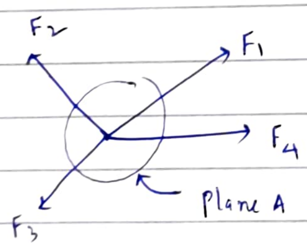
System of forces

- Co-planar (lie on same plane)
  - Concurrent
  - non concurrent
    - Parallel
    - General
- non-coplanar
  - Concurrent
  - non-concurrent
    - parallel
    - General

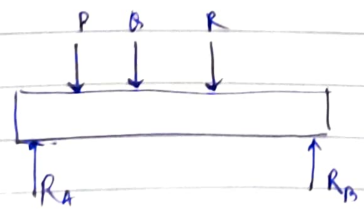
Concurrent force system in a plane :-

In this system lines of action of all forces pass through a single point and forces lie in the same plane



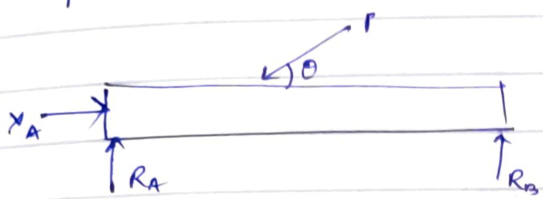
- ## Parallel force system in a plane :-

In this system line of ~~for~~ action of all forces lie in the same plane and are parallel to eachother



General Force System in a Plane :-

The line of action of all these forces lie in the same plane but they are neither parallel nor concurrent.



- → Concurrent force system can act on a particle or a rigid body
- → Parallel or General force system can act on a system of particles, a rigid body or a system of rigid bodies.

Statics :

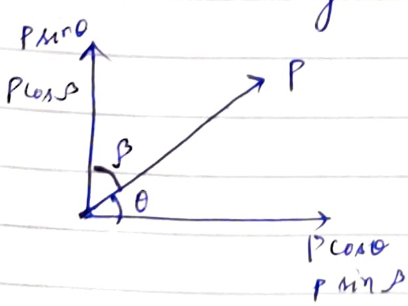
It deals with the equilibrium of the bodies in rest acted upon by force.
Deals with forces in the absence of ~~forces~~ motion.

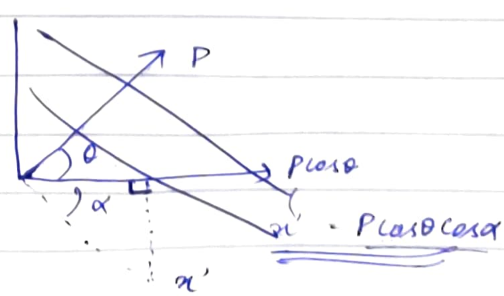
Dynamics :

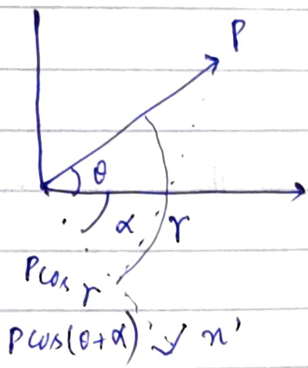
The branch of mechanics that deals with the affect that forces have on the motion of objects.

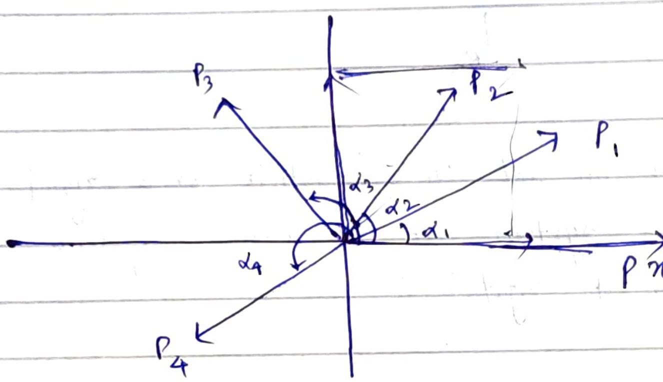
Resolution of forces :-

Replacement of a single force by several components will be equivalent in the action to the given force is called resolution of force.



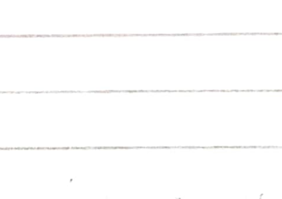






$$P_x = P_1 \cos\alpha_1 + P_2 \cos\alpha_2 + P_3 \cos\alpha_3 + P_4 \cos\alpha_4 .$$

$$P_y = P_1 \sin\alpha_1 + P_2 \sin\alpha_2 + P_3 \sin\alpha_3 + P_4 \sin\alpha_4 .$$



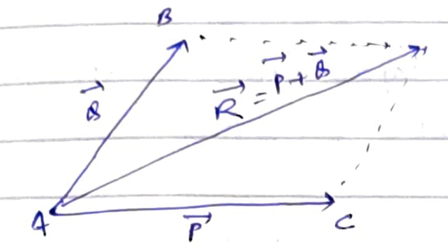
$$R = \sqrt{P_x^2 + P_y^2 + 2 P_x P_y \cos(90^\circ)}$$

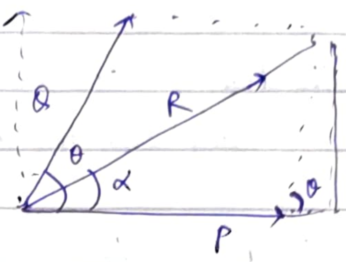
$$R = \sqrt{P_x^2 + P_y^2}$$

$$\tan\alpha = \frac{P_y}{P_x}$$

Composition of forces :-

The reduction of given system of forces to the simplest system that will be its equivalent is called problem of composition.





$X_{component} = P + Q\cos\theta$ ~~$+ R\cos\alpha$~~

$Y_{component} = Q \sin\theta.$

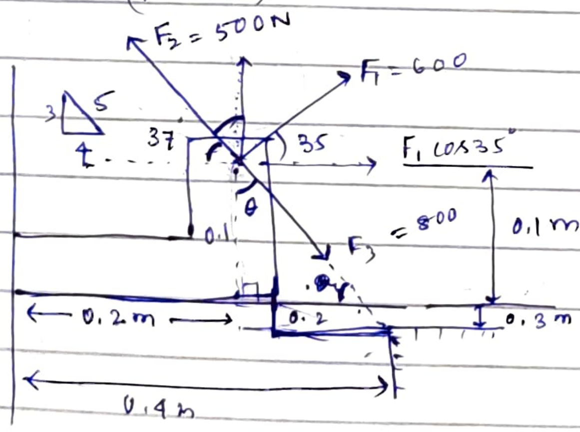
$$R = \sqrt{(P+Q\cos\theta)^2 + (Q\sin\theta)^2}$$

$$= \sqrt{P^2 + Q^2\cos^2\theta + 2PQ\cos\theta + Q^2\sin^2\theta}$$

$$= \sqrt{P^2 + Q^2 + 2PQ\cos\theta}.$$

$$\tan\alpha = \frac{Q\sin\theta}{(P+Q\cos\theta)}.$$

Q.



F_x ?

F_y ?

$\sqrt{(0.1)^2 + (0.2)^2}$

$= \sqrt{0.01 + 0.04}$

$= \sqrt{0.05}$

$= \frac{\sqrt{5}}{10}$

$\tan\theta = \frac{0.1}{0.2}$

$\tan\theta = 1/2$

$\theta = \tan^{-1}(1/2)$

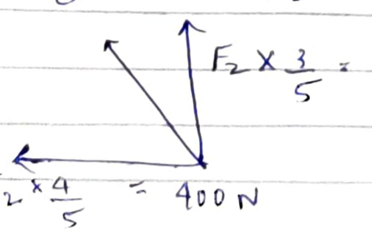
$\sqrt{0.16 + 0.04}$

0.20

$\cos\theta = \frac{0.2 \times 10}{\sqrt{5}} = \frac{2}{\sqrt{5}}$

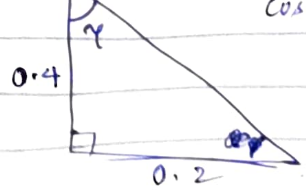
$\sqrt{3^2 + 4^2}$

$= \cos\theta = \frac{4}{5}$



$= 400N$

$\cos\gamma =$

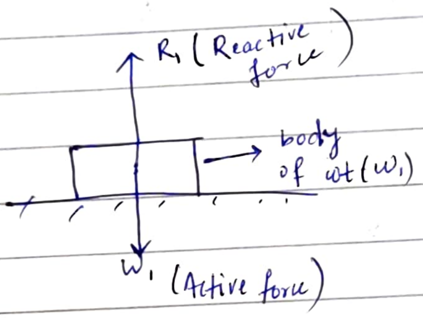


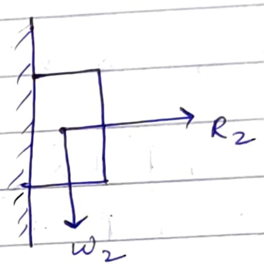
Reaction at planes :

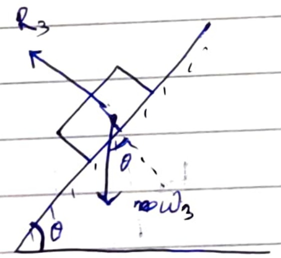
A reaction is always perpendicular to the plane, the horizontal plane having vertical reaction and vertical plane has horizonatal reaction.

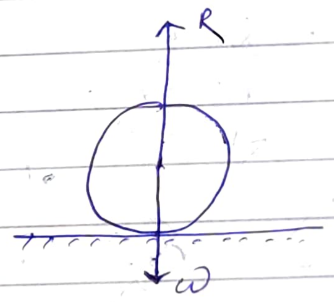
Active Forces : are the forces which are externally applied to the body or forces acting due to gravity. (weight of the body).

Reactive Forces :- These are the forces which act as a result of active forces



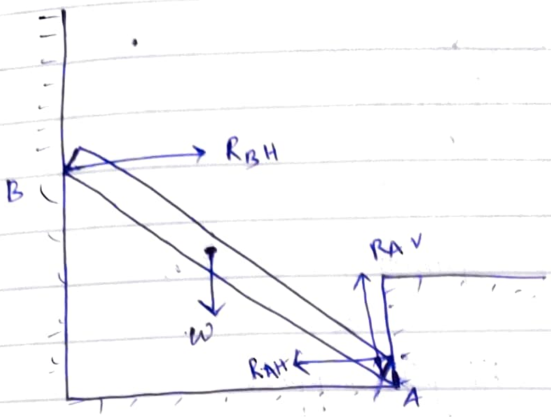






Reactive force will pass through the centre.

Hinged



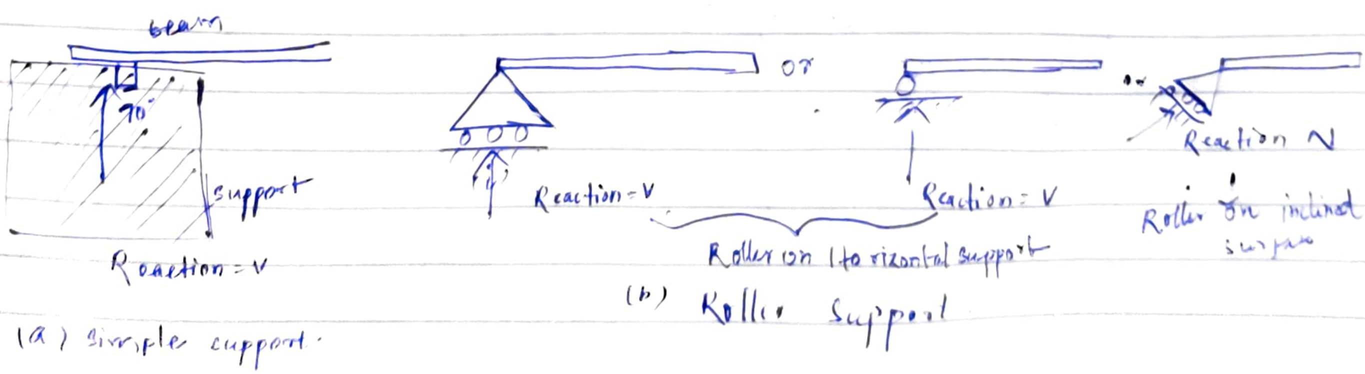
Types of Supports

- **Simple Support :**
  If one end of the beam rests on a fixed support, the support is known as simple support.

- **Roller Support :-**
  Here one end of the beam is supported on a roller.

- **Hinged Support :-**
  The beam does not move either along or normal to the axis but can rotate.

- **Fixed Support :-**
  The beam is not free to rotate or slide along the length of the beam or in the direction normal to the beam. Therefore three reaction components can be observed for 3-D.



or

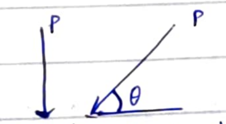
Guided
(ii) Roller

Reaction = R

Its components in vertical and horizontal direction are V & H, respectively.

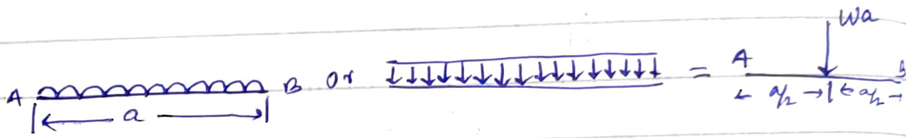
(c) Hinged support.

Types of Load



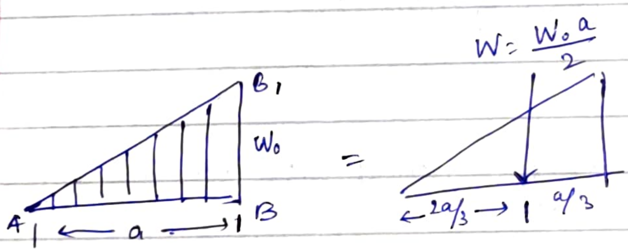
Vertical Inclined

(a) Concentrated or point load

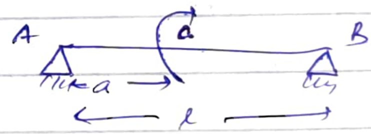


Total load = w.a

(b) Uniformly distributed load



(c) Uniformly varying load



(d) pure moment

Necessary Condition for Equilibrium :-

Body is said to be equilibrium under coplanar force, if it satisfies the following condition :

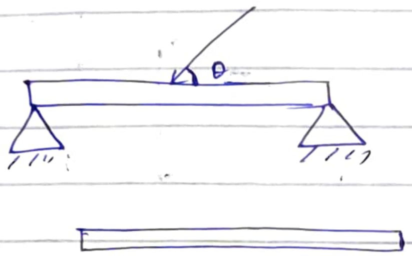
$$\Sigma F_x = 0$$
$$\Sigma F_y = 0$$
$$\Sigma M = 0$$

Free Body Diagram :-

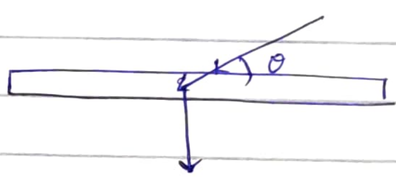
A Free Body diagram is a sketch of isolated body which shows the external forces (applied forces or active forces) on the body and the reaction extended on it by removed element of the surface.

