which there are not more than 2 unknown forces. The procedure is continued until all the joints are considered thereby calculating the forces in all member of truss.

Each joint ⇒ F.B.D. then use $\Sigma V = 0$ and $\Sigma H = 0$.

(2). Method of section :- This method is particularly convenient when the forces in few members of the structure are required to be determined.

→ In this method, a section line is passed through the members in which forces are required to be determined. A part of the truss on any

side of section line is taken and treated as FBD in equilibrium under the action of all the forces, external forces, loading, reactions, etc.

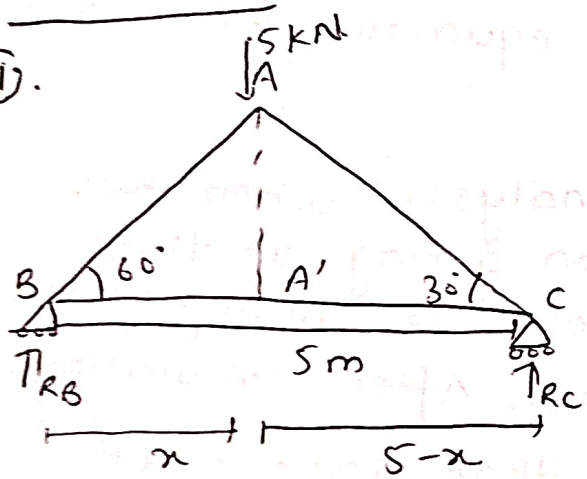
→ The unknown forces are then determined by application of equilibrium by equation,

$$\Sigma M = 0.$$

→ Care should be taken while drawing a section line that it should not cut more than 3 members in which forces are unknown.

Numericals :-

①.



from $\Delta AA'B$,

$$\tan 60° = \frac{AA'}{x}$$

$$\Rightarrow AA' = x \tan 60° \quad \text{—(I)}.$$

from $\Delta AA'C$,

$$\tan 30° = \frac{AA'}{5-x}$$

$$\Rightarrow AA' = (5-x)\tan 30° \quad \text{—(II)}$$

by (I) & (II) :-

$$x\sqrt{3} = \frac{(5-x)}{\sqrt{3}}$$

$$3x = 5 - x$$

$$\boxed{x = 1.25}$$

Reactions :-

Let R_B & R_C be the reactions at B & C respectively.

Now,

taking moment about B.

$$\Sigma M_B = 0 \quad [\circlearrowleft +ve, \circlearrowright -ve]$$

$$+R_C \times 5 - 5 \times 1.25 = 0$$

$$\boxed{R_C = 1.25 kN}$$

Considering vertical equilibrium,

$$\Sigma V = 0 \quad [\uparrow +ve, \downarrow -ve]$$

$$+R_B + R_C - 5 = 0$$

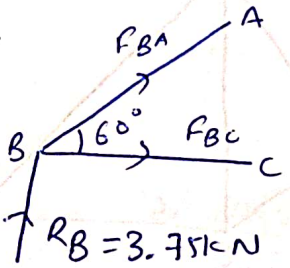
$$R_B = 5 - 1.25$$

$$\boxed{R_B = 3.75 kN}$$

Methods - Method of joints.

[outward from point will be tensile →]

Joint (B).



(F_{BO})

Considering vertical equillibrium,

$\Sigma V = 0$ [↑ +ve, ↓ -ve]

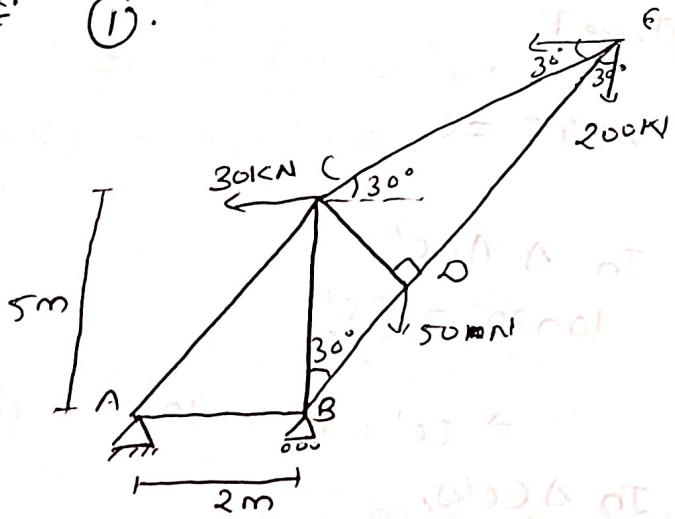
$+R_B + F_{BA} \sin 60° = 0$

$3.75 + F_{BA} \sin 60° = 0$

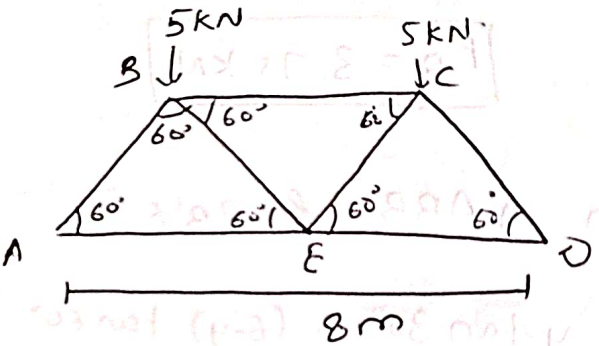
$$F_{BA} = -4.33 \text{ kN}$$

Q.

(1).



(2).



↳ considering horizontal equillibrium,

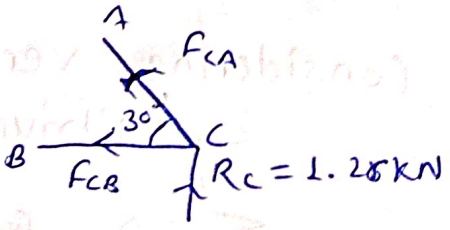
$\Sigma H = 0$ [→ +ve, ← -ve]

$+F_{BC} + F_{BA} \cos 60° = 0$

$$F_{BC} = -\frac{(-4.33)}{2}$$

$$F_{BC} = 2.165 \text{ kN}$$

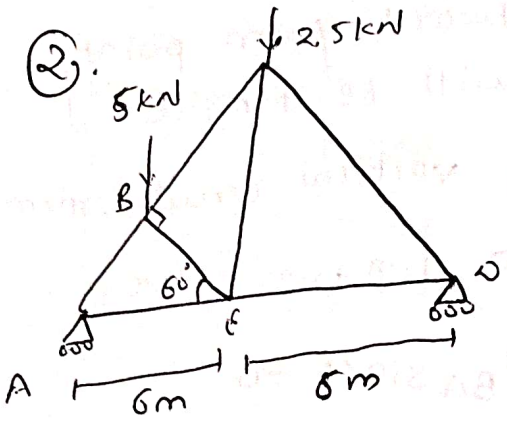
considering joint-C

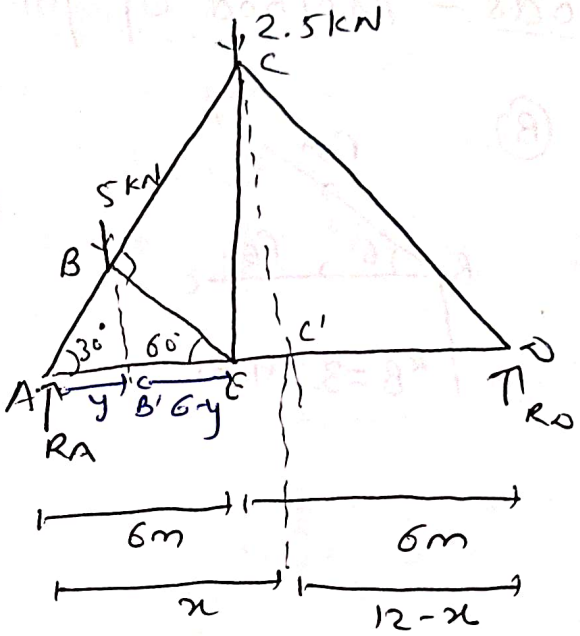


Result :-

Member	Force	Nature
BA	4.33kN	Compressive
BC	2.165 KN	Tensile
CA	2.5 KN	compressive

②.





