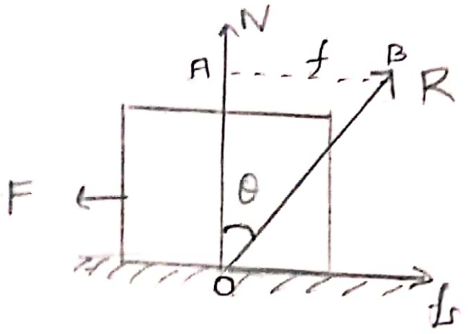
IAT-2 Civil

1(a)

→ Angle of friction

Angle of friction is the angle between the Resultant of Normal & friction force to the Normal force.



In the above diagram θ is the angle of friction.

$$\tan\theta = \frac{AB}{AO} = \frac{f}{N} = \mu$$

∴ we know that

$f = \mu N$

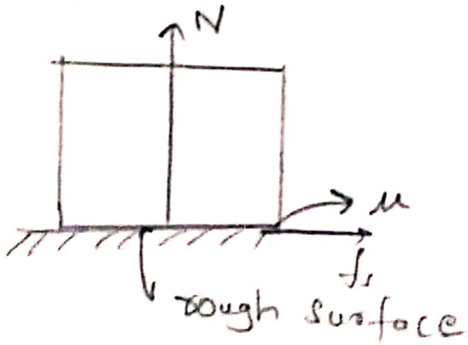
$\frac{f}{N} = \mu$

$$\tan\theta = \mu$$

$$\boxed{\theta = \tan^{-1}\mu}$$

→ Coefficient of friction: (μ)

Coefficient of friction is the constant ratio obtain when by the frictional force to the Normal reaction force. which exists when the object is contact with another object.



$f = \mu N$

$$\boxed{\mu = \frac{f}{N}}$$

where f is frictional force

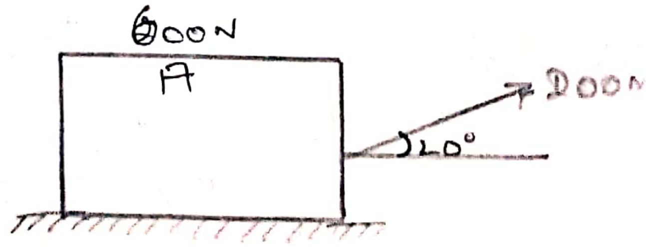
N is Normal reaction force

& P = 10N is the P_{max} value.

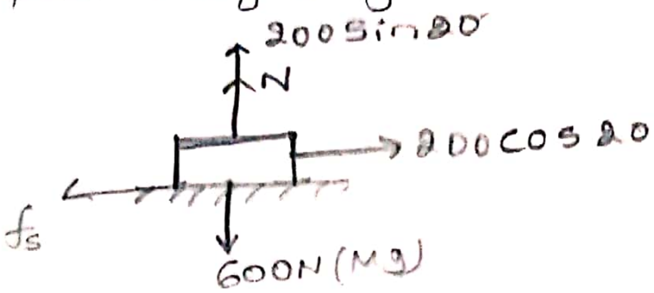
2(a) <u>laws of dry friction:</u>

* Frictional force always acts opposite to the direction of the motion of the body.
* The ratio of the frictional force & the Normal reaction force is always constant = μ = constant = $\frac{f}{N}$
* limiting friction of the static friction doesnot depends on the area of contact.
* limiting friction of the static friction depends on the nature of the surfaces which are in contact.
* In static friction the ~~friction~~ force acting on the body is equal to frictional force when the body tends to move.

(b).



The free body diagram of block A is



Let us consider the given system is in Equilibrium.

$\Sigma F_y = 0$ $\quad\quad$ $\therefore$ $Mg = 600N$, $\theta = 20$

$200\sin\theta + N_A = Mg$

$200\sin 20^\circ + N_A = 600$

$68.404 + N_A = 600$

$N_A = 600 - 68.404$

$$\boxed{N_A = 531.596N}$$

$\Sigma F_x = 0$

$200\cos\theta = f_s$

$200 \times \cos 20^\circ = f_s$

4(a).