Procedure :-

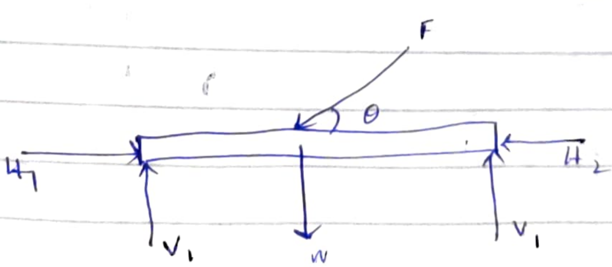
(i) A sketch of body is drawn by removing the surface



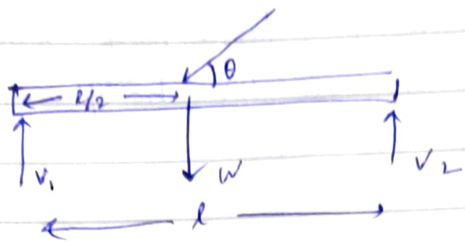
(ii) Indicate the applied or active forces which tend to set the body in motion such as those caused by the weight of the body or applied forces.



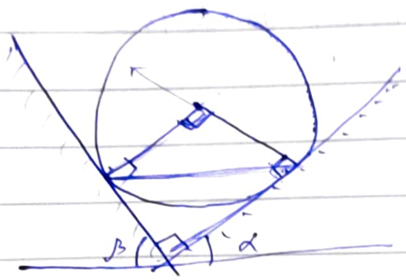
(iii) Also indicate on all the reactive forces such as those are caused by constraints or supports that tend to prevent the motion. (The sense of unknown reactant should be assumed). The correct sense will be determined by the solution of the problem.

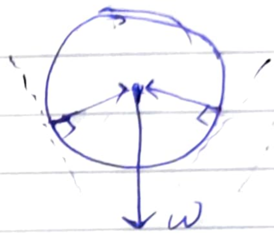


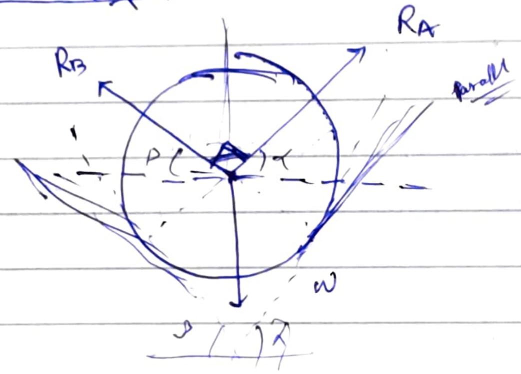
iv) All relevent dimensions and angles reference axis should be shown in the sketch.



Ex:-

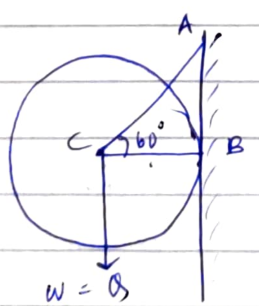






$\alpha + \beta = 90^\circ$

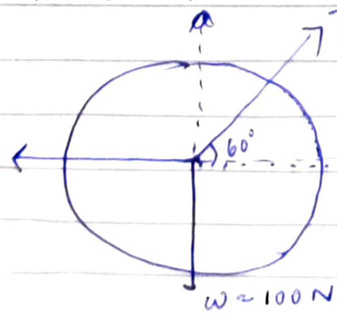
Ex:-

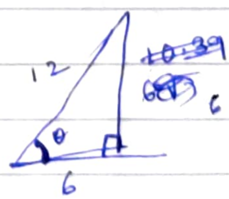


AC = 12 cm

radius of the sphere = 6 cm

wt. of the sphere = 100 N.





$\sqrt{144-36}$

$= \sqrt{108}$

$= 6\sqrt{3}$

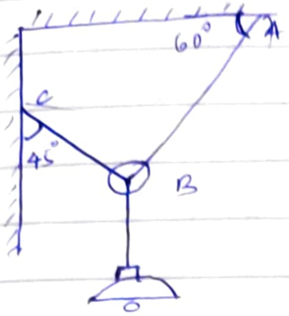
$\cos\theta = \frac{6}{12}$

$\boxed{\cos\theta = 1/2}$

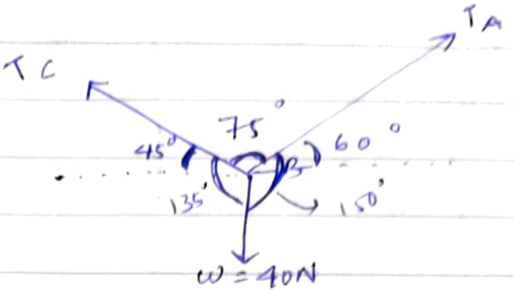
$\theta = 60^\circ$

$\sin\theta = \frac{6\sqrt{3}}{12}$

Ex:-



$Q = 40N$.



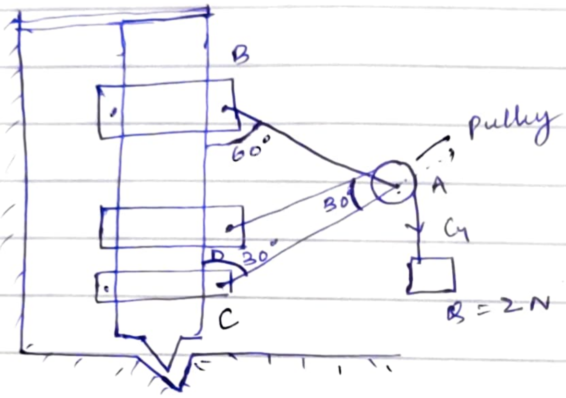
45
60
105

180 -
105
75

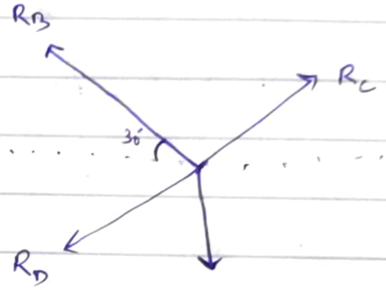
45
90
135

90
60

Ex:-

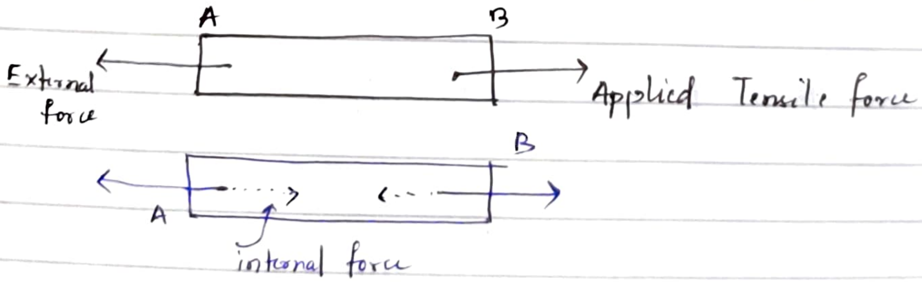


Bars = AB & AC hinged at B & C

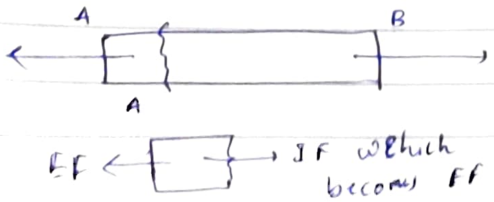


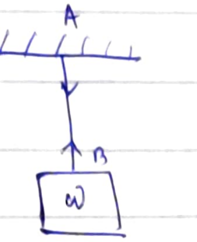
Tension & Compression :

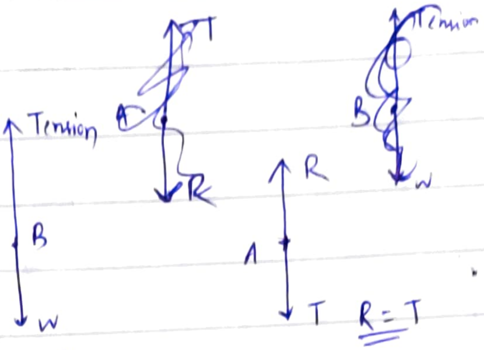
Tension is the force of resistance which opposes the elongation of the
It is always away from the point of action from force and along the



FBD of AB



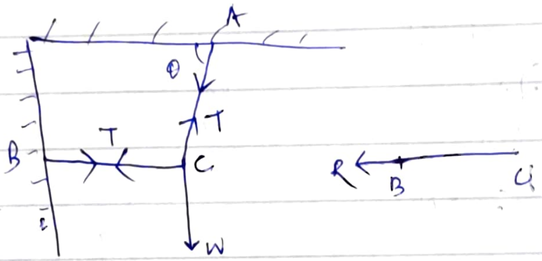




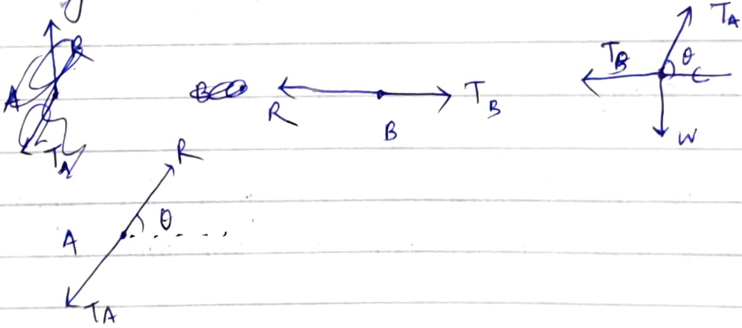
FBD of AB

T = W

R = T



FBD diagram of A, B & C,



Compression is the force of resistance which opposes any contraction of a member under external load.

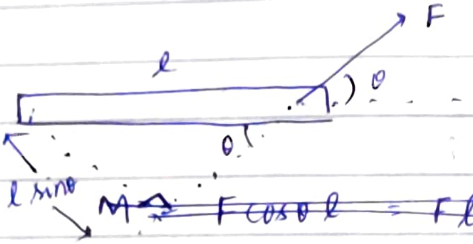
Moment of force :

Moment of the force is defined as product of the force and perpendicular distance of the force ~~Res~~ at that point.

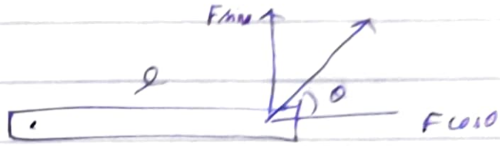
Unit - N/M

$M = r F$

↳ $\perp^{er}$ distance between Force and that point.

8. 

or



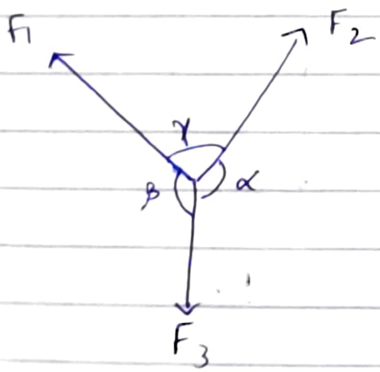
~~$M = F\cos\theta\, l = F l \cos\theta$~~.

$M = F l \sin\theta$

$M = F \sin\theta\ l$

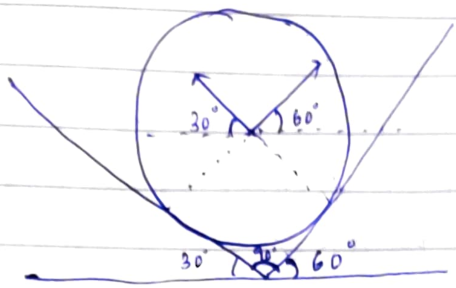
$= F l \sin\theta$.

Lamis Theorem :



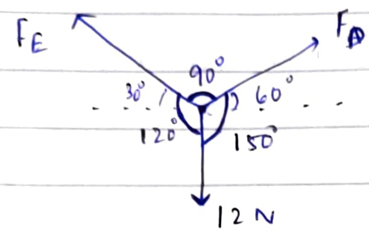
$$\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{F_3}{\sin\gamma}$$

Three forces acting on a point are in equilibrium then each force is proportional to the sine of angle with closing the other two forces



Determine the forces exerted on the sides of the turf D and F if the surfaces are perfectly smooth.

$Q = 12N$



$$\frac{F_E}{\sin(150^\circ)} = \frac{F_D}{\sin(120^\circ)} = \frac{12}{\sin(90^\circ)}$$

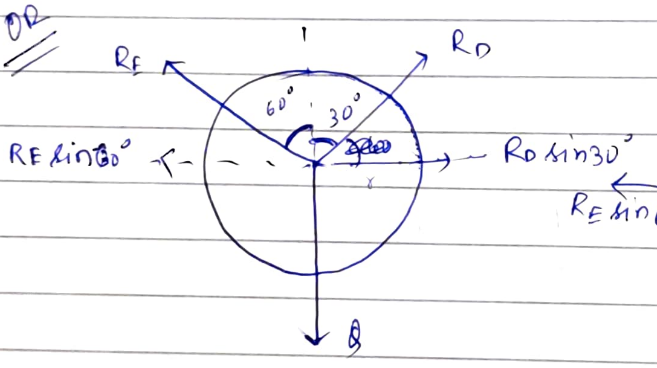
$$\frac{F_E}{0.5} = \frac{12}{1}$$

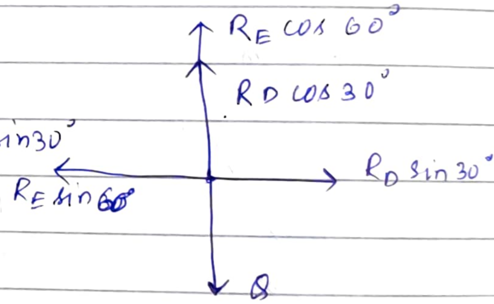
$$F_E = \frac{\cancel{12} \times 1}{\cancel{2}} \; 6$$