Reactions!-

Let R_A and R_D be reactions at A and D respectively. Taking moment about A.

$$\Sigma M_A = 0 \quad [\uparrow +ve, \curvearrowleft -ve]$$

$$+R_D \times 12 - 2.5g \times 9 - 5 \times 4.5 = 0$$

$$\boxed{R_D = 3.75\,kN}$$

In $\Delta ABB'$ & $BB'E$

$$y \tan 30° = (6-y) \tan 60°$$

As above process,

$$\boxed{y = 4.5\,m}$$

Considering vertical Equillibrium,

$$\Sigma_V = 0 \quad [\uparrow +ve, \downarrow -ve]$$

$$R_A + R_D - 5 - 2.5 = 0$$

$$R_A = 7.5 - 3.75$$

$$\boxed{R_A = 3.75\,kN}$$

In $\Delta ACC'$,

$$\tan 30° = \frac{CC'}{x}$$

$$\Rightarrow CC' = x \tan 30° \quad \text{—①}$$

In $\Delta CC'D$,

$$\tan 60° = \frac{CC'}{12-x}$$

$$\Rightarrow CC' = (12-x) \tan 60° \quad \text{—②}.$$

Equating ① & ② !-

$$\frac{x}{\sqrt{3}} = (12-x)\sqrt{3}$$

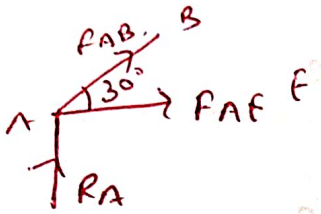
$$x = 36 - 3x$$

$$4x = 36$$

$$\boxed{x = 9\,m}$$

Method :- Method of joints,

Joint A,



Let F_{AB} & F_{AE} be the tensile force.

[→ outward from joint]

Considering vertical eqm.

$\Sigma V = 0$ [↑ +ve, ↓ -ve]

$+R_A + F_{AB} \sin 30° = 0$

$F_{AB} = -3.75 \times 2$

$$\boxed{F_{AB} = -7.5 \text{ KN}}$$

Considering horizontal eqm,

$\Sigma H = 0$ [→ +ve, ← -ve]

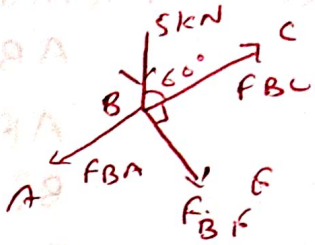
$F_{AB} \cos 30° + F_{AE} = 0$

$F_{AE} = -F_{AB} \cos 30°$

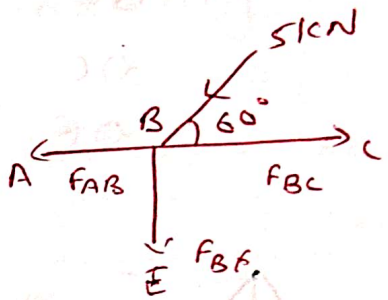
$= -(-7.5)\frac{\sqrt{3}}{2}$

$$\boxed{F_{AE} = 6.495 \text{ KN}}$$

Joint B,



Redraw →



Resolving all the forces ⊥ar to ABC.

$-F_{BE} - 5 \sin 60° = 0$

$$\boxed{F_{BE} = -4.33 \text{ kN}}$$

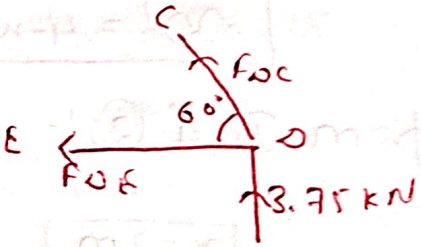
Resolving forces along ABC

$-F_{AB} + F_{BC} - 5 \cos 60° = 0$

$-(-7.5) + F_{BC} - 2.5 = 0$

$$\boxed{F_{BC} = +5 \text{ KN}}$$

Joint E,



Considering horizontal eqm,

$-F_{EB} - F_{EC} \cos 60° = 0$

$F_{EB} = \frac{-(-4.33)}{2}$

$$\boxed{F_{EB} = 2.165 \text{ kN}}$$

Considering vertical eqm,

$\Sigma V = 0$

$+3.75 + F_{EC} \sin 60° = 0$

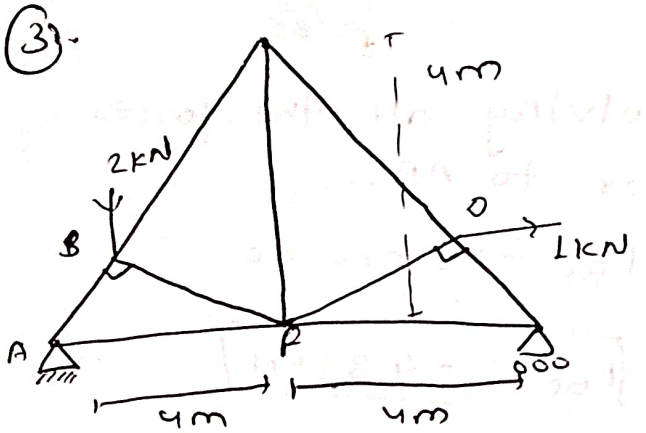
$F_{EC} = \frac{-3.75}{\sin 60}$

$$\boxed{F_{EC} = -4.33 \text{ kN}}$$

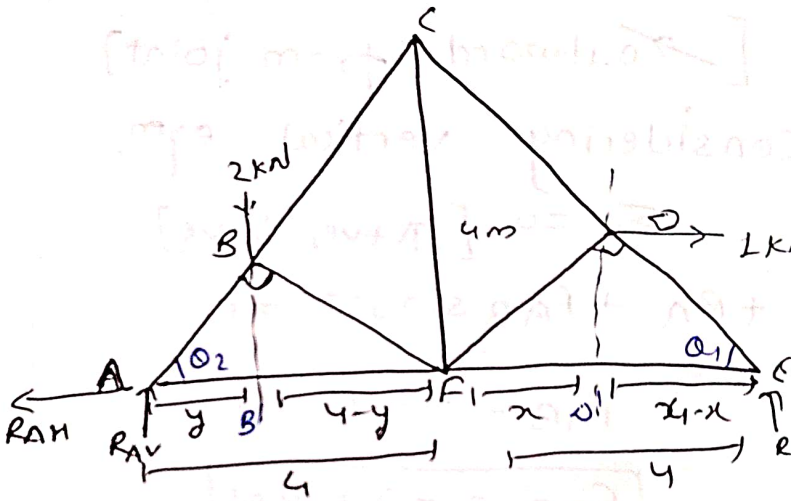
Result!-

Member	Force (kN)	Nature
AB	7.5	Compressive
AF	6.495	Tensile
BF	4.33	Compressive
BC	5	Tensile
OC	4.33	Compressive
OF	2.165	Tensile

(3).



⇒



* Roller support → 1 reaction
* Hinge support → 2 reaction

→ from $\Delta OO'F$,

$$\tan 45^\circ = \frac{OO'}{4-x} = 1$$

$$\boxed{OO' = 4-x} \quad — (2)$$

from (1) & (2) :-

$$x = 4-x$$

$$\boxed{x = 2m}$$

$\therefore OO' = 2m$

Similarly, from $\Delta ABB'$ & $BB'F$

$$\boxed{y = 2m}$$

$$\boxed{BB' = 2m}$$

from ΔCFE,

$$\tan\theta_1 = \frac{CF}{FE} = 1$$

$$\boxed{\theta_1 = 45^\circ}$$

from ΔACF,

$$\tan\theta_2 = \frac{CF}{FA} = \frac{4}{4} = 1$$

$$\boxed{\theta_2 = 45^\circ}$$

from $\Delta FOO'$,

$$\tan\theta_1 = \frac{OO'}{x}$$

$$OO' = x$$

$$\boxed{x = OO'} \quad — (1)$$

→

~~Method~~ !- Let R_{AV} & R_{AH} be the reactions of A
Let R_F be reaction at F.

Taking moment about A,

$$\Sigma M_A = 0 \quad [\circlearrowleft +ve, \circlearrowright -ve]$$

$$+R_F \times 8 - 1 \times 2 - 2 \times 2 = 0$$

$$R_F = \frac{6}{8}$$

$$\boxed{R_F = 0.75\ kN}$$

consedering vertical eqm,

$$\Sigma V = 0 \quad [\uparrow +ve, \downarrow -ve]$$

$$R_{AV} + R_F - 2 = 0$$

$$\boxed{R_{AV} = 1.25\ kN}$$

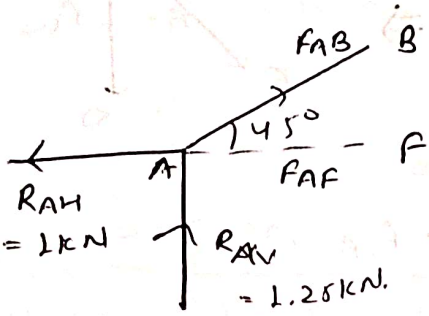
Considering horizontal equillibrium,

$$\Sigma H = 0 \quad [\underset{+ve}{\rightarrow}, \underset{-ve}{\leftarrow}]$$

$$+1 - R_{AH} = 0$$

$$\boxed{R_{AH} = 1\ kN}$$

Method !- Joint A,



Considering horizontal eqm,

$$-R_{AH} + F_{AF} + F_{AB}\cos 45° = 0$$

$$-1 + F_{AF} - 1.76\cos 45° = 0$$

$$\boxed{F_{AF} = 2.25\ kN}$$

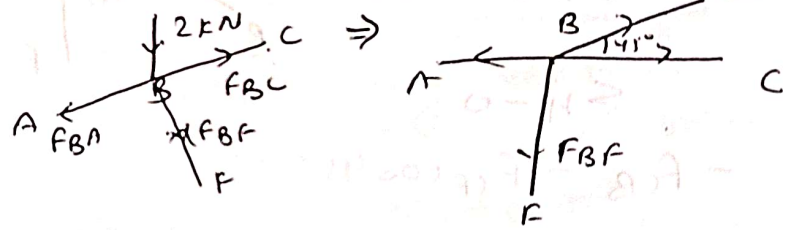
considering vertical eqm,

$$R_{AV} + F_{AB}\sin 45° = 0$$

$$F_{AB} = \frac{-R_{AV}}{\sin 45°}$$

$$\boxed{F_{AB} = -1.76\ kN}$$

... Joint B,



Resolving for along ABC,

$$-F_{BA} + F_{BC} - 2\cos 45° = 0$$

$$-(-1.76) + F_{BC} - 1.414 = 0$$

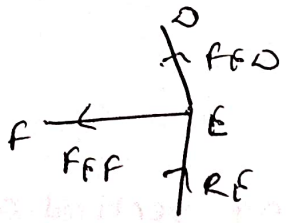
$$\boxed{F_{BC} = -0.346\ kN}$$

Resolving forces perpendicular ABC,

$$-F_{BF} - 2\sin 45° = 0$$

$$\boxed{F_{BF} = -1.414\ kN}$$

Joint E,



$\Sigma V = 0,$

$R_E + F_{ED}\sin 45° = 0$

$F_{ED} = \frac{-0.75}{\sin 45°}$

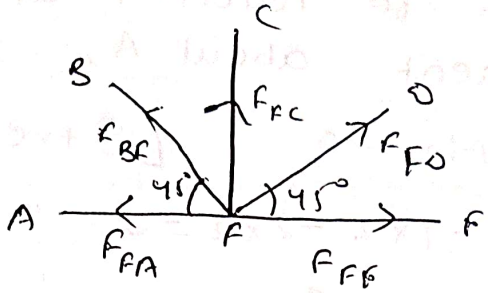
$\boxed{F_{ED} = -1.06\ KN}$

$\Sigma H = 0,$

$-F_{EF} - F_{ED}\cos 45° = 0$

$\boxed{F_{EF} = -0.75\ KN}$

Joint F,



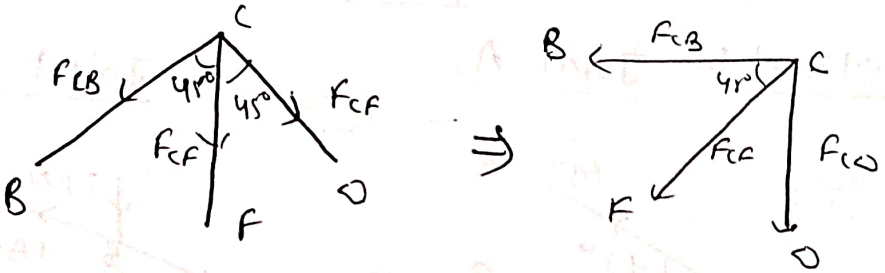
$\Sigma H = 0$

$-2.25 + 0.75 - (-1.414)\cos 45° + F_{FD}\cos 45° = 0$

$\frac{0.501}{\cos 45°} = F_{FD}$

$\boxed{F_{FD} = +0.71\ KN}$

Joint C,



$\Sigma H = 0$

$-F_{CB} + F_{CF}\cos 45° = 0$

$F_{CF} = \frac{-(-0.346)}{\cos 45°}$

$\boxed{F_{CF} = 0.48\ KN}$

$\Sigma V = 0$

$-F_{CD} - F_{CF}\sin 45° = 0$

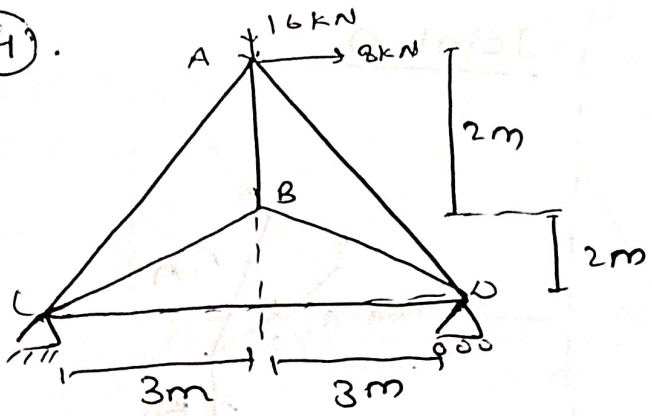
$F_{CD} = -0.48\sin 45°$

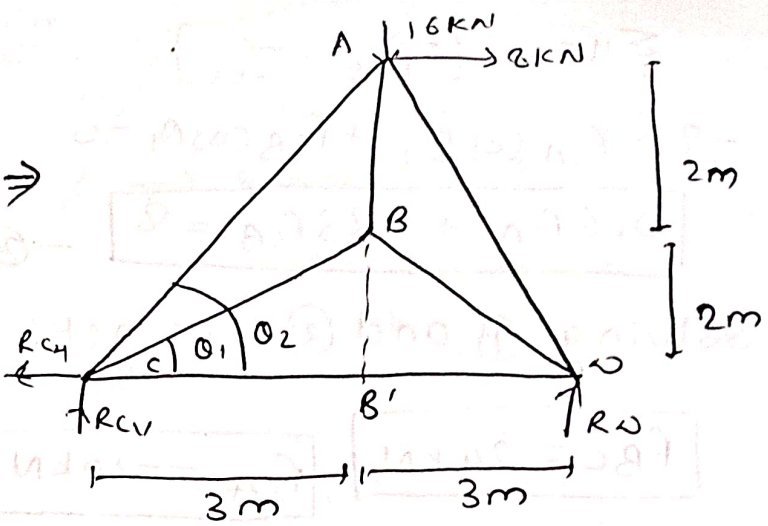
$\boxed{F_{CD} = -0.353\ KN}$

Result:-

Member	Force (KN)	Nature.
AB	1.76	C
AF	2.25	T
BC	0.346	C
BF	1.414	C
ED	1.06	C
FF	0.75	C
FD	0.71	T
CF	0.48	T
CD	0.353	C

(4).





* CD is not a member it is a dashed line.

Let R_{CV} and R_{CH} be reactions at C and

Taking moment about C,

$$\Sigma M_C = 0$$

$$R_D \times 6 - 16 \times 3 - 8 \times 4 = 0$$

$$R_D = \frac{40}{3}$$

$$\boxed{R_D = 13.33\ KN}$$

Considering horizontal equillibrium,

$$\Sigma H = 0 \quad [\rightarrow +ve, \leftarrow -ve]$$

$$-R_{CH} + 8 = 0$$

$$\boxed{R_{CH} = 8\ KN}$$

In $\Delta ACB'$,

$$\tan\theta_2 = \frac{4}{3}$$

$$\boxed{\theta_2 = 53.06^\circ}$$

In $\Delta CBB'$,

$$\tan\theta_1 = \frac{2}{3}$$

$$\boxed{\theta_1 = 33.69^\circ}$$

Considering vertical equillibrium,

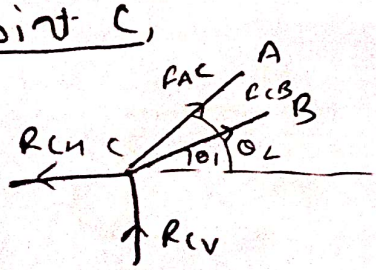
$$\Sigma V = 0 \quad [\uparrow +ve, \downarrow -ve]$$

$$R_{CV} - 16 + R_D = 0$$

$$\boxed{R_{CV} = 2.67\ KN}$$

Methods:- Method of joint.