$$\frac{F_D}{\sin(90+30^\circ)} = 12$$

$$F_D = 12 \times \frac{\sqrt{3}}{2} = \underline{6\sqrt{3}}$$

OR





$$Q = \frac{R_E}{2} + \frac{R_D \cdot \sqrt{3}}{2}$$

$$\Rightarrow 24 = R_E + \sqrt{3} R_D$$

$$\frac{R_D}{2} = \frac{\sqrt{3}}{2} R_E$$

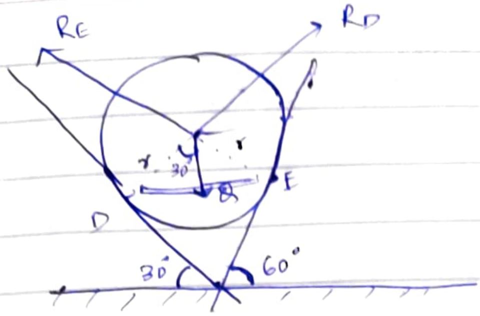
$$R_D = \sqrt{3} R_E$$

$$\boxed{R_D = 6\sqrt{3}}$$

$$\Rightarrow 24 = R_E + 3 R_E$$

$$\Rightarrow 24 = 4 R_E$$

$$\Rightarrow \boxed{R_E = 6}$$



Moment about D,

$$\Sigma M_D = 0$$

$$(R_D \times 0) + R_E r - Q r \sin 30^\circ = 0$$

$$\rightarrow R_E r - Q r \sin 30^\circ = 0$$

$$\rightarrow R_E = Q \sin 30^\circ$$

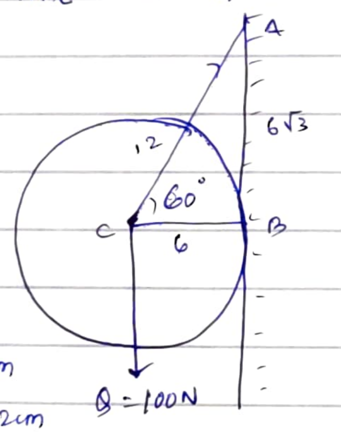
Moment about E,

Anticlockwise → +ve
Clock

$$(R_E \times 0) - R_D r + Q r \sin 60^\circ = 0$$

$$R_D = \frac{Q\sqrt{3}}{2}$$

Q. Determine 'T' in tie rod and force R_B exerted against the wall B.



$r = 6cm$
$AC = 12cm$

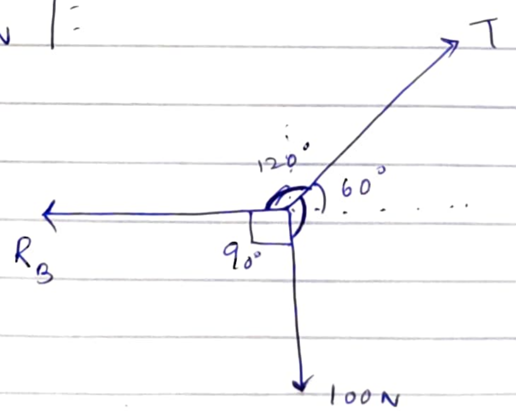
$$\sqrt{144-36}$$

$$\sqrt{108}$$

$$144 - 36 = 108$$

2 | 108
2 | 54
3 | 27
3 | 9

$$\cos\theta = \frac{6}{12} = \frac{1}{2}$$

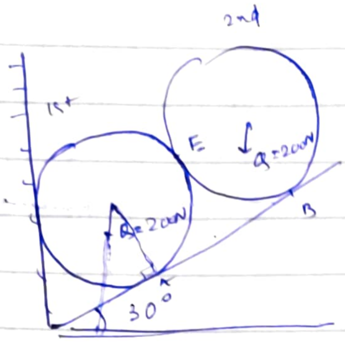


$$\frac{T}{\sin 90^\circ} = \frac{100}{\sin(120^\circ)} = \frac{R_B}{\sin(90+60^\circ)}$$

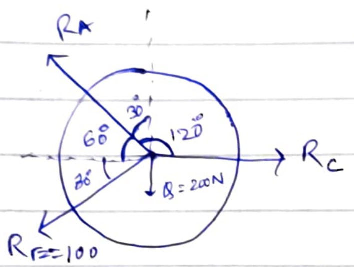
$$\rightarrow \frac{T}{1} = \frac{100}{\cos 30^\circ} = \frac{R_B}{\cos 60^\circ}$$

$$\rightarrow T = \frac{100 \times 2}{\sqrt{3}} = \frac{200}{\sqrt{3}}$$

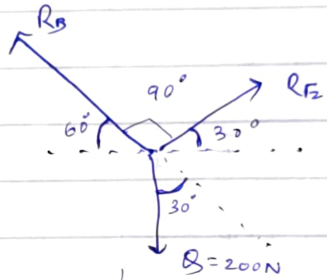
$$R_B = \frac{100 \times \cancel{2}}{\sqrt{3}} \times \frac{1}{\cancel{2}} = \frac{100}{\sqrt{3}}$$

Q. 

Find R_A, R_B, R_C.



FBD of 1st sphere

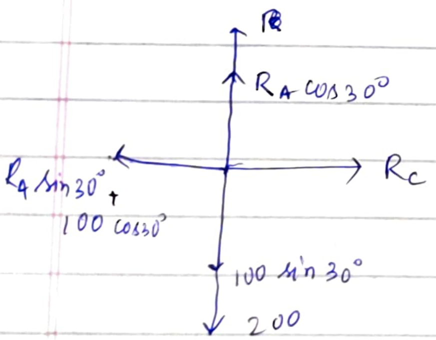


FBD of 2nd sphere

$$\frac{R_B}{\sin(90+30^\circ)} = \frac{200}{\sin 90^\circ} = \frac{R_E}{\sin(90^\circ+60^\circ)}$$

$$\Rightarrow \frac{R_B}{\cos 30^\circ} = \frac{200}{1} = \frac{R_E}{\cos 60^\circ}$$

$$\Rightarrow \boxed{R_B = \frac{200\times\sqrt{3}}{2}} \qquad \boxed{R_E = 100}$$



$$R_C = \frac{R_A}{2} + \frac{100\sqrt{3}}{2}$$

$$\frac{R_A\sqrt{3}}{2} = 200 + 50$$

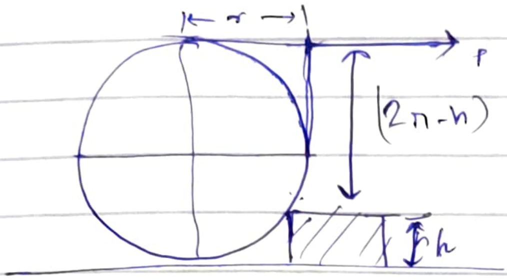
$$\sqrt{3}R_A = \frac{250}{2}$$

$$\boxed{R_A = 125\sqrt{3}}$$

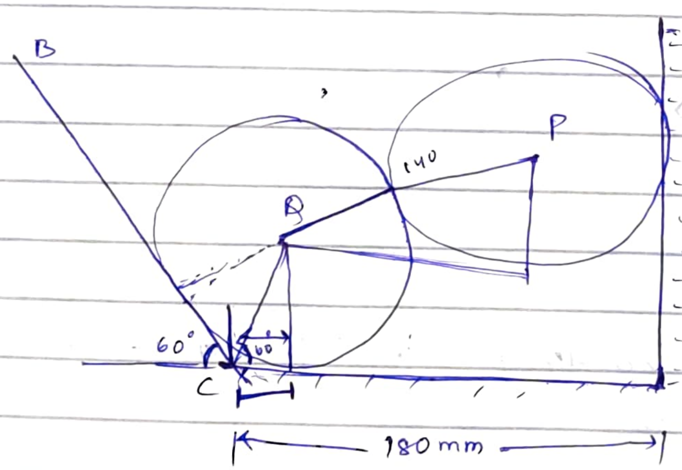
$$R_C = \frac{125\sqrt{3}}{2} + \frac{100\sqrt{3}}{2} = \frac{225\sqrt{3}}{2}$$

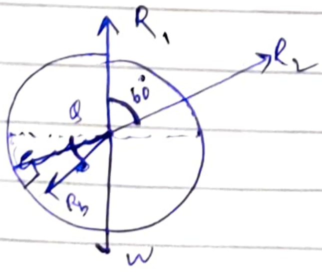
$$\boxed{R_C = \frac{225\sqrt{3}}{2}}$$

Q. A roller of weight of 500 N and radius of 120 mm and is pulled over a step of height 60 mm by horizontal force 'p'. Find the magnitude of 'p' to just start the roller over the step.



Q. Two cylinder p and q rest in a channel as shown, the dimeter of p and q are 100mm and 180 mm respectively and weight of 200N and 500 N respectively. Find the support reactions develop at the points of contact.



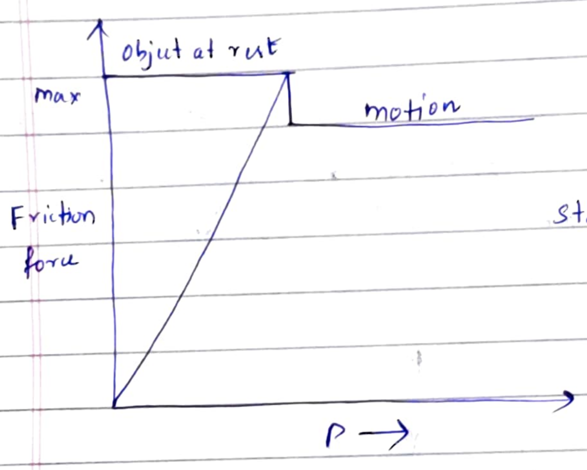


Friction

- Whenever two bodies are in contact there will be limited amount of resistance to sliding between them which is called friction.

Types of Friction

(i) Static friction
(ii) Kinetic friction – (a) sliding friction
(b) rolling friction.



static > sliding

Laws of friction :

1. Total friction that can be developed in independent of magnitude of apparent area of contact.

2. Total friction that can be developed proportional to the normal force.

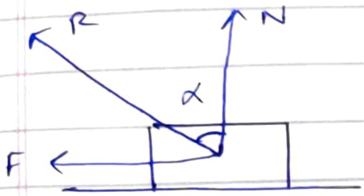
$$F = \mu N$$

F = frictional force
N = Normal force
μ = Co-efficient of friction.

3. Total friction is independent of velocity.

Angle of Friction :

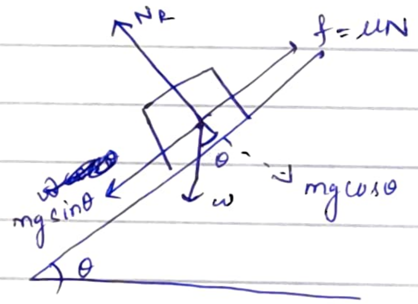
Angle between the resultant of frictional force and ~~reaction~~ normal reaction to the normal.



$$\boxed{\tan\alpha = \frac{F}{N} = \mu}$$

Angle of Repose :-

The minimum angle of inclined force on ~~the~~ inclined plane on which the body is about to slide down is called as angle of repose.



From figure :-

$N = mg\cos\theta$ ——— (i)

$F = mg\sin\theta$

→ $\mu N = mg\sin\theta$ —(ii)

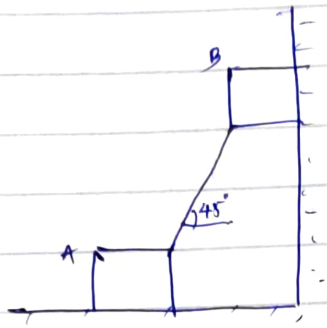
→

~~ta~~ dividing eqⁿ (i) & (2),

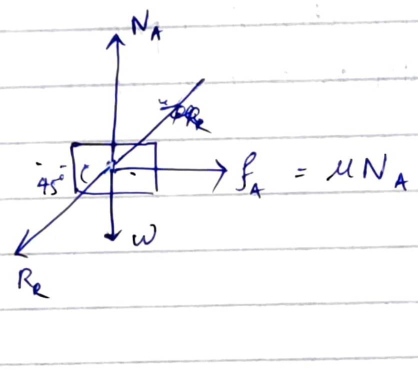
$$\frac{\mu \cancel{N}}{\cancel{N}} = \frac{\cancel{mg}\sin\theta}{\cancel{mg}\cos\theta}$$

→ $\boxed{\tan\theta = \mu}$

Q: Two identical blocks of weights 'w' are supported by rod inclined at 45° with the horizontal. If both ~~bod~~ blocks are limiting equilibrium, Find the coffecient of friction, Assuming same at surface and wall.



FBD of A



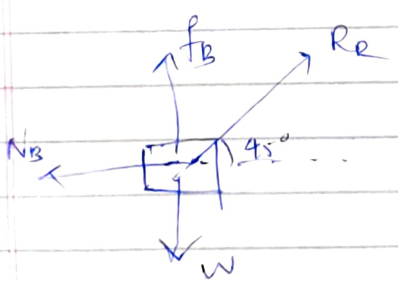
$N_A = w + R_R \sin 45°$

$R_R \cos 45° = \mu N_A$

$\Rightarrow R_R \frac{1}{\sqrt{2}} = \mu \left(w + \frac{R_R}{\sqrt{2}}\right)$

$\Rightarrow \mu = \frac{R_R}{\sqrt{2}} \times \cancel{\sqrt{2}} (\sqrt{2} w + R_R)$

$\mu = R_R (\sqrt{2} w + R_R)$



$f_B + R_R \sin 45° = w$

$= \mu N_B + R_R \sin 45° = w$ —— (1)

$N_B = R_R \cos 45°$ —— (2)

$= \frac{R_R}{\sqrt{2}}$

$\mu \left(\frac{R_R}{\sqrt{2}}\right) + \frac{R_R}{\sqrt{2}} = w$

~~$\mu \frac{R_R}{\sqrt{2}} = w - \frac{R_R}{\sqrt{2}}$~~

$\mu = \frac{w \times \sqrt{2}}{2 R_R}$ ~~$\Rightarrow \mu = \frac{\sqrt{2}}{R_R}\left(w - \frac{R_R}{\sqrt{2}}\right)$~~

$= \frac{\sqrt{2} w}{R_R} - 1$ ~~$= \frac{\sqrt{2}}{R_R}\left(\frac{\sqrt{2} w - R_R}{\sqrt{2}}\right)$~~

$$\cancel{R_R(\sqrt{2}w + R_R) = \frac{w \times \sqrt{2}}{2R_R}}$$

$$\cancel{R_R(\sqrt{2}w + R_R) = \frac{\sqrt{2}}{R_R}\left(w - \frac{R_R}{2}\right)}$$

$$\cancel{2R_R^2(\sqrt{2}w + R_R) = \sqrt{2}w}$$

$$\Rightarrow \cancel{2\sqrt{2}R_R^2} +$$

$$R_R(\sqrt{2}w + R_R) = \frac{\sqrt{2}w}{R_R} - 1$$

$$\Rightarrow R_R\sqrt{2}w + R_R^2 = \frac{\sqrt{2}w - R_R}{R_R}$$

$$u R_R + \frac{R_R}{\sqrt{2}} = w$$

$$u \frac{R_R}{\sqrt{2}} = w - \frac{R_R}{\sqrt{2}}$$

$$u = \frac{\sqrt{2}}{R_R}\left(w - \frac{R_R}{\sqrt{2}}\right)$$

$$u = R_R(\sqrt{2}w + R_R)$$

$$\frac{\sqrt{2}}{R_R}\left(w - \frac{R_R}{\sqrt{2}}\right) = R_R(\sqrt{2} + R_R)$$

$$\Rightarrow \frac{\sqrt{2}}{R_R}\left(w - \frac{R_R}{\sqrt{2}}\right) = \sqrt{2}R_R + R_R^2$$

$$\Rightarrow \frac{\cancel{\sqrt{2}}}{R_R}\left(\frac{\sqrt{2}w - R_R}{\cancel{\sqrt{2}}}\right) = \sqrt{2}R_R + R_R^2$$

$$\Rightarrow \frac{\sqrt{2}w}{R_R} - 1 = \sqrt{2}R_R + R_R^2$$

$$\Rightarrow$$

$N_A = S\sin 45^\circ + \omega$ —— (I)

$\mu N_A = S\cos 45^\circ$ —— (II)

$\omega = \mu N_b + S\sin 45^\circ$ —— (II)

$N_b = S\cos 45^\circ$

$N_A = \frac{S}{\mu\sqrt{2}}$

$\mu\left(\frac{S}{\sqrt{2}} + \omega\right) = \frac{S}{\sqrt{2}}$

$\Rightarrow \mu\left(\frac{S+\sqrt{2}\omega}{\cancel{\sqrt{2}}}\right) = \frac{S}{\cancel{\sqrt{2}}}$

$\Rightarrow \mu = \frac{S}{S+\sqrt{2}\omega}$

$\omega = \mu \cdot \frac{S}{\sqrt{2}} + \frac{S}{\sqrt{2}}$

$\omega = \frac{S}{\sqrt{2}}(\mu+1)$ —— (i)

$\Rightarrow \frac{\sqrt{2}\omega}{S} = \mu+1$

$\Rightarrow \sqrt{2}$

$\frac{\sqrt{2}\,\omega}{\mu(S+\sqrt{2}\omega)} = \mu+1$

$\Rightarrow \frac{\sqrt{2}\,\omega}{S+\sqrt{2}\,\omega} = \mu(\mu+1)$

$\Rightarrow \frac{S+\sqrt{2}\omega}{\sqrt{2}\omega} = \frac{1}{\mu(\mu+1)}$

$\Rightarrow \frac{S}{\sqrt{2}\omega} - 1 = \frac{1}{}$

$N_A = \frac{S}{\mu\sqrt{2}}$

$\frac{S}{\mu\sqrt{2}} = \frac{S}{\sqrt{2}} + \omega$

$\omega = \frac{S}{\mu\sqrt{2}} - \frac{S}{\sqrt{2}}$

$\omega = S\left(\frac{1}{\mu\sqrt{2}} - \frac{1}{\sqrt{2}}\right)$ —— (ii)

from comparing (i) & (ii)

$\frac{\cancel{S}}{\sqrt{2}}(\mu+1) = \cancel{S}\left(\frac{1}{\mu\sqrt{2}} - \frac{1}{\sqrt{2}}\right)$

$\Rightarrow \frac{\mu+1}{\cancel{\sqrt{2}}} = \frac{1}{\cancel{\sqrt{2}}}\left(\frac{1}{\mu} - 1\right)$

$\Rightarrow (\mu+1)\mu = 1-\mu$

$\Rightarrow \mu^2 + \mu + \mu - 1 = 0$

$\Rightarrow \mu^2 + 2\mu - 1 = 0$

$\mu = \frac{-2 \pm \sqrt{4 - 4(1)(-1)}}{2}$

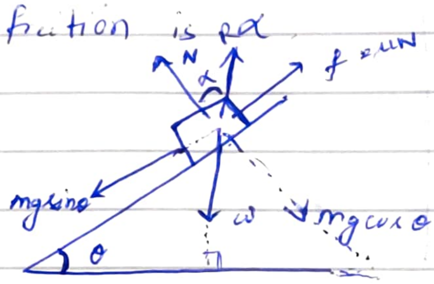
$= \frac{-2 \pm \sqrt{4+4}}{2} = \frac{-2 \pm 2\sqrt{2}}{2} = \boxed{-1 \pm \sqrt{2}}$ Ans

$\mu = -1 + \sqrt{2}$ or $\mu = -1 - \sqrt{2}$

↳ neglected as it is negative

$\boxed{\mu = 0.414}$

Q. A flat stone slab rest on an inclined skidway that makes an angle 'θ' with the horizontal. What is the condition of equilibrium is angle of friction is α.



$\tan\alpha = \frac{f}{N}$

$f = N \tan\alpha$

$f = mg\sin\theta$

$\Rightarrow N\tan\alpha = mg\sin\theta$ — ①

$N = mg\cos\theta$ — ②

$\Rightarrow \cancel{mg}\cos\theta \cdot \tan\alpha = \cancel{mg}\sin\theta$

$\Rightarrow \tan\alpha = \tan\theta$.

for equilibrium,

$\mu N \geq \omega \sin\theta$

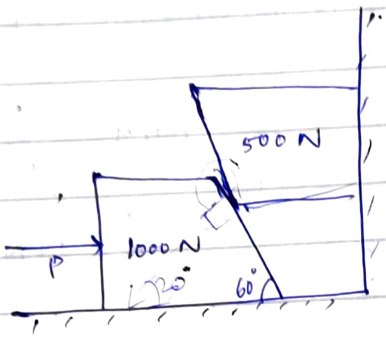
$\mu \cancel{\omega}\cos\theta \geq \cancel{\omega}\sin\theta$

$\mu \geq \tan\theta$

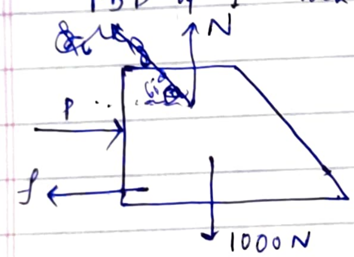
$\tan\alpha \geq \tan\theta$

$\boxed{\alpha \geq \theta}$

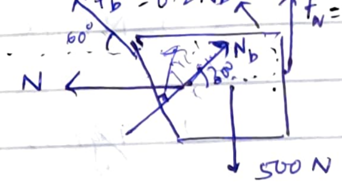
5. Two blocks of 1000 N and 500 N are arranged as shown is the figure, if the coefficient of friction at floor is 0.25, coefficient of the wall is 0.3 and coefficient of friction b/w the blocks is 0.2 then find the minimum force 'p' to be applied on the lower block that will hold the system in equilibrium



FBD of 1st block.



FBD of 2nd block

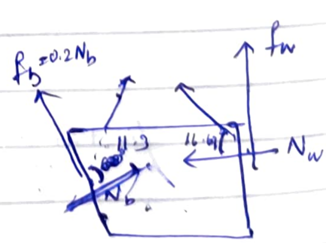


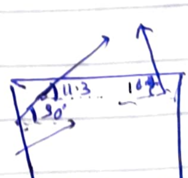
$\tan \alpha_w = \frac{0.3 \cancel{N_w}}{\cancel{N_w}}$

$\boxed{\alpha_w = 16.69^\circ}$

$\tan \alpha_b = 0.2$

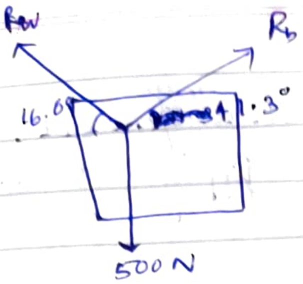
$\boxed{\alpha_b = 11.3^\circ}$





41.3
16.69
57.99

180
- 57.99

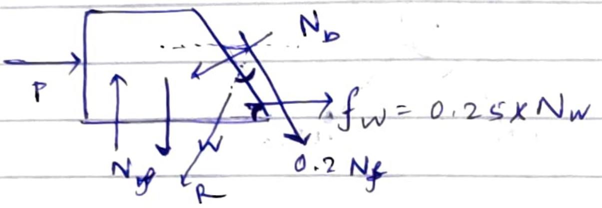


By Lamis theorem,

$$\frac{500}{\sin(122.01)} = \frac{R_b}{\sin(106.69)} = \frac{R_w}{\sin(131.3)}$$

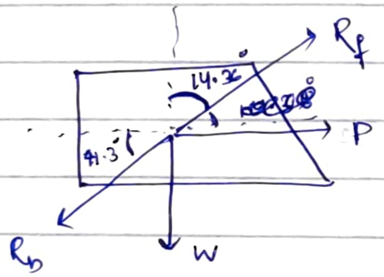
$R_b = 562.9 N.$

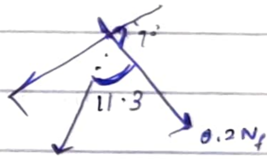
FBD of 1st.



$\tan\alpha = \dfrac{0.2 \cancel{N_b}}{\cancel{N_b}}$

$\alpha = \tan^{-1}(0.2) = \underline{\underline{11.30^\circ}}$





$\tan\alpha_f = \dfrac{0.25 \cancel{N_f}}{\cancel{N_f}}$

$\alpha_f = \tan^{-1}(0.25)$

$= 14.36^\circ$

$\Sigma f_x = 0$

$R_f \sin(14.36^\circ) + P = R_b \cos(41.3^\circ)$ —— (1)

$\Sigma f_y = 0$

$W + R_b \sin(41.3^\circ) = R_f \cos(14.36^\circ)$ —— (2)

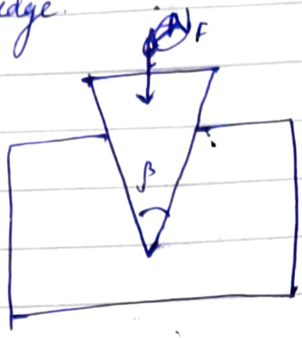
$R_f \times 0.24 + P = 562.9 \times$

$1000 + 562.9 \sin(41.3^\circ) = R_f \cos(14.36^\circ)$

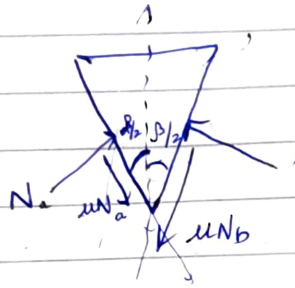
$1000 + 562.9 \times 0.66 = R_f \times 0.968$

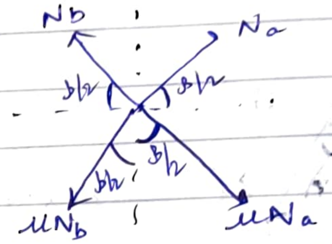
$R_f = \dfrac{1371.514}{0.968} = \underline{1416.85} N.$

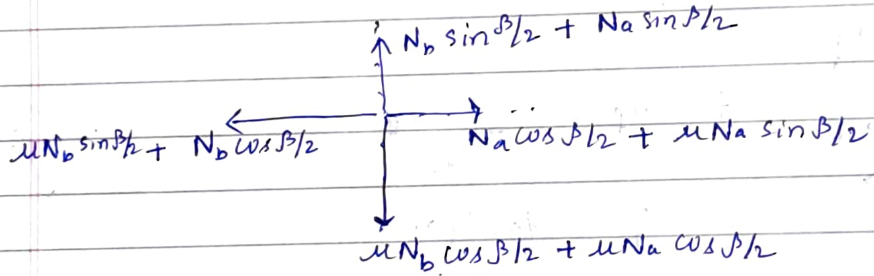
Q. What must be the angle of plane faces of steel ~~wedges~~ sledge used for splitting logs if there is no danger of wedge slipping out after each blow of sledge.



Let μ be the coefficient of friction b/w wedge and wood.







$$\Sigma F_y = 0$$

$$\Rightarrow N_b \sin\beta/2 + N_a \sin\beta/2 = \mu N_b \cos\beta/2 + \mu N_a \cos\beta/2$$

$$\Rightarrow \sin\beta/2\,(N_a + \cancel{N_b}) = \mu \cos\beta/2\,(N_a + \cancel{N_b})$$

$$\Rightarrow \boxed{\mu = \tan\beta/2}$$

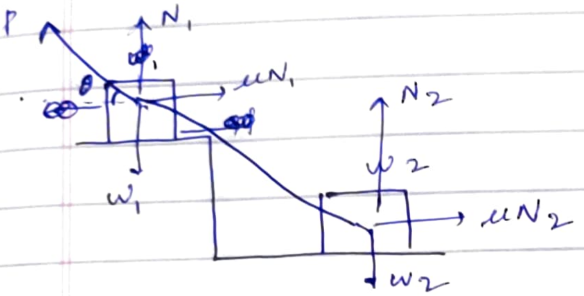
$$\Sigma F_x = 0$$

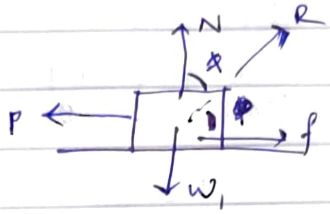
$$\mu N_b \sin\beta/2 + N_b \cos\beta/2 = N_a \cos\beta/2 + \mu N_a \sin\beta/2$$

$$\Rightarrow N_b(\mu \sin\beta/2 + \cos\beta/2) = N_a(\cos\beta/2 + \mu \sin\beta/2)$$

$$\mu \sin\beta/2 + \cos\beta/2 \neq 0$$

8. Two bodies having weight W_1 & W_2 are connected by a string and rest on horizontal plane as shown, if the angle of friction of each block is 'ϕ'. Find the magnitude and direction of least applied force P on the upper block that will induce sliding





$\tan\phi = \frac{f}{N}$

$\Sigma f_y = 0$

$P\sin\theta + N_1 + N_2 = W_1 + W_2$

$N_1 + N_2 = W_1 + W_2 - P\sin\theta$ —— (i)

$\Sigma f_x = 0$

$P\cos\theta = \mu N_1 + \mu N_2$

$P\cos\theta = \mu(N_1 + N_2)$

$P\cos\theta = \mu(W_1 + W_2 - P\sin\theta)$

$\cancel{P = \frac{\mu(W_1+W_2)}{\cos\theta} - \frac{\mu P\sin\theta}{\cos\theta}}$

$(\cos\theta + \mu\sin\theta)^{-1}$

-1

$P\cos\theta + \mu P\sin\theta = \mu(W_1 + W_2)$

$P(\cos\theta + \mu\sin\theta) = \mu(W_1 + W_2)$

$P = \frac{\mu(W_1 + W_2)}{\cos\theta + \mu\sin\theta}$ —— (2)

The minimum value of p is when denominator is $\max^m$.

$\frac{d}{d\theta}(\cos\theta + \mu\sin\theta) = 0$

$-\sin\theta + \mu\cos\theta = 0$

$\Rightarrow \boxed{\mu = \tan\theta}$

$\therefore \tan\phi = \tan\theta$

$\boxed{\phi = \theta}$

$\frac{\cos\phi}{\sin\phi} \quad \cos^2\phi$

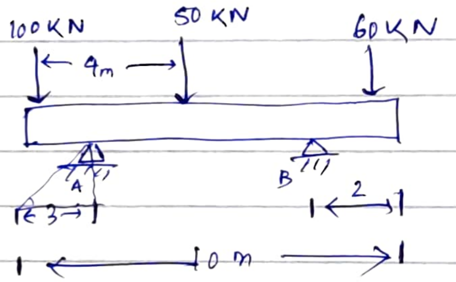
$P = \frac{\tan\phi\,(W_1 + W_2)}{\cos\phi + \mu \sin\phi}$

$P = \frac{W_1 + W_2}{\frac{\cos\phi}{\tan\phi} + \frac{\mu \sin\phi}{\tan\phi}}$

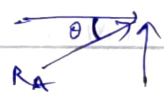
$= \frac{W_1 + W_2}{\frac{\cos^2\phi}{\sin\phi} + \sin\phi}$

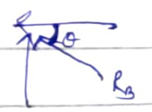
$= \frac{(W_1 + W_2)\sin\phi}{\sin^2\phi + \cos^2\phi} = (W_1 + W_2)\sin\phi.$

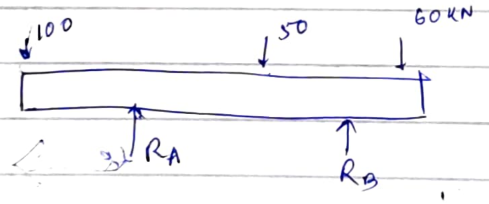
Q.