Joint C,



Here $\theta_2 = 53.06^\circ$ and $\theta_1 = 33.69^\circ$

$$\Sigma V = 0 \quad [\uparrow +ve, \downarrow -ve]$$

$$R_{CV} + F_{CA}\sin\theta_2 + F_{CB}\sin\theta_1 = 0$$

$$\boxed{0.79 F_{CA} + 0.55 F_{CB} = -2.67}$$

— (1).

$\Sigma H = 0$ [→ +ve, ← -ve]

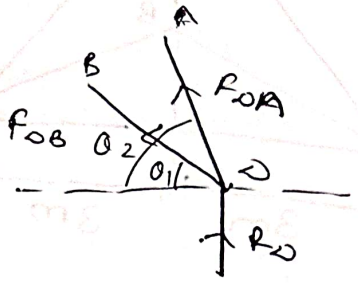
$-8 + F_{CA}\cos\theta_2 + F_{CB}\cos\theta_1 = 0$

$$0.6F_{CA} + 0.83F_{CB} = 8 \quad -(2)$$

Solving (1) and (2), we get,

$$F_{BC} = 24\ kN, \quad F_{CA} = -20\ kN$$

Joint D,



Considering vertical eqm,

$\Sigma V = 0$ [↑ +ve, ↓ -ve]

$+13.33 + F_{DB}\sin\theta_1 + F_{DA}\sin\theta_2 = 0$

$$\Rightarrow 0.55F_{DB} + 0.79F_{DA} = -13.33 \quad -(1)$$

$\Sigma H = 0$ [→ +ve, ← -ve]

$-F_{DB}\cos\theta_1 - F_{DA}\cos\theta_2 = 0$

$-0.83F_{DB} - 0.60F_{DA} = 0$

$$F_{DB} = \frac{-0.60}{0.83}F_{DA}$$

$$F_{DB} = -0.72F_{DA}$$

Put this in eqn (1),

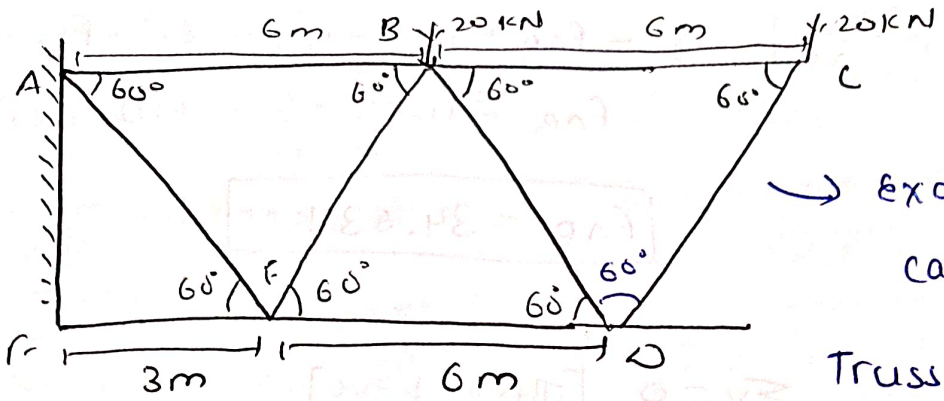
$0.55 \times (+0.72\ F_{DA}) + 0.79F_{DA} = -13.33$

$(-0.39 + 0.79)F_{DA} = -13.33$

$$F_{DA} = -33.32\ kN$$

$$F_{DB} = 24.02\ kN$$

(5).



→ example of cantilever truss

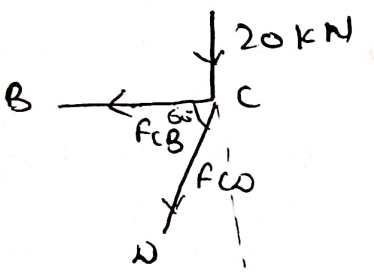
↓

Truss whose is fixed and other end is open in air.

We need not to find reactions in this problem.

Method of joints,

Joint C,



considering vertical eqm,

$\Sigma V = 0$ [↑ +ve, ↓ -ve]

$-20 - F_{CD}\sin 60° = 0$

$F_{CD} = \frac{-20}{\sin 60°}$

$F_{CD} = -23.09$ KN

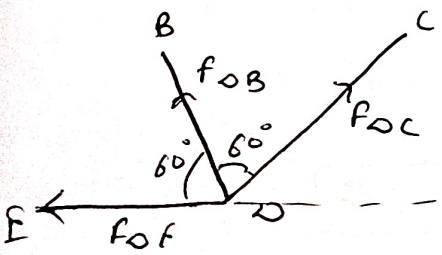
$\Sigma H = 0$ [→ +ve, ← -ve]

$-F_{CB} - F_{CD}\cos 60° = 0$

$F_{CB} = -(-23.09)\times\frac{1}{2}$

$F_{CB} = 11.54$ KN

Joint D,



$\Sigma V = 0$ [↑ +ve, ↓ -ve]

$F_{DC}\sin 60° + F_{DB}\sin 60° = 0$

$F_{DB} = -F_{DC}$

$F_{DB} = 23.09$ KN

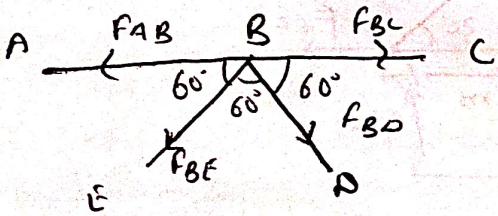
$\Sigma H = 0$ [→ +ve, ← -ve]

$-F_{DE} = -F_{DB}\cos 60° + F_{DC}\cos 60° = 0$

$F_{DE} = -23.09\times\frac{1}{2} - 23.09\times\frac{1}{2}$

$F_{DE} = -23.09$ KN

Joint B,



$\Sigma V = 0$ [↑ +ve, ↓ -ve]

$-F_{BD}\sin 60° - F_{BE}\sin 60° = 0$

$F_{BE} = -F_{BD}$

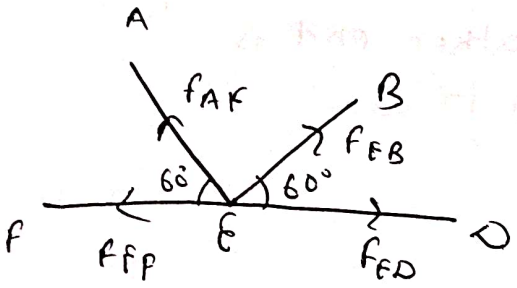
$F_{BE} = -23.09$ KN

$\Sigma H = 0$ [$\rightarrow$ +ve, $\leftarrow$ -ve] $\Rightarrow -f_{AB} + 11.54 - f_{BF}\cos 60° + f_{BD}\cos 60° = 0$

$f_{AB} = 11.54 - (-23.09)\frac{1}{2} + 23.09 \times \frac{1}{2}$

$$\boxed{f_{AB} = 34.63 \text{ KN}}$$

Joint f,



$\Sigma V = 0$ [↑ +ve, ↓ -ve]

$f_{EB}\sin 60° + f_{EA}\sin 60° = 0$

$f_{EA} = -f_{EB}$

$$\boxed{f_{EA} = +23.09 \text{ KN}}$$

$\Sigma H = 0$ [$\rightarrow$ +ve, $\leftarrow$ -ve]