Find R_A & R_B.







$M_A = 0$

$(100 \times 3) + (R_A \times 0) - (50 \times 1) + (R_B \times 5) - (60 \times 7) = 0$

$R_B = 34\,KN$

$R_A + R_B = 100 + 50 + 60$

$R_A = 210 - 34$

$= 176\,KN.$

Truss

- A truss is made up of several bars called members joined together by hinges ~~or~~ or revits.
- The joints of a truss are called nodes
- A truss is designed to carry the loads at the nodes only.

* **Plane Truss:-**
If centre line on the member of the truss lie in one plane is called plane Truss.

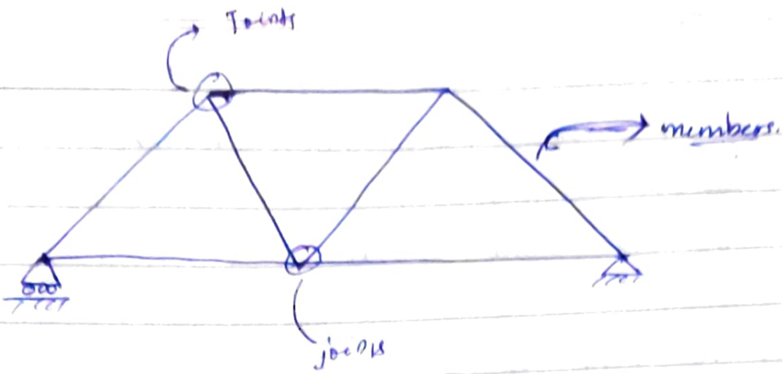
* **Space Truss:**
If the centre line of the member of the truss doesn't lies in one plane is called perfect truss.

* **Perfect Truss:**
~~If the centre lines of a member of a truss lie in on~~
If the truss contains the least no. of members required to prevent distortion of its shape, when loaded, it is called perfect truss.
If the no. of nodes or joints in a perfect truss is "J" then the no. of members is a "$n = 2J-3$"

→ ~~If~~ ~~it~~
Deficient Truss:-
If the no. of members is less than required i.e., $n < 2J-3$ is called deficient truss.

Redundant Truss:

$n > 2J-3$



Assumptions to solve Plane Truss :-

1. All the members are in one plane.
2. The members are connected at the ends by smooth hinges
3. The loads are applied at the joints only.
4. Statically determinant the structure.

Analysis of Truss

1. Determine the reaction at ~~surface~~ supports
2. Detemination of the force in member of truss.

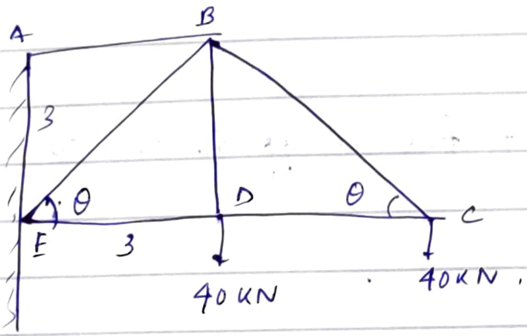
Note :- The reaction are determined by the condition that the applied load system and the induced reaction at the supports are in equilibrium.

3. The force in the member of the truss are determined by the condn that every point should be in equilibrium.

A Truss can be analysed by the following methods:

1) Method of joints
2) Method of sections.

1) Method of joint:
In this method after determining the reaction at the supports we consider equilibrium of every joints, where no. of unknown members should be maximum '2'.

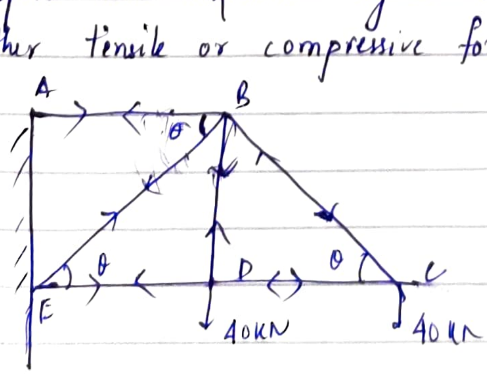


Step-1: Find the angle of inclination of all the inclined members.

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

$$\theta = 45^\circ$$

Step-2: Look for a joint at which there are two unknowns. If such a joint is not found, determine the reactions at supports and then add the supports these unknowns may be reduced to two. Also ~~mark~~ assume the members whether tensile or compressive forces are applied

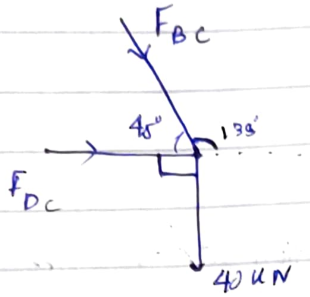


Force towards the joint is compressive.

Step-3:

Joint C

180
45



$\Sigma f_y = 0$

$F_{BC} \sin 45° + 40 \text{ kN} = 0$

$F_{BC} = -40\sqrt{2} \text{ kN}$

$\Sigma f_x = 0$

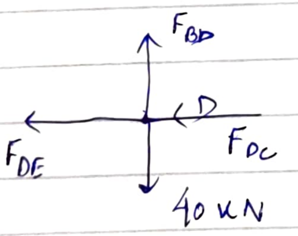
$F_{DC} + F_{BC} \cos 45° = 0$

$F_D = 40 \text{ kN}$

→ If the assumed direction of force is opposite then the value will be negative.

Step-4:

Joint - D.



$\Sigma f_x = 0$

⇒ $F_{DE} + F_{DC} = 0$

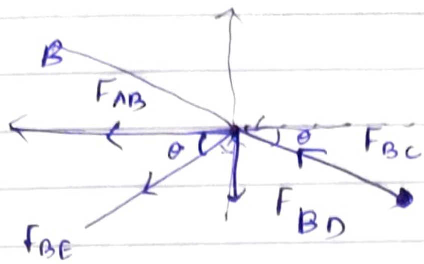
⇒ $\boxed{F_{DE} = -40 \text{ kN}}$

$\Sigma f_y = 0$

⇒ $\boxed{F_{BD} = 40 \text{ kN}}$

Step - 5

Joint B



$\Sigma F_x = 0$

$\Rightarrow F_A + F_{BE}\cos 45° + F_{BC}\cos 45° = 0$

$\Rightarrow F_{AB} + \frac{F_{BE}}{\sqrt{2}} + \frac{F_{BC}}{\sqrt{2}} = 0$

$\Sigma f_y = 0$

$\Rightarrow f_{BD} + F_{BE}\sin 45° = F_{BC}\sin 45°$

$\Rightarrow 40 + \frac{F_{BE}}{\sqrt{2}} = -40\cancel{\sqrt{2}} \times \frac{1}{\cancel{\sqrt{2}}}$

$\Rightarrow 40 + 40 = -\frac{F_{BE}}{\sqrt{2}}$

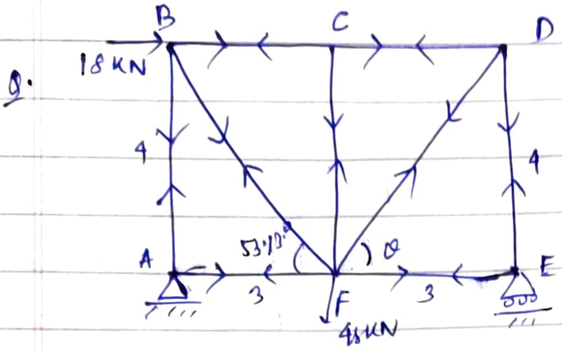
$\Rightarrow \boxed{-80\sqrt{2} = F_{BE}}$

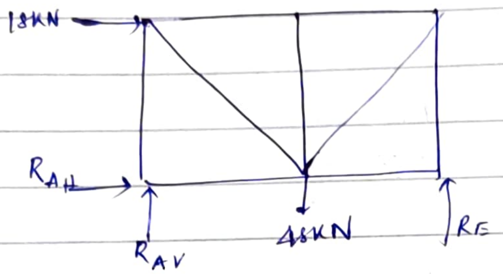
$\Rightarrow F_{AB} - 80 - 40 = 0$

$\Rightarrow \boxed{F_{AB} = 120 \text{ kN}}$

Member	Magnitude	Nature.
AB	120 kN	Tensile
BC	$40\sqrt{2}$	Tensile
CD	40	~~Tensile~~ compressive
DE	40 kN	Compressive.
BE	$80\sqrt{2}$	Compressive
BD	40	~~Compressive~~ Tensile

Q.





Considering while body under equilibrium

$\Sigma M_A = 0$

$18 \times 4 - 6R_E + 48 \times 3 = 0$

$\cancel{6R_E = 18 \times 4}$

$\cancel{R_E = \frac{18 \times 4}{6} = 12\,KN}$

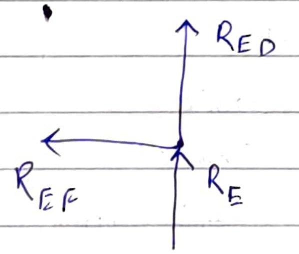
$R_{AV} + R_E = 48\,KN$

$\boxed{R_{AV} = -18\,KN}$

$72 + 144 = 6R_E$

$\frac{216}{6} = \boxed{R_E = 36\,KN.}$

At joint E

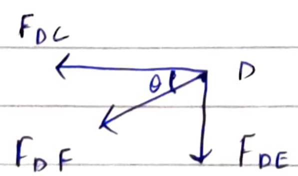


$R_{ED} + R_E = 0$

$\boxed{R_{ED} = -36\,KN}$

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

At joint D,



$F_{DE} + F_{DF} \sin(53.13°) = 0$

$-36 + F_{DF} \times 0.79 = 0$

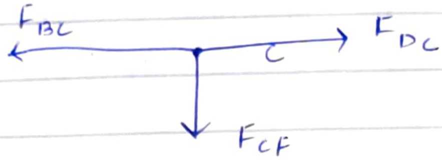
$F_{DF} = \frac{36}{0.79} = 45.5\,KN$

$F_{DC} + F_{DF} \cos(53.13°) = 0$

$F_{DC} + 45.5 \times 0.6 = 0$ $F_{DC} = 27.3\,N$

At point C,

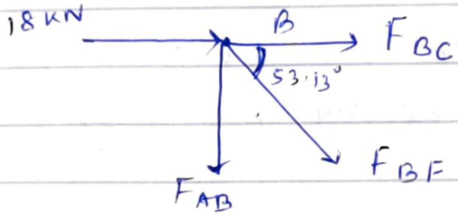
$\boxed{F_{CF} = 0}$



$F_{DC} = F_{BC}$

$\boxed{F_{BC} = 27.3N}$

At point B,



$18 + F_{BC} + F_{BF} \cos(53.13°) = 0$

$18 + 27.3 + F_{BF} \times 0.6 = 0$

$F_{BF} \times 0.6 = -45.3$

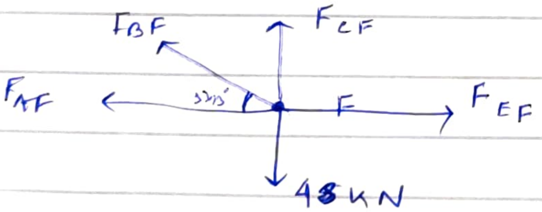
$\boxed{F_{BF} = -75.5N}$

$F_{AB} + F_{BF} \sin(53.13°) = 0$

$F_{AB} = -(-75.5) \times 0.79$

$= 59.645$

At point F,



$F_{BF} \sin(53.13°) = 48 \text{ kN}$

$\frac{48}{0.799}$

$F_{AF} + F_{BF} \cos 53.13° = F_{EF}$

Method of Sections :-

Method of section especially useful in those sections where forces in only a few intermediate members are required.

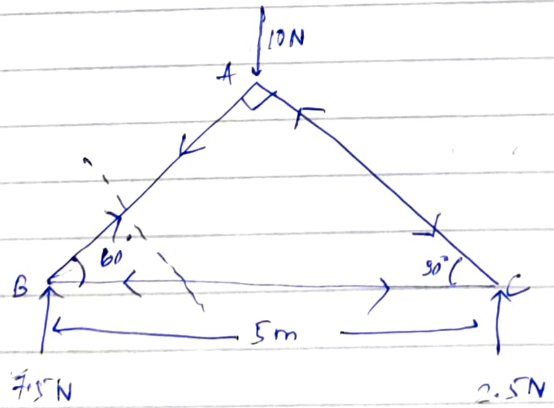
This is method is followed by dividing the truss into two parts by an imaginary section drawn in such a way as not to cut more than three members with unknown forces in them.

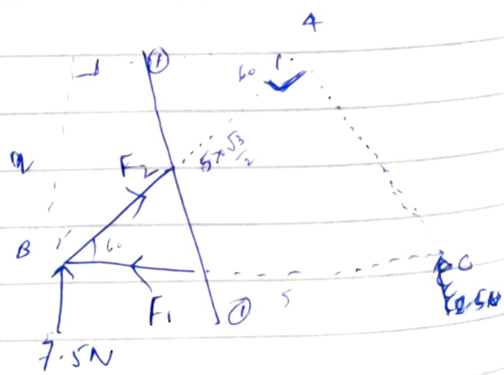
Then we apply the conditions of equilibrium to one of the parts which is in loads and forces exerted upon it by members cut by the section.

- While considering whole frame of truss, the internal forces in the members are not taken into account.

- After taking the section we can consider the internal forces in the cut members as external force to any one part of the section.

Q.





cut the section ① ①, cutting section AB & BC, as shown, considering the left part only taking moment about c.

$$M_c = 0$$

$$-(7.5N \times 5) - (F_2 \sin 60 \times 5) = 0$$

$$37.5 + F_2 \times \frac{\sqrt{3}}{2} \times 5 = 0$$

$$F_2 \times \frac{5\sqrt{3}}{2} = -37.5$$

$$F_2 = \frac{15}{\sqrt{3}} = -8.66 \text{ (compressive)}$$

$$M_A = 0$$

$$-7.5 \times \cos^2 60° \times 5 - F_1 \frac{5\sqrt{3}}{4} = 0$$

$$-7.5 \times \frac{1}{4} \times 5 - F_1 \frac{5\sqrt{3}}{4} = 0$$

$$F_1 \times \frac{\cancel{5}\sqrt{3}}{\cancel{4}} = -7.5 \times \frac{\cancel{5}}{\cancel{4}} = -4.33 N \text{ (T)}$$

$$\begin{array}{r} 7.5 \\ \times 5 \\ \hline 37.5 \end{array}$$

$\cos 60° = \frac{b}{h}$

$b = \cos 60° \times$

$\cos 60° = \frac{b}{5}$

$b = 5\cos 60°$

$\frac{\sqrt{3}}{2} \times 5$

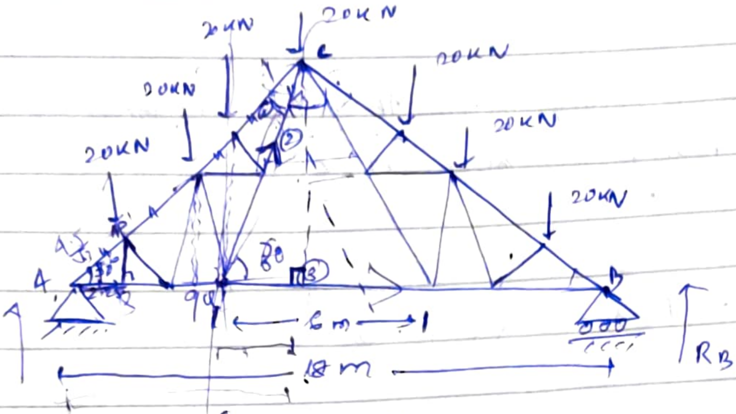
$\sin 60° = \frac{x}{5\cos 60°}$

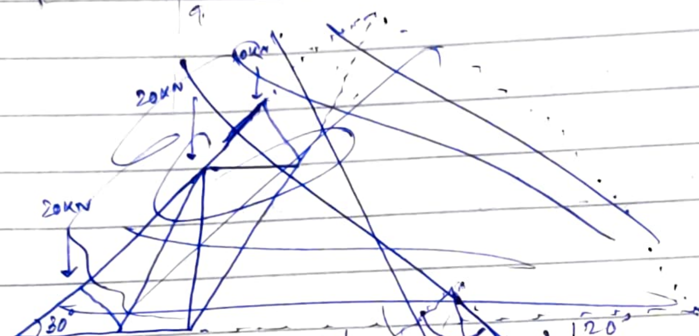
$\sin 60° \times 5\cos 60° = x$

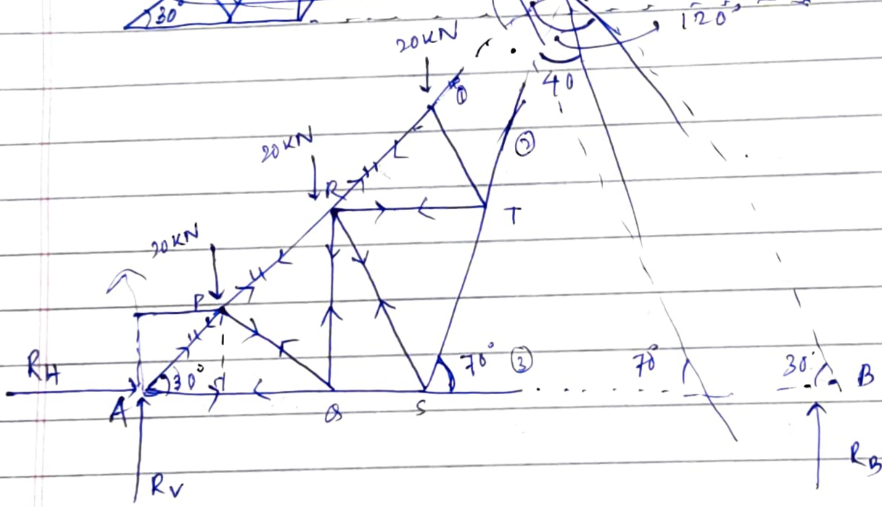
$\frac{\sqrt{3}}{2} \times \frac{1}{2} \times 5 = x$

$\frac{5\sqrt{3}}{4} = x$

8.







The given figure is french truss, find out the forces in a truss ①, ②, ③

$$\cos 30^\circ = \frac{9}{AC}$$

$$AC = \frac{9 \times 2}{\sqrt{3}} = \frac{18}{\sqrt{3}}$$

$$4A' = \frac{\cancel{18}\,\cancel{9}\; 4.5}{\sqrt{3} \times \cancel{4}}$$

$$= \frac{4.5}{\sqrt{3}}$$

$$\cos 30^\circ = \frac{AQ \times \sqrt{3}}{4.5}$$

$$\frac{\sqrt{3}}{2} \times \frac{4.5}{\sqrt{3}} = AQ$$

$$\boxed{AQ = 2.25}$$

$$= \frac{h\sqrt{3}}{9} = \frac{1}{2}$$

$$\Rightarrow h = \frac{9}{2\sqrt{3}}$$

Since it is a symmetrical french truss, $R_V = R_B$

$$R_V + R_B = 20 \times 7$$

$$2R_B = 140\ kN$$

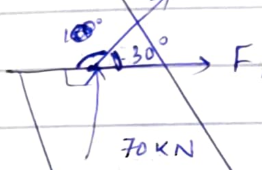
$$R_V = 70\ kN$$

$$R_H = 0$$

$\Sigma M_A = 0$

$\cancel{R_B \times 18} = 20$

At Joint A



$\cancel{\Sigma F_x} = 0$

$\cancel{F_{AQ} + F_{AP}\sin 3}$

$F_{AQ} + F_{AP}\cos 30° = 0$

$\Rightarrow F_{AQ} = -F_{AP} \times \frac{\sqrt{3}}{2}$

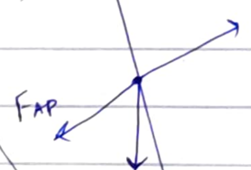
$= -\frac{\overset{70}{\cancel{140}} \times \sqrt{3}}{\cancel{2}} =$

$= -121.24\,kN\,(c)$

$F_{AP}\sin 30° + 70 = 0$

$F_{AP} = -70 \times 2 = -140\,kN \quad (c)$

At P,



$\Sigma M_B = 0$

$-70 \times 18 - F_{AP}\sin 30° \times 18 = 0$

$F_{AP}\,\frac{1}{\cancel{2}} \times \cancel{18}\,9 = -70 \times 18$

$F_{AP} = -\frac{70 \times \cancel{18}\,2}{1 \times 9} = -\cancel{80.82\,kN}\ \underline{-140\,KN}.$

Σ

By method of sections :-

$$\Sigma M_A = 0$$

$$\Rightarrow \quad 20 \times 2.25 + 20 \times \frac{9\sqrt{3}}{2} + 20 \times \frac{13.5}{\sqrt{3}} \times \cos 30^\circ$$

$$- F_2 \sin 60^\circ \times 9 = 0$$

$$\Rightarrow \quad F_2 = 51.9 \text{ kN (T)}.$$

$$\Sigma M_C = 0$$

$$70 \times 9 - 20 \times 6.75 - 20 \times 4.5 - 20 \times 2.25 - F_3 \times \frac{9}{\sqrt{3}} = 0$$

$$360 = F_3 \frac{9}{\sqrt{3}}$$

$$\Rightarrow F_3 = \frac{360 \times \sqrt{3}}{9} \qquad F_3 = 69.28 N.$$

$$\Sigma M_B$$

$$-70 \times 18 + 20 \times 15.75 + 20 \times 13.5 + 20 \times 11.25 - F_1 \sin 30 \times 18$$
$$- F_2 \sin 70 \times 12 = 0$$

$$-450 - F_2 \sin 70 \times 12 = F_1 \sin 30 \times 18$$

$$-480 - 539.9 = F_1 \sin 30 \times 18$$

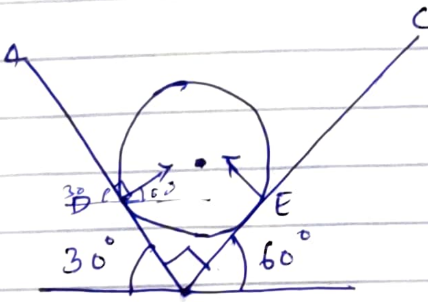
$$\frac{-1019.9}{9} = F_1 \qquad F_1 = -109.98 \text{ kN}.$$

$$F_1 = -113.32$$

$\cos 30° = \frac{b \times \sqrt{3}}{4.5}$

$\frac{\sqrt{3}}{2} \times \frac{9.5}{\sqrt{3}} = 6$

Varingnon Theorem
Priciple of transmissibility.
Lami's theorem
Friction (limiting friction, sliding friction, static, Rolling).