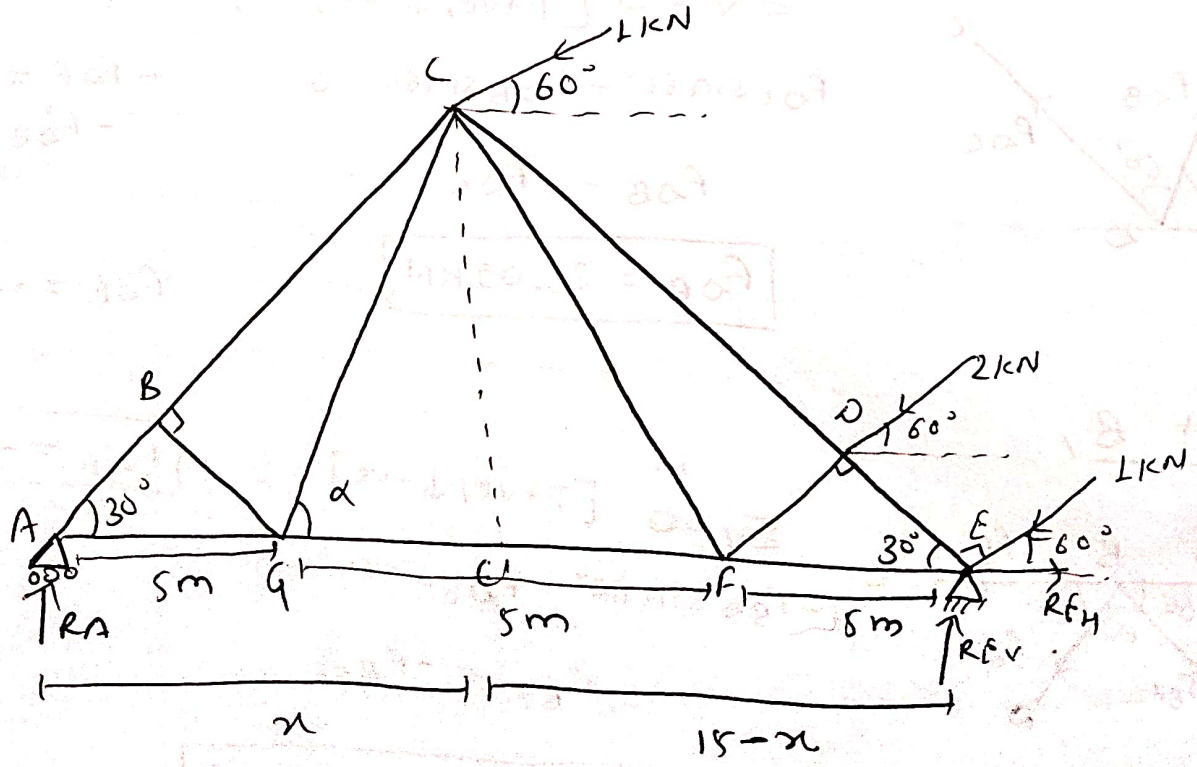
$-23.09 + f_{FB}\cos 60° - f_{FA}\cos 60° - f_{FF} = 0$

$-23.09 - 23.09 \times \frac{1}{2} - 23.09 \times \frac{1}{2} = f_{EF}$

$$\boxed{f_{FF} = -46.18 \text{ KN}}$$

* Result table is must, nahi toh number cut ho jayenge.

(6).



→ Let R_{FV} and R_{FH} be reactions at F and R_A be reactions of A.

Taking moment at F.

$\Sigma M_F = 0$ [↺ +ve, ↻ -ve]

$-R_A \times 15 + 1 \times 8.66 + 2 \times 4.33 = 0$

$$\boxed{R_A = 1.154 \text{ kN}}$$

Considering vertical eqⁿ,

$\Sigma V = 0$ [↑ +ve, ↓ -ve]

$+R_A - 1\sin 60° - 2\sin 60 - 1\sin 60° + R_{FV} = 0.$

$1.154 - 4\sin 60° + R_{FV} = 0$

$$\boxed{R_{FV} = 2.31 \text{ kN}}$$

Considering horizontal eqⁿ,

$+R_{FH} - 1\cos 60° - 2\cos 60 - 1\cos 60° = 0.$

$R_{FH} - 4 \times \frac{1}{2} = 0$

$$\boxed{R_{FH} = 2 \text{ kN}}$$

In $\triangle ODF$,

$\cos 30° = \frac{OF}{EF}$

$OF = 5\cos 30°$

$$\boxed{OF = 4.33 \text{ kN}}$$

In $\triangle CC'E$,

$\tan 30° = \frac{CC'}{15-x}$

$CC' = \tan 30°(15-x)$ ---①.

In $\triangle CC'A$,

$\tan 30° = \frac{CC'}{x}$

$CC' = x\tan 30°$ ---②.

eqⁿ ① and ②,

$x\tan 30° = (15-x)\tan 30°$

$$\boxed{x = 7.5 \text{ m}}$$

Now In $\triangle CC'E$,

$\cos 30° = \frac{C'F}{CE}$

$CE = \frac{C'E}{\cos 30°} = \frac{7.5}{\cos 30°}$

$$\boxed{CE = 8.66}$$

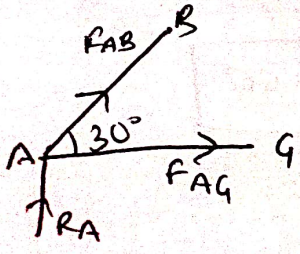
from ②,

$CC' = 7.5\tan 30°$

$$\boxed{CC' = 4.33 \text{ kN}}$$

Method - Method of joints :-

Joint A,



consider vertical eqⁿ,

$\Sigma V = 0$ [↑ +ve, ↓ -ve]

$F_{AB}\sin 30° + R_A = 0$

$F_{AB} \times \frac{1}{2} = -1.154$

$$\boxed{F_{AB} = -2.308 \text{ kN}}$$

Consider horizontal eqⁿ

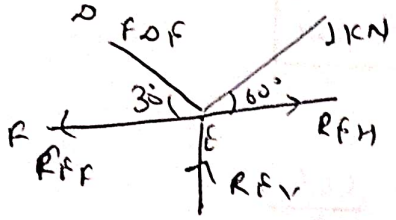
$\Sigma H = 0$

$F_{AG} + F_{AB}\cos 30° = 0$

$F_{AG} = -(-2.308)\cos 30°$

$$\boxed{F_{AG} = 1.99 \text{ kN}}$$

Joint E,



$\Sigma V = 0$

$2.31 - 1\sin 60° + F_{DE}\sin 30° = 0$

$\frac{F_{DE}}{2} = 1\sin 60° - 2.31$

$F_{DE} = -1.44 \times 2$

$\boxed{F_{DE} = -2.88\ kN}$

$\Sigma H = 0$

$[\rightarrow +ve, \leftarrow -ve]$

$-F_{EF} + R_{FH}$

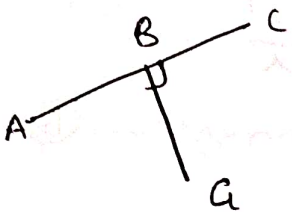
$-1\cos 60° - F_{DE}\cos 30° = 0$

$\Rightarrow$

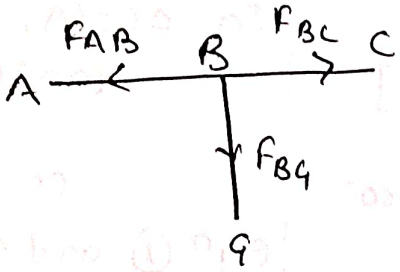
$F_{EF} = 1.5 + 2.49$

$\boxed{F_{EF} = 3.99\ kN}$

Joint B,



$\Rightarrow$



Resolve force Lar to ABC,

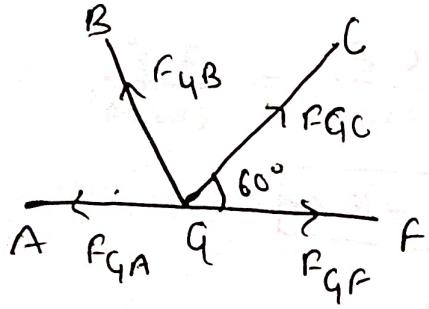
$\boxed{F_{BG} = 0\ kN}$

Resolve force along ABC,

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

$\boxed{F_{CB} = -2.308\ kN}$

Joint G,



$\Sigma V = 0$ [↑ +ve, ↓ -ve]

$F_{GC}\sin 60° = 0$

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

$\Sigma H = 0$

$[\rightarrow +ve, \leftarrow -ve]$

$F_{GF} + F_{GC}\cos 60° - F_{GA}$

$\boxed{F_{GF} = 1.99\ kN}$

In $\Delta CGC'$

$\tan\alpha = \frac{CC'}{GC'}$

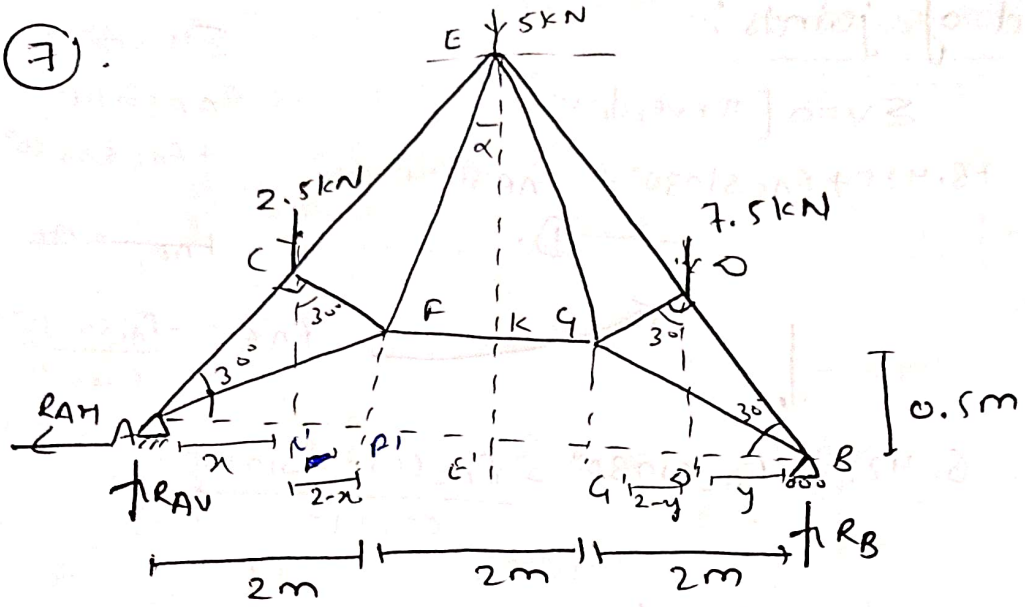
$\tan\alpha = \frac{4.33}{2.5}$

$\tan\alpha = 1.732$

$\Rightarrow \boxed{\alpha = 59.99 \simeq 60°}$

Result table

(7).



Let R_{AV} and R_{AH} be reactions at A and R_B be the reactions at B.

Taking moment about A,

$$\Sigma M_A = 0.$$

$$+R_B \times 6 - 7.5 \times 4.29 - 5 \times 3 - 2.5 \times 1.71 = 0.$$

$$6R_B = 32.175 + 15 + 4.275$$

$$R_B = \frac{51.45}{6}$$

$$\boxed{R_B = 8.575 \text{ kN}}$$

considering vertical eqm,

$$\Sigma V = 0 \quad [\uparrow +ve, \downarrow -ve]$$

$$R_{AV} - 2.5 - 5 - 7.5 + R_B = 0$$

$$\boxed{R_{AV} = 6.425 \text{ kN}}$$

$$\Sigma H = 0 \quad [\rightarrow +ve, \leftarrow -ve]$$

$$\boxed{R_{AH} = 0}$$

In $\Delta AFP'$

$$\tan\theta = \frac{0.5}{2} = \frac{1}{4}$$

$$\boxed{\theta = 14.03^\circ}$$

Now,

$$\cos 14.03^\circ = \frac{2}{AF}$$

$$AF = \frac{2}{\cos 14.03}$$

$$\boxed{AF = 2.06}$$

Now, In ΔAFG,

$$\cos(15.97^\circ) = \frac{AC}{AF} = \frac{AC}{2.06}$$

$$AC = 2.06 \cos(15.97)$$

$$\boxed{AC = 1.98}$$

Now, In $\Delta ACC'$

$$x = AC\cos 30^\circ$$

$$= 1.98 \cos 30^\circ$$

$$\boxed{x = 1.71}$$

similarly,

$$\boxed{y = 1.71}$$

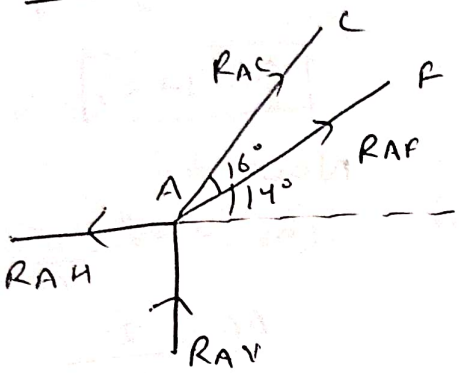
$R_B = 8.575$ kN

$R_{AV} = 6.425$ kN

$R_{AH} = 0.$

Method :- Method of joints :-

Joint A,



$\Sigma V = 0$ [↑ +ve, ↓ -ve]

$+6.425 + F_{AC}\sin 30° + F_{AF}\sin 14° = 0$ —— ①

$\Sigma H = 0$

$F_{AF}\cos 14° + F_{AC}\cos 30° = 0$

$F_{AF} = -\dfrac{F_{AC}\cos 30°}{\cos 14°}$

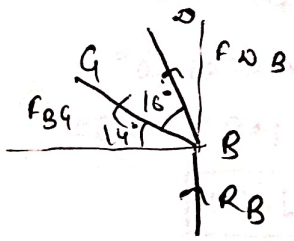
$6.425 + F_{AC}\sin 30° - \dfrac{F_{AC}\cos 30°\sin 14°}{\cos 14°} = 0$

$6.425 + F_{AC}(0.5 - 0.215) = 0$

$F_{AC} = -\dfrac{6.425}{0.285} = -22.54$

$F_{AC} = -22.54$ kN and $F_{AF} = 20.11$ kN

Joint B,



$\Sigma V = 0$ [↑ +ve, ↓ -ve]

$F_{BO}\sin 30° + F_{BG}\sin 14° + R_B = 0$

$\Sigma H = 0$ [→ +ve, ← -ve]

$-F_{BG}\cos 14° - F_{BO}\cos 30° = 0$

$F_{BG} = -\dfrac{F_{BO}\cos 30°}{\cos 14°}$

$F_{BO} \times 0.5 + \left(-\dfrac{F_{BO}\cos 30°\sin 14°}{\cos 14°}\right) + R_B = 0$

$F_{BO}(0.5 - 0.215) = -8.575$

$F_{BO} = \dfrac{-8.575}{0.285}$

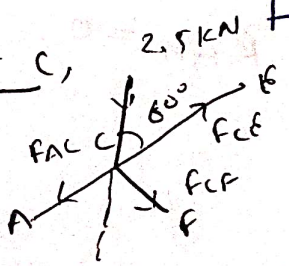
$F_{BO} = -30.08$ kN

$F_{BG} = -(-30.08)\cos$

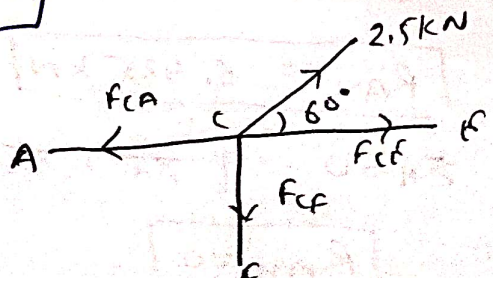
$\cos 14°$

$F_{BG} = 26.84$ kN

Joint C,



⇒



Resolve force lar to ACF,

$-F_{CF} = 2.5\sin 60° = 0$

$F_{CF} = -2.5\sin 60°$

$\boxed{F_{CF} = -2.165\ kN}$

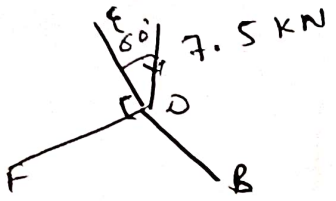
Resolve force along ACF,

$2.5\cos 60° + F_{CF} - F_{AC} = 0$

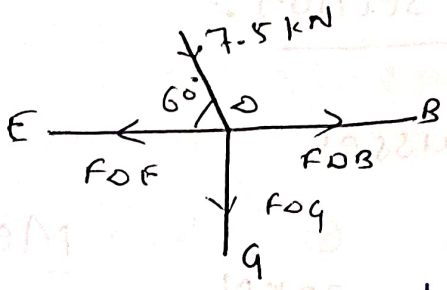
$2.5 \times 0.5 + F_{CF} + 22.54 = 0$

$\boxed{F_{CE} = 23.79\ KN}$

Joint D,



$\Rightarrow$



Resolve forces lar to EDB,

$-F_{DG} - 7.5\sin 60° = 0$

$\boxed{F_{DG} = -6.49\ KN}$

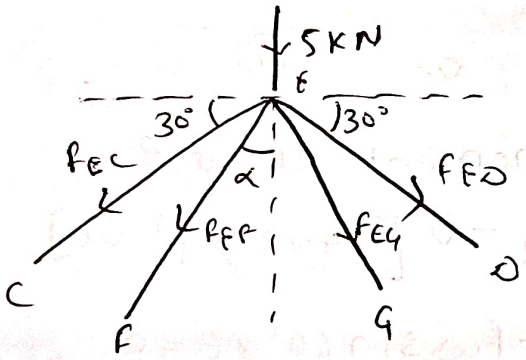
Resolve forces along FDB,

$-F_{DF} = 7.5\cos 60° + F_{DB} = 0$

$F_{DF} = -7.5 \times 0.5 - 30.08$

$\boxed{F_{DF} = -33.83\ KN}$

Joint E,



$\Sigma V = 0$ [↑ +ve, ↓ -ve]

$-5 - F_{EC}\sin 30° - F_{EF}\cos\alpha$

$- F_{EG}\cos\alpha - F_{ED}\sin 30° = 0$

$-5 - 23.79 \times 0.5 - F_{EF} \times 0.77 - F_{EG} \times 0.7$

$+33.83 \times 0.5 = 0$

$\Rightarrow F_{EF} + F_{EG} = \dfrac{16.91 - 5 - 11.89}{0.77} = \dfrac{0.02}{0.77}$

$\boxed{F_{EF} + F_{EG} = 0.025}$ —(1).