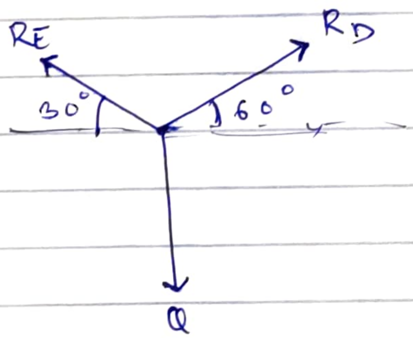


, $Q = 53.4N$

$\frac{53.4}{2}$ 106.8

To. find : R_D & R_E

f.b.d :⇒



$R_D \sin 60° + R_E \sin 30° = 53.4$

$\Rightarrow R_D \times \frac{\sqrt{3}}{2} + \frac{R_E}{2} = 53.4$

$\Rightarrow \sqrt{3} R_D + R_E = 106.8$

$\Rightarrow 3 R_E + R_E = 106.8$

$\Rightarrow 4 R_E = 106.8$

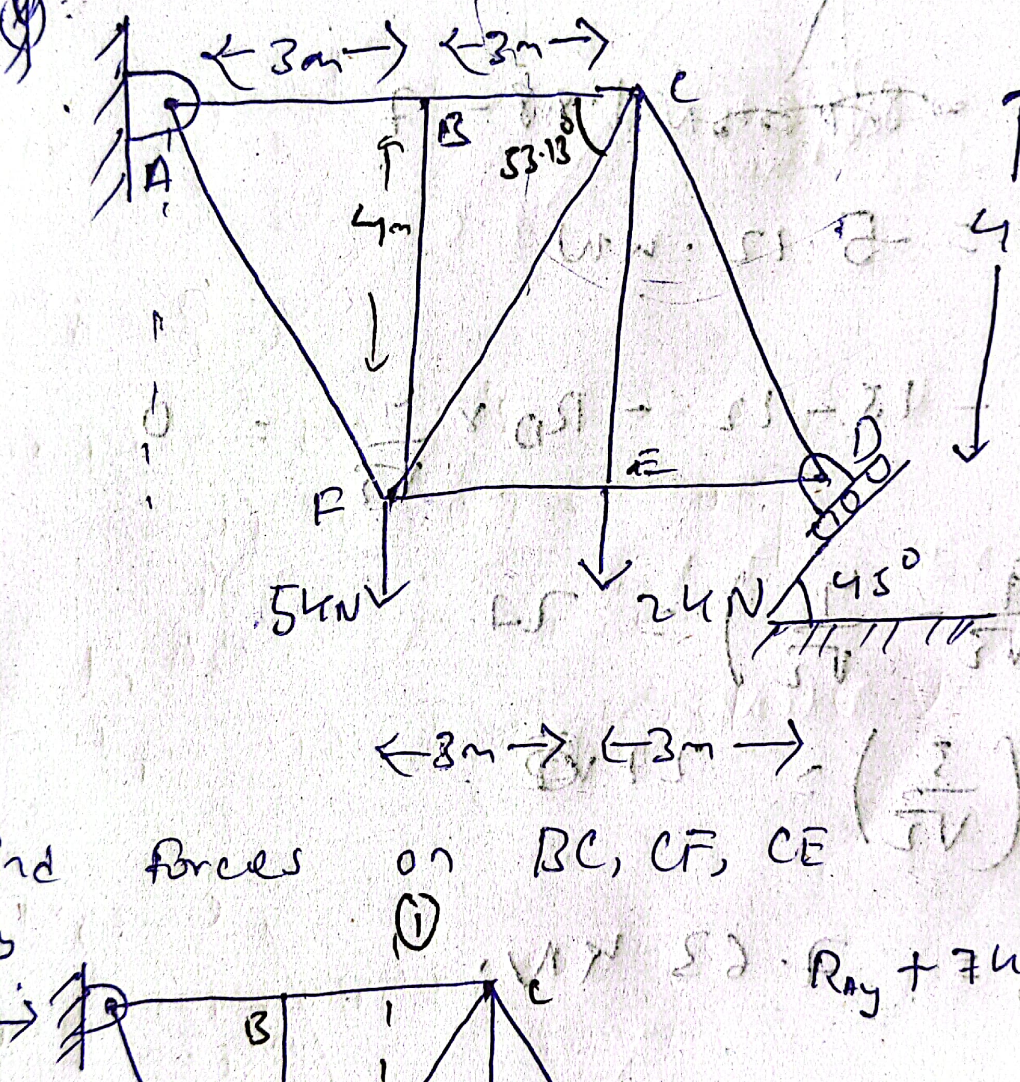
$R_E = \frac{106.8}{4} = 26.7N$

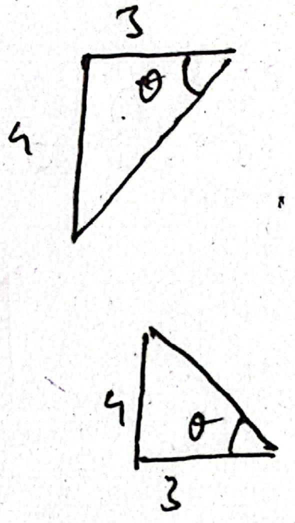
$R_E \cos 30° = R_D \cos 60°$

$\Rightarrow R_E \times \frac{\sqrt{3}}{\cancel{2}} = \frac{R_D}{\cancel{2}}$

$\Rightarrow R_D = \sqrt{3} \times 26.7N$

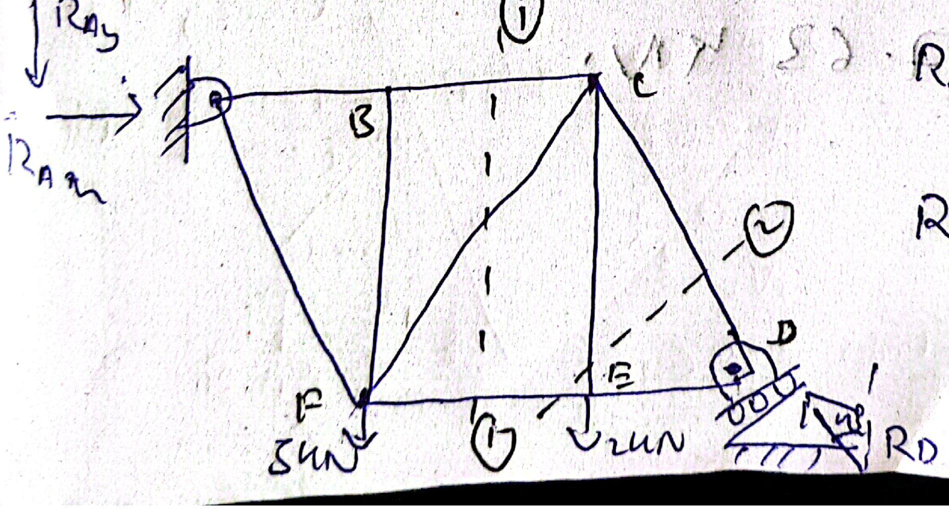
$= 1.732 \times 26.7 = 46.244\ N.$





$\theta = 53.13$

Find forces on BC, CF, CE



$R_{Ay} + 7kN = \frac{R_D}{\sqrt{2}}$

$R_{Ax} = \frac{R_D}{\sqrt{2}}$

$\Sigma M_A = 0$

$R_D \left(\overset{\sin}{\cancel{\cos}}\right) 45 \cdot \times 9$

$R_D \sin 45 \times 9 - 5 \times 3 - 2 \times 6 - R_D \cos 45 \times 4 = 0$

$R_D \frac{9}{\sqrt{2}} = 12 + 15$

$R_D = \frac{17 \times \sqrt{2}}{9} = 2.67\ kN$

$R_{Ax} = \cancel{1.88\ kN} = 1.884N$

$R_{Ay} = \frac{R_D}{\sqrt{2}} - 7$

$= \cancel{1.88\ kN}\ 1.88 - 7$

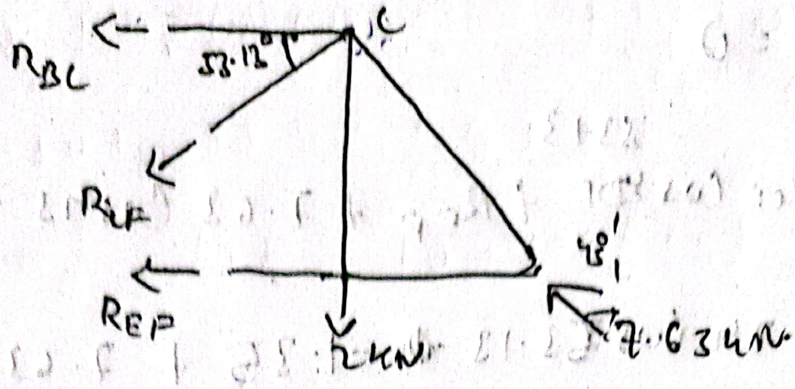
$= -5.12\ kN$

$R_D \times \frac{9}{\sqrt{2}} - 15 - 12 - R_D \times \frac{4}{\sqrt{2}} = 0$

$R_D\left(\frac{9}{\sqrt{2}} - \frac{4}{\sqrt{2}}\right) = 24$

$R_D\left(\frac{5}{\sqrt{2}}\right) = 27\sqrt{2}$

$R_D = 7.63\ kN.$



$\Sigma M_C = 0$

$-R_{EF} \times 4 + 7.63 \sin 45 \times 3 \cancel{- 7.63 \cos 45} - 7.63 \cos 45 \times 4 = 0$

$-R_{EF} \times 4 = 7.63 \times \frac{4}{\sqrt{2}} - 7.63 \times \frac{3}{\sqrt{2}}$

$R_{EF} = -\left(\frac{7.63 \times 4/\sqrt{2} - 7.63 \times 3/\sqrt{2}}{4} \right)$

$= -\left(\frac{21.58 - 16.18}{4} \right)$

$R_{EF} = -1.35 \quad (C)$

$\Sigma F_y = 0$

$R_{CF} \sin 53.13 + 2 = 7.63 \sin 45$

$R_{CF} \sin 53.13 = 7.63 \sin 45 - 2$

$R_{CF} = \frac{7.63 \sin 45 - 2}{\sin 53.13}$

$R_{CF}) = 4.24 \text{ kN } (T)$

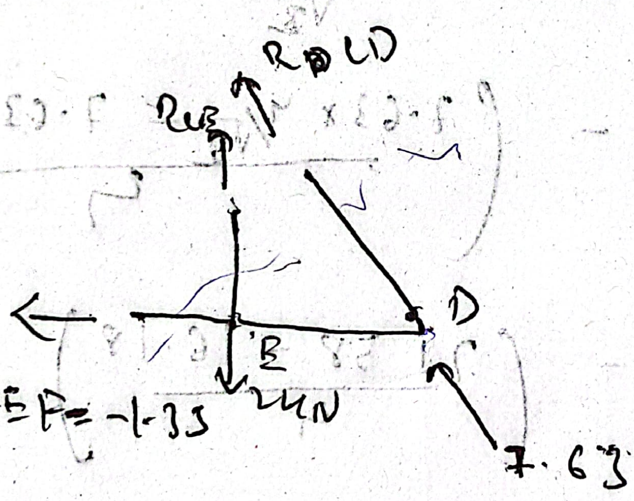
$\Sigma F_x = 0$

$R_{BC} + R_{CF} \cos \cancel{45}\, 53.13 + R_{EF} + 7.63 \cos 45 = 0$

$R_{BC} + 4.24 \cos 53.13 - 1.35 + 7.63 \cos 45 = 0$

$R_{BC} = -7.63 \cos 45 + 1.35 - 4.24 \cos 53.13$

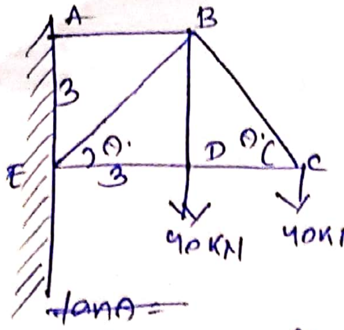
$R_{BC} = -6.58$ kN (C)



$\Sigma M_D = 0$

$-R_{CE} \times 3 + 2 \times 3$

$R_{CE} = 2$kN.



Step-1

Determine the angle of inclination of all the inclined members.

$\tan\theta = 3/3$.

$\theta = 45°$.

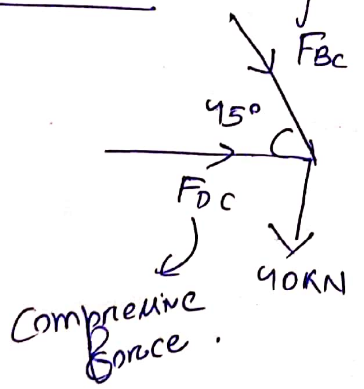
Step-2

look for a joint at which there are only two unknowns. if such a joint is not found determine the reactions at supports and then at the supports these unknowns may be reduced to two. Also mark the members whether tensile or compressive forces are applied (assume)

Step-3

Joint C

tensile force (so F_{BC} is coming -ve)



$\Sigma F_y = 0$

$F_{BC} \sin 45 + 40KN = 0$.

$F_{BC} = -40\sqrt{2}$ KN.

$\Sigma F_x = 0$,

$F_{DC} + F_{BC} \cos 45 = 0$

$F_{DC} + F_{BC} \times \frac{1}{\sqrt{2}} = 0$.

$\Rightarrow F_{DC} = -\frac{F_{BC}}{\sqrt{2}}$

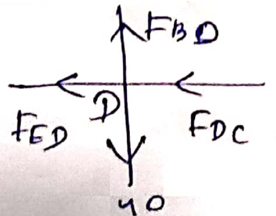
$= \frac{40\sqrt{2}}{\sqrt{2}} = 40$ KN.

if The assumed direction of unknown forces is opposite the value will be -ve.

Internal forces are showed in pairs.

Step-4

Joint D



$\Sigma F_y = 0$

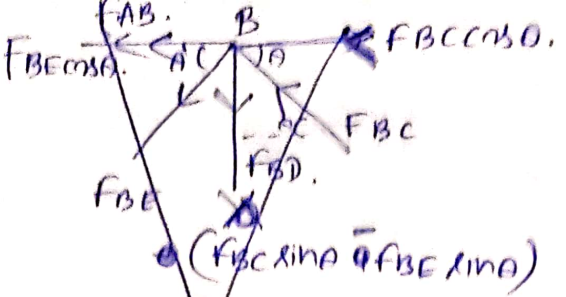
$F_{BD} = 40KN$,

$\Sigma F_x = 0$.

$F_{ED} + F_{DC} = 0$.

$\Rightarrow F_{ED} + 40 = 0$

$\Rightarrow F_{ED} = -40KN$,



$\sum F_x = 0$

$F_{AB} + F_{BE}\cos\theta + F_{BC}\cos\theta = 0.$

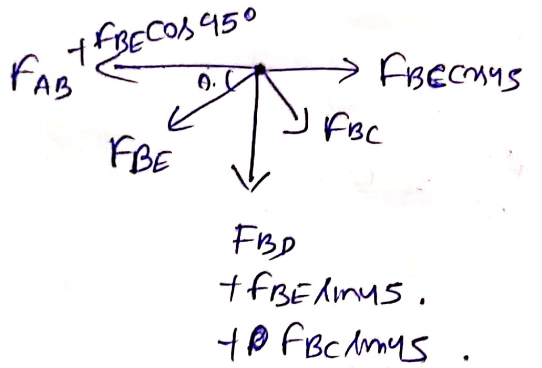
$\Rightarrow -40\sqrt{2} \times 1/\sqrt{2} + F_{BE} \times 1/\sqrt{2} + F_{AB} = 0.$

$\Rightarrow \cancel{\frac{F_{BE}}{\sqrt{2}} = 40\sqrt{2}}$

$\sum F_y = 0.$

$\frac{F_{BC}}{\sqrt{2}} - \frac{F_{BE}}{\sqrt{2}} - F_{BD} = 0.$

$\Rightarrow -\frac{40\sqrt{2}}{\sqrt{2}} - \frac{40\sqrt{2}}{\sqrt{2}} - 40$



$\sum F_y = 0.$

$F_{BD} + \frac{F_{BE}}{\sqrt{2}} + \frac{F_{BC}}{\sqrt{2}} = 0.$

$\Rightarrow 40 + \frac{40\sqrt{2}}{\sqrt{2}} + \frac{F_{BE}}{\sqrt{2}} = 0.$

$\Rightarrow F_{BE} = -80\sqrt{2}$ KN.

$\sum F_y = 0.$

$F_{BC}\cos 45 = F_{AB} + F_{BE}\cos 45$

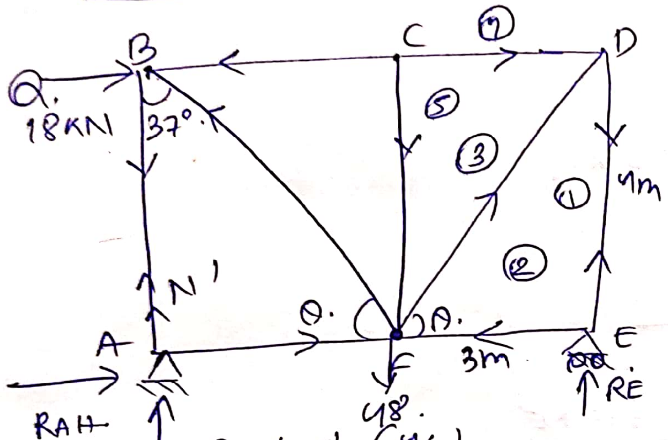
$\frac{F_{BC}}{\sqrt{2}} = F_{AB} + \frac{F_{BE}}{\sqrt{2}}$

$\frac{40\sqrt{2}}{\sqrt{2}} = F_{AB} - \frac{80\sqrt{2}}{\sqrt{2}}$

$\Rightarrow F_{AB} = 40+80$

$= 120$ KN.

member	magnitude (in KN)	Nature
AB	120KN	tensile
BC	$40\sqrt{2}$KN	tensile
CD	40KN	compressive
DE	40 KN	compressive
BE	$80\sqrt{2}$KN	compressive
BD	40KN	tensile



$\theta = \tan^{-1}(4/3)$

$= 53.13°$.

at Joint E

$R_{DE} = -RE$

$= -3\cancel{8}$KN.

~~$\Sigma F_x = 0$.~~

~~$F_{EF} = 0$.~~

Joint B

$F_{BF} \times 4/5$

18KN.

$F_{BC} + F_{BF}\, 3/5$

F_{BF}

F_{AB}

$\Sigma F_y = 0. \quad \frac{F_{BF}\,4}{5} = F_{AB}.$

$F_{BF} = \frac{5F_{AB}}{4}$

$\Sigma F_x = 0.$

$F_{BC} + F_{BF} \times 3/5 = 18.$

$F_{BC} + \frac{\cancel{5}F_{AB}}{4} \times 3/\cancel{5} = 18.$

$\Rightarrow F_{BC} + \frac{F_{AB} \times 3}{4} = 18.$

$N' = - F_{AB}.$

at Joint C.

$F_{BC} = F_{CD}$

$F_{CF} = 0$.

at Joint F

$\Sigma F_y = 0.$

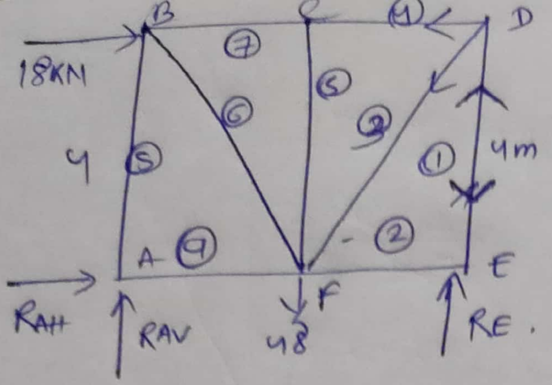
$F_{BF} \times 4/5 + F_{FD} \times 4/5 = 0.$

~~$+ F_{AF} = F$~~

$\Rightarrow . F_{BF} \times 4/5 + F_{FD} \times 4/5 = 0$

$\Rightarrow \cancel{4/5} \times \frac{\cancel{5}F_{AB}}{4} + F_{FD} \times 4/5 = 0.$

$\Rightarrow F_{AB} + \frac{4F_{FD}}{5} = 0.$



$R_{AH} = -18\,KN.$

$\Sigma A = -4\times 18 + 6\times R_E = \cancel{0}.\ -48$

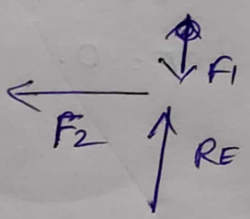
$\Rightarrow 3\times\cancel{48} + 72 = 6R_E$

$\Rightarrow R_E = \dfrac{72+48\times 3}{6} = \cancel{12\,KN},\ 12 + \cancel{28} = 36\,KN.$

$F_{DE} = -36\,kN.$

$F_{EF} = 0.$

at Joint E

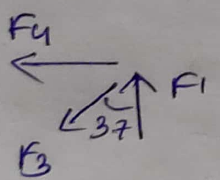


$F_1 = R_E$

$\Rightarrow F_1 = 36\,KN,$

$F_2 = 0.$

at Joint D



$\Sigma F_x = 0.$

~~⇒ F4 = 0~~

$R_4 + R_3 \sin 37 = 0$

$R_3 = \cancel{\dfrac{36\times 5}{4} = 45\,KN}.$

36 N

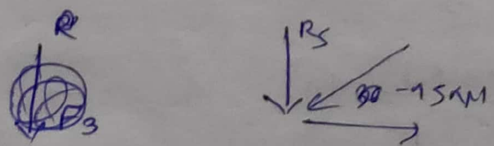
$\Sigma F_y = 0.$

$R_3 = -36\times 5/4 = 45\,KN$

$R_3 = -45\,KN$

$R_4 = 36\,KN.$

at Joint F



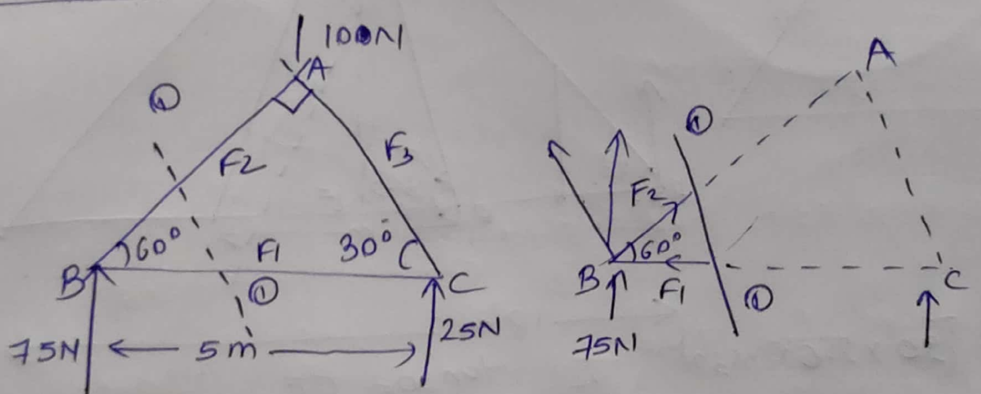
Method of Section is useful in those cases where forces in only intermediate members are required. This method is followed by dividing the truss into 2 parts by an imaginary section drawn in such a way as not to cut more than 3 members, with unknown forces in them, then we apply the conditions of equilibrium to one of the parts, which is in loads and forces exerted upon it by the members cut by the section.