$\Sigma H = 0$ [→ +ve, ← -ve]

$-F_{EC}\cos 30° - F_{EF}\sin\alpha + F_{EG}\sin\alpha + F_{ED}\cos 30° = 0$

$-23.79\cos 30° - F_{EF} \times 0.63 + F_{EG} \times 0.63 - 33.83\cos 30° = 0$

$F_{EG} - F_{EF} = \dfrac{29.92 + 20.60}{0.63}$

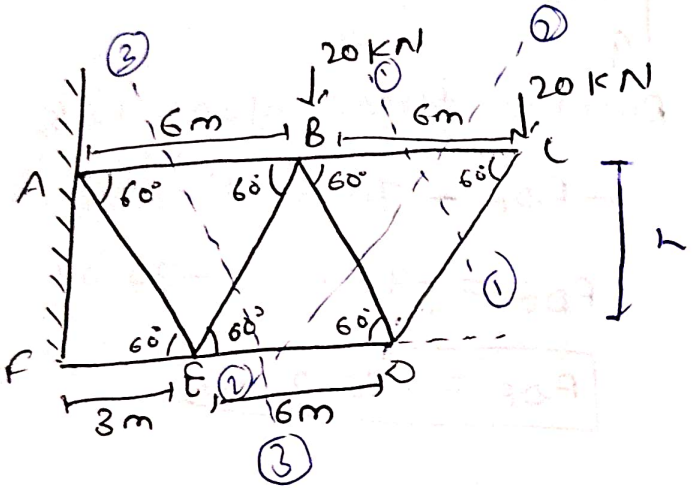
$$F_{FG} - F_{EF} = 80.19 \quad \text{— (2)}.$$

Solving (1) & (2);

$$F_{EF} = 40.10\,KN \quad \& \quad F_{EG} = -40.08\,KN$$

- Method of section :-

Cantilever trusses.



$$\tan 60° = \frac{h}{3}$$

$$h = 3\sqrt{3}$$

$$h = 5.196$$

Taking moment about D,

$$\Sigma M_D = 0$$

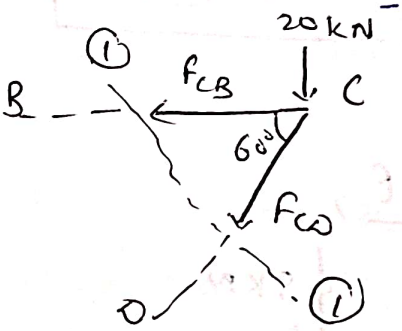
$$F_{CB} * 3\sqrt{3} - 20 \times 3 = 0$$

$$F_{CB} = 11.54\,KN$$

Method,

Method of section,

Section (1)(1); [→ ⇒ outward from joint - tensile]



Taking moment about B,

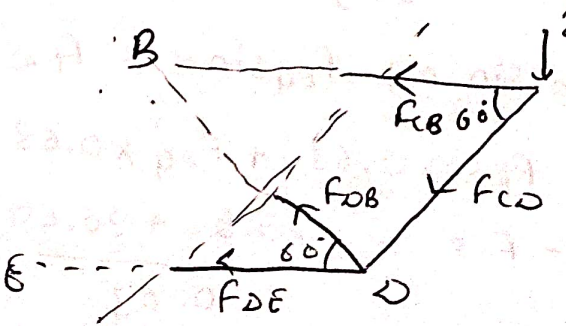
$$\Sigma M_B = 0 \quad [\circlearrowleft +ve, \circlearrowright -ve].$$

$$-20 \times 6 - F_{CD} \sin 60° \times 6 = 0$$

$$F_{CD} = \frac{20 \times 2}{\sqrt{3}}$$

$$F_{CD} = -23.09\,KN$$

Section (2)(2) :-



Taking moment f,

$\Sigma M_F = 0$

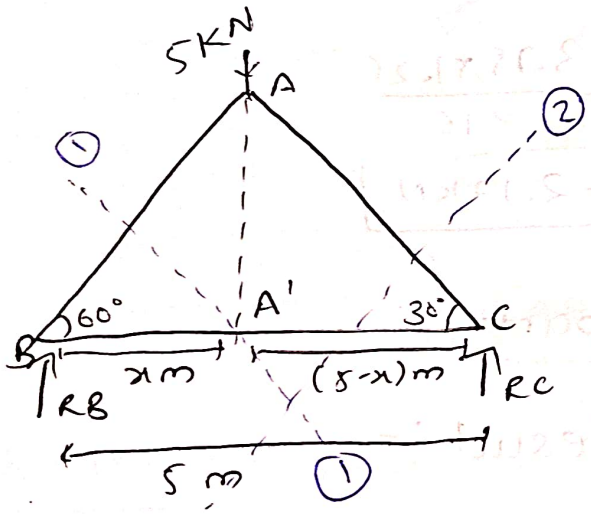
$-20 \times 9 - F_{CD}\sin 60° \times 9 + F_{CD}\cos 60° \times 5.196 + F_{BC} \times 5.196$

$+ F_{DB}\sin 60° \times 6 = 0$

$-20 \times 9 - (-23.09)\sin 60° \times 9 + 11.54 \times 5.1696 = -F_{DB}\sin 60° \times 6$

$$F_{DB} = 23.09\ KN$$

- Method of Section :-



In $\Delta AA'B$,

$\tan 60° = \frac{AA'}{x}$

$AA' = x \tan 60°$

In $\Delta AA'C$,

$\tan 30° = \frac{AA'}{(5-x)}$

$AA' = (5-x)\tan 30°$

$x \tan 60° = (5-x)\tan 30°$

$3x = 5 - x$

$$x = 1.25\ m$$

$AA' = 1.25 \tan 60°$

$$AA' = 2.16\ m$$

Reactions :- Let R_B and R_C be reactions at B and C, respectively.

Taking moment about B,

$\Sigma M_B = 0$ [5 +ve, ↑ -ve]

$R_C \times 5 - 5 \times 1.25 = 0$

$$R_C = 1.25\ KN$$

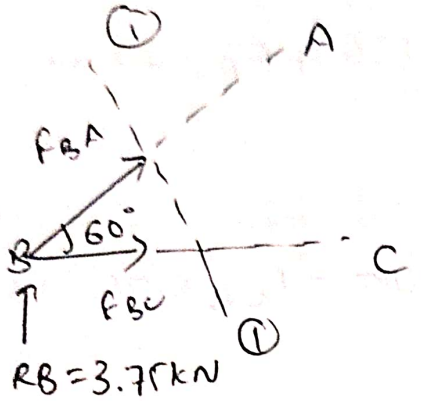
$\Sigma V = 0$ [↑ +ve, ↓ -ve]

$-5 + R_B + 1.25 = 0$

$$R_B = 3.75\ KN$$

by section method,

Section ①①, left part [→ outward from joint ⇒ tensile]



Taking moment about C

$\Sigma M_C = 0$ [↺ +ve, ↻ -ve]

$-3.75 \times 5 - f_{BA} \times 4.33 = 0$

$\boxed{f_{BA} = -4.33}$

Taking moment about A,

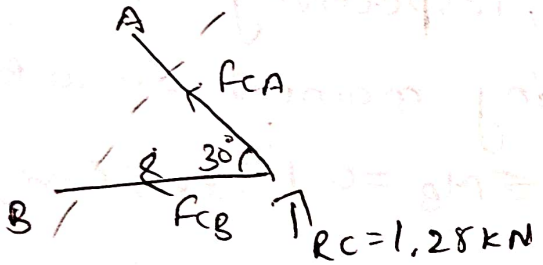
$\Sigma M_A = 0$

$-R_B \times 1.25 + f_{BC} \times 2.16 = 0$

$f_{BC} = \frac{3.75 \times 1.25}{2.16}$

$\boxed{f_{BC} = 2.17 kN}$

Section ②②,



Right part.

$\Sigma M_B =$ [↺ +ve, ↻ -ve]

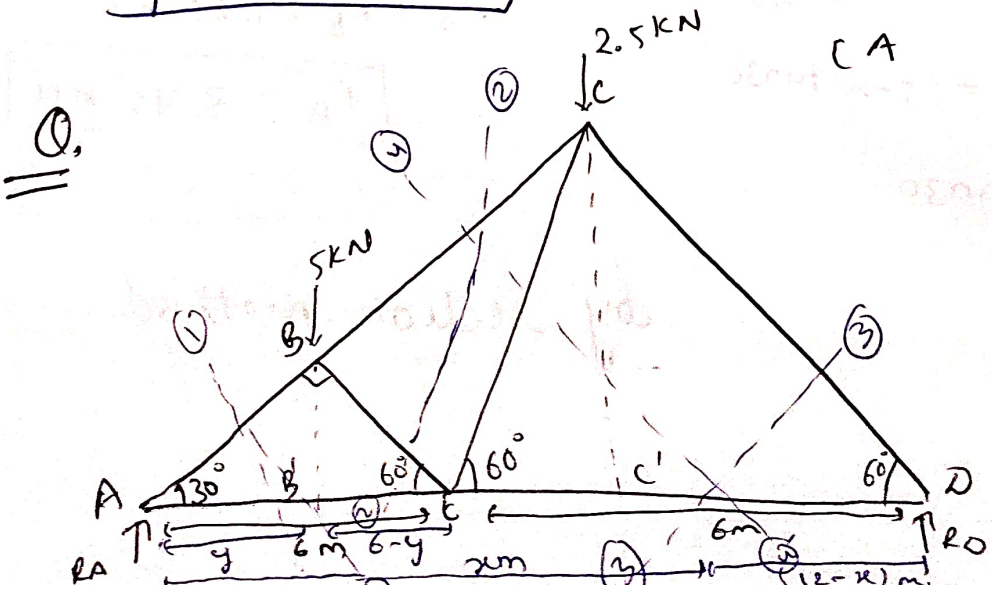
$+R_C \times 5 + f_{AC} \times 2.5 \sin\theta = 0$

$\boxed{f_{CA} = -2.5 kN}$

Result :-

Member	Force	Nature
AB	4.33kN	Comp.
BC	2.17 kN	Tens.
CA	2.5 kN	Comp.

Q.



In $\Delta ACC'$,

$$\tan 30^\circ = \frac{CC'}{x}$$

$$CC' = \frac{x}{\sqrt{3}} \quad -(1)$$

from $\Delta CC'D$,

$$\tan 60^\circ = \frac{CC'}{12-x}$$

$$CC' = (12-x)\sqrt{3} \quad -(2)$$

eq. (1) & (2),

$$\frac{x}{\sqrt{3}} = (12-x)\sqrt{3}$$

$$x = 36 - 3x$$

$$\boxed{x = 9\,m}$$

from $\Delta BB'A$,

$$\tan 30^\circ = \frac{BB'}{y}$$

from $\Delta BB'E$,

$$\tan 60^\circ = \frac{BB'}{(6-y)}$$

$$y\tan 30^\circ = (6-y)\tan 60^\circ$$

$$y = (6-y)3$$

$$4y = 18$$

$$\boxed{y = 4.5\,m}$$

from $\Delta ABB'$

$$\cos 30^\circ = \frac{4.5}{AB}$$

$$\boxed{AB = 5.196\,m}$$

$$BB' = 4.5\tan 30^\circ$$

$$\boxed{BB' = 2.598}$$

Reactions:- Let R_A & R_D be reactions at A and D respectively,

Taking moment about A,

$$\Sigma M_A = 0 \quad [\circlearrowleft +ve,\ \circlearrowright -ve]$$

$$R_D \times 12 - 2.5\times 9 - 5\times 4.5 = 0$$

$$R_D \times 12 = 22.5 + 22.5$$

$$R_D = \frac{45}{12} = 3.75$$

$$\boxed{R_D = 3.75\,kN}$$

consider vertical equillibrium,

$$\Sigma V = 0$$

$$[\uparrow +ve,\ \downarrow -ve]$$

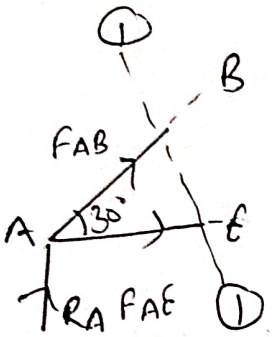
$$R_A - 5 - 2.5 + R_D = 0$$

$$R_A = 7.5 - 3.75$$

$$\boxed{R_A = 3.75\,kN}$$

Method of section :-

Section ①,①, [→ outward from joint – tensile]



Taking moment about E,

$\Sigma M_E = 0$

$-3.75 \times 6 - F_{AB}\sin 30° \times 6 = 0$

$F_{AB} \times \frac{1}{2} = -3.75$

$$F_{AB} = -7.5\ KN$$

Taking moment about B,

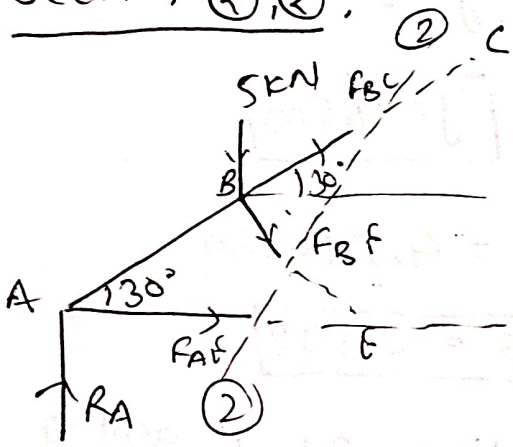
$\Sigma M_B = 0$

$-R_A \times 4.5 + F_{AE} \times BB' = 0$

$F_{AE} = \frac{3.75 \times 4.5}{2.598}$

$$F_{AE} = 6.495\ kN$$

Section ②,②.



Taking moment about E,

$\Sigma M_E = 0$ [⟳ +ve, ⟲ -ve]

$-R_A \times 6 + 5 \times 1.5 - F_{BC} \times BF = 0$

$-3.75 \times 6 + 5 \times 1.5 - F_{BC} \times 3 = 0$

$$F_{BC} = -5\ KN$$

Taking moment about A,

$\Sigma_A = 0$

$-5 \times 4.5 - F_{BE} \times AB = 0$

$F_{BE} = \frac{-5 \times 4.5}{5.196}$

$$F_{BE} = -4.33\ KN$$

from $\Delta BB'E$

$\cos 60° = \frac{B'E}{BE}$

$\frac{1}{2} = \frac{1.5}{BE}$

$$BE = 3m$$

Taking moment about B,

$\Sigma_B = 0$

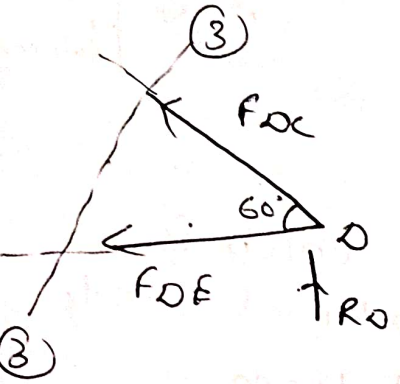
$-R_A \times 4.5 + F_{AE} \times BB' = 0$

$$-3.75 \times 4.5 + F_{AE} \times 2.598 = 0$$

$$F_{AF} = \frac{3.75 \times 4.5}{2.598}$$

$$\boxed{F_{AE} = 6.495 \text{ kN.}}$$

Section ③③,



$$\Sigma M_E = 0 \; [\circlearrowleft +ve, \circlearrowright -ve]$$

$$F_{OC} \sin 60° \times 6 + 3.75 \times 6 = 0$$

$$\boxed{F_{OC} = -4.33 \text{kN}}$$

$$\Sigma M_C = 0 \; [\circlearrowleft +ve, \circlearrowright -ve]$$

$$-F_{OE} \times 3\sqrt{3} + 3.75 \times 3$$

$$\boxed{F_{OE} = 2.165 \text{ kN}}$$

In $\Delta CC'O$,

$$\tan 60° = \frac{CC'}{3}$$

$$\boxed{CC' = 3\sqrt{3}}$$

Section ④④;