Note

① While considering the whole frame of truss the internal forces of the members are not taken into account.

② After taking the section we can consider the internal forces in the cut members as external force to any one part of the section.

Method of Section.



Cutting member AB and BC as shown.

Considering the left part only

taking moment about C.

$M_c = 0$

$-(7.5\times 5)+(F_2\cos 60\times 0)-(F_2\sin 60\times 5)=0$.

$\Rightarrow -F_2\times\frac{\sqrt{3}}{2}\times\cancel{5} = 7.5\times\cancel{5}$

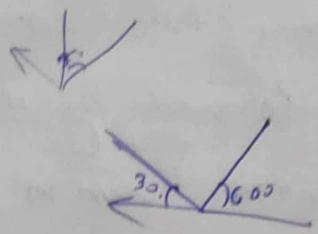
$\Rightarrow F_2 = \frac{-7.5\times 2}{\sqrt{3}} = \frac{-15}{\sqrt{3}}$

$= -8.66$

$m_A = 0.$

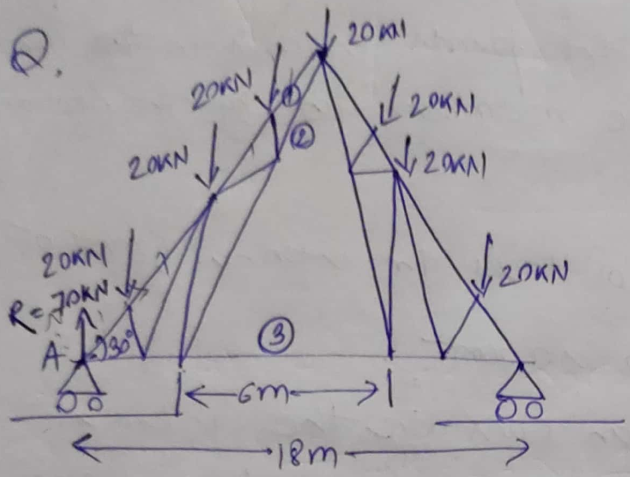
$-\left(5 \times \frac{1}{2} \times 7.5\right) - \left(F_1 \times \frac{\sqrt{3}}{2} \times 3\right) = 0.$

$\Rightarrow F_1 = \frac{-7.5 \times 5}{2} \times \frac{2}{3\sqrt{3}}$



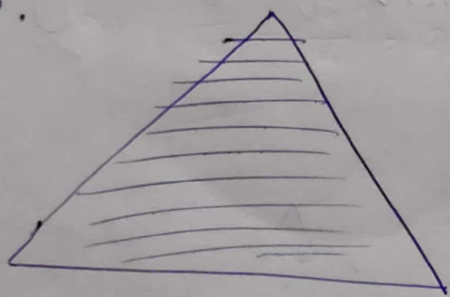
$= ~~-43.30\,N~~ = -4.330\,N.$

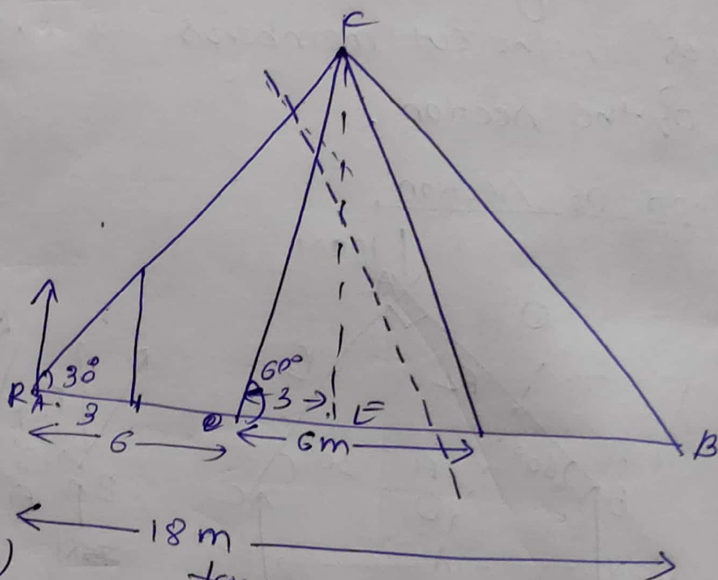
Q.



Find out the forces in members 1, 2, 3?

Cross $\Rightarrow$.





$m_A = 0$

$(F_2 \sin 60 \times 6) - (20 \times 2.6 \times \cos 30)$

$- (20 \times 2 \times 2.6 \times \cos 30) -$

$(20 \times 3 \times 2.6 \times \cos 30) = 0$

$F_2 = 51.96\,kN\ (T).$

$\tan 30 = \frac{CE}{AE}$

$CE = 9/\sqrt{3}$

$\tan \theta = \frac{CE}{DE}$

$\frac{2\sqrt{3}}{3\sqrt{3}} = 60°$

$\theta = 60°.$

$m_c = 0$

$F_3 \tan 60 \times 3 + (20 \times 2.6 \cos 30) + (20 \times 2 \times 2.6 \cos 30)$

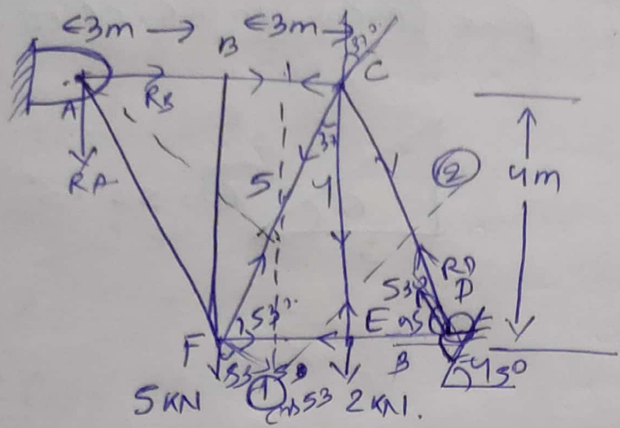
$+ 20 \times 3 \times 2.6 \cos 30 - (70 \times 9) = 0$

$F_3 = 69.28\,kN.$

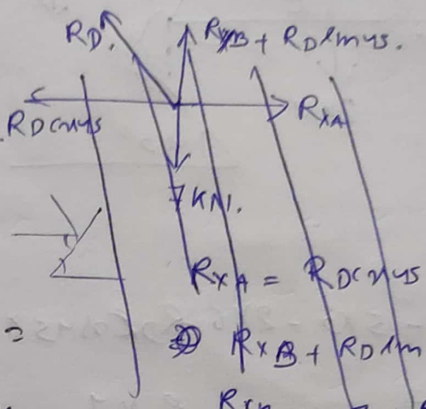
Lami's theorem

Friction (Rolling friction, Static friction, ~~Limiting~~ limiting friction).

Q.



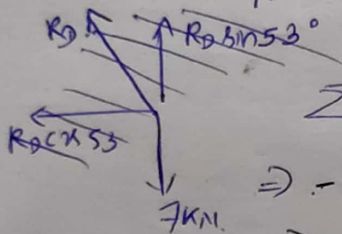
Find forces on BC, CF, CE.



$R_{xA} = R_D \cos 45$.

$R_{yB} + R_D \sin 45 = 7\text{KN}$

$R_{yB} = 7 - \frac{R_D}{\sqrt{2}}$.



$\Sigma M_A = 0$.

$\Rightarrow -15 - 12 ~~4 R_D \sin 53 = 0~~ - R_D \cos 45 \times 4$

$+ R_D \sin 45 \times 9 = 0$.

$\Rightarrow$ ~~$4 \sin 53 = 27$~~ 3

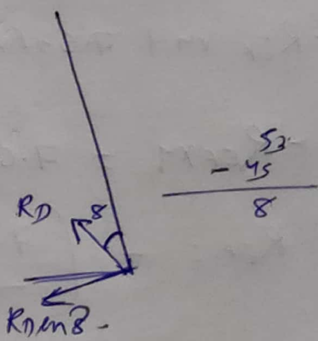
~~$\Rightarrow R_D = 3 \times 5/4 = 15/4$~~.

$\Rightarrow R_D = \frac{27\sqrt{2}}{5}$ KN.

(2) ~~$\Sigma F = 0$~~. $\Sigma M_A = 0$.

$-3 \times 5 - F_{FC} \cos 37 = 0$.

$\Rightarrow F_{FC} = \frac{-15}{4/5} = \frac{-15 \times 5}{4} = \frac{-75}{4}$ N.



$\Sigma M_D = 0$.

$6 + 30 + 9 \times R_A - 4 \times R_B = 0$.

$\Rightarrow 9R_A - 4R_B = -36$.

$\Rightarrow 4R_B - 9R_A = 36$.

$\Sigma M_C = 0$.

(4) $6R_A + 5 \times 5 \cos 53 - R_D \sin 8 = 0$.

$\Rightarrow 6R_A + \cancel{25}^{5} \times 3/\cancel{5} - \frac{27\sqrt{2}}{5}$

$= 6R_A = \frac{5.31}{5} - 15$

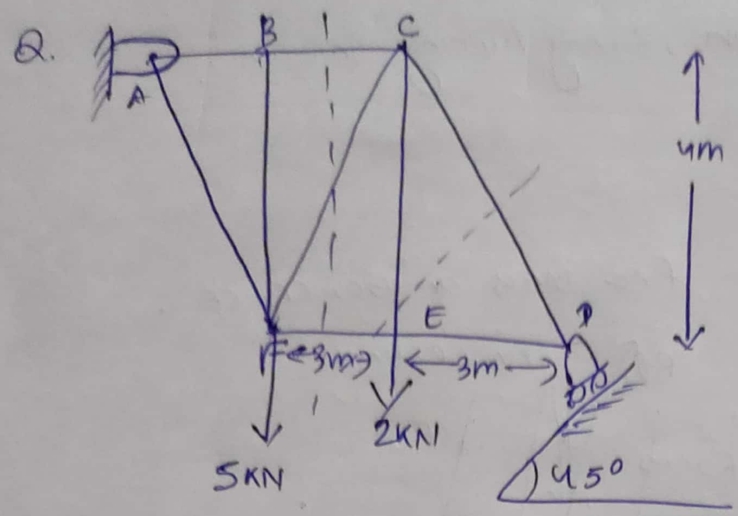
$= 1.06 - 15 = \frac{13.94}{6} = 2.32$ N.

$4R_B - 9 \times 2.32 = 36$

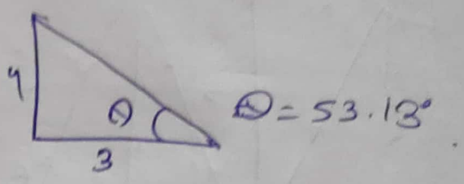
$\Rightarrow R_B = \frac{56.88}{4} = 14.2$

~~$M_c = 0$.~~

Q.



Find forces on BC, CF, CE &



$\theta = 53.13^\circ$

$\Sigma M_A = 0$.

$R_D \sin 45 \times 9 - 5\times3 - 2\times6\; R_D \cos 45 \times 4 = 0$.

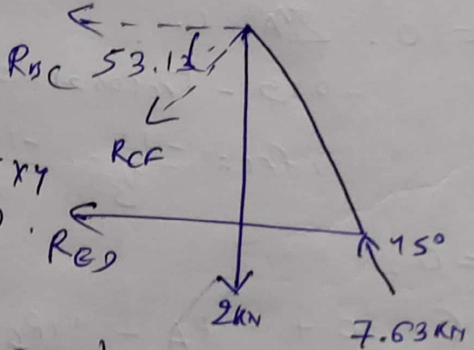
$R_D \times \frac{9}{\sqrt2} - 15 - 12 - R_D \times \frac{4}{\sqrt2} = 0$

$R_D \left(\frac{9}{\sqrt2} - \frac{4}{\sqrt2}\right) = 27$

$R_D \left(\frac{5}{\sqrt2}\right) = 27$

$R_D = \frac{27\sqrt2}{5} = 7.63\,KN$

$\Sigma M_C = 0$.



$-R_{EF} \times 4 + 7.63 \sin 45 \times 3 - 7.64 \cos 45 \times 4 = 0$.

$-R_{EF} \times 4 = 7.63 \times \frac{4}{\sqrt2} - 7.63 \times \frac{3}{\sqrt2}$

$R_{EF} = -\left(\frac{7.63 \times 4/\sqrt2 - 7.63 \times 3/\sqrt2}{4}\right)$

$= -\left(\frac{21.58 - 16.18}{4}\right)$

$R_{EF} = -1.35$.

$\Sigma F_y = 0$.

$R_{CF} \sin 53.13^\circ + 2 = 7.63 \sin 45^\circ$

$R_{CF} = \frac{7.63 \sin 45 - 2}{\sin 53.13}$

$R_{CF} = 4.24\,KN$ (T).

$\Sigma F_y = 0$.

$R_{BC} + R_{CF} \cos 53.13 + R_{EF} + 7.03 \cos 45 = 0$.

$R_{BC} + 4.24 \cos 53.13 - 1.35 + 7.63 \cos 45 = 0$.

$R_{BC} = -7.63 \cos 45 + 1.35 - 4.24 \cos 53.13$

$R_{BC} = -6.58$ KN (C)

$\Sigma M_D = 0$.

$-R_{CE} \times 3 + 2 \times 3 = 0$

$R_{CE} = 2$ KN.

$\frac{\text{Rotmi}}{2}$