$$\boxed{F_{max} = 187.938N}$$

$F_{max} = f_s = \mu_s N_A$

$f_s = \mu_s N_A$

$187.938 = \mu_s \times N_A$

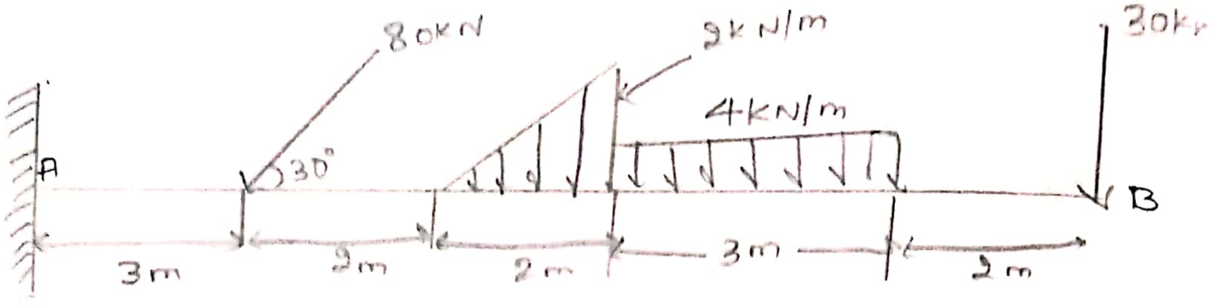
$187.938 = \mu_s \times 531.596$

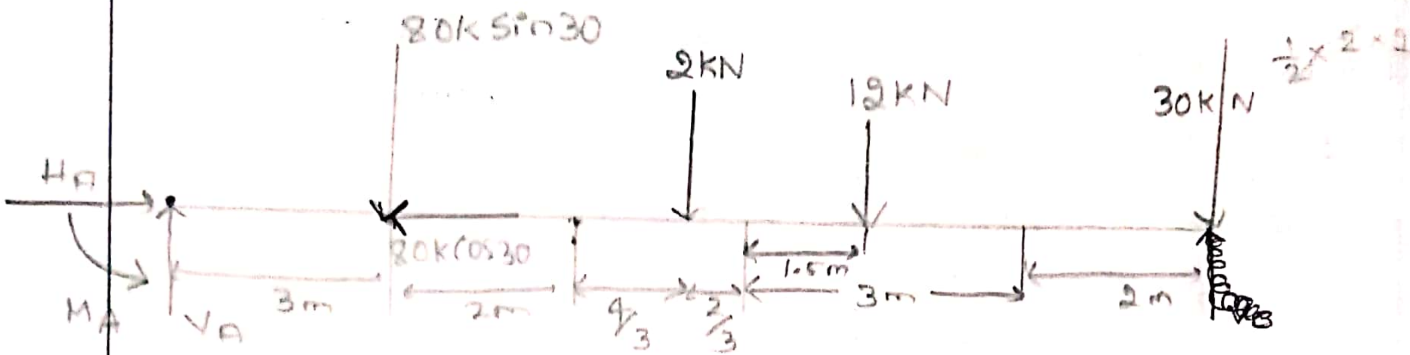
$$\boxed{\mu_s = 0.3535 \approx 0.35}$$

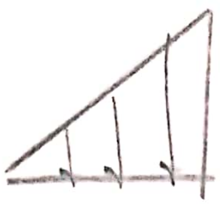
The coefficient of static friction between block and the floor, ~~of weight of the block is 600N~~ is

$0.3535 = \mu_s$

6(a)







force $= \frac{1}{2} \times 2 \times 2 = 2kN$

force $= 4 \times 3 = 12\ kN$

Let us consider the given System is in Equilibrium

$\Sigma F_x = 0$

$H_A = 80\cos 30°$

$\boxed{H_A = 69.282KN}$

$\Sigma F_y = 0$

$V_A - 80\sin 30 - 2 - 12 - 30 = 0$

$V_A = 80 \times \frac{1}{2} + 14 + 30$

$\boxed{V_A = 84KN}$

$V_A = 40 + 14 + 30$

$\boxed{V_A = 84KN}$ — ①

Moment at A = 0 $\Sigma M_A = 0$

$$-M_A + 80\sin 30 \times 3 + 2 \times (6.333) + 12(8.5) + 30(12) = 0$$

$$-M_A + 40 \times 3 + 12.666 + 102 + 360 = 0$$

$$\cancel{-M_A = -514.666\,KN}$$

$$\cancel{\boxed{M_A = 514.666\,KN}}$$

$$-M_A + 120 + 12.666 + 102 + 360 = 0$$

$$-M_A = -594.666$$

$$\boxed{M_A = 594.666\,KN}$$

$$R_A = \sqrt{(H_A)^2 + [V_A]^2}$$

$$R_A = \sqrt{(69.282)^2 + [84)^2}$$

$$\boxed{R_A = 108.885\,KN}$$

$$\theta_A = \tan^{-1}\left[\frac{V_A}{H_A}\right]$$

$$= \tan^{-1}\left[\frac{84}{69.282}\right]$$

$$\boxed{\theta_A = 50.484^0}$$

$$\boxed{M_A = 594.666\,KN}$$

$$\boxed{V_A = 84\,KN}$$

$$\boxed{R_A = 108.885\,KN}$$

$$\boxed{\theta_A = 50.484^0}$$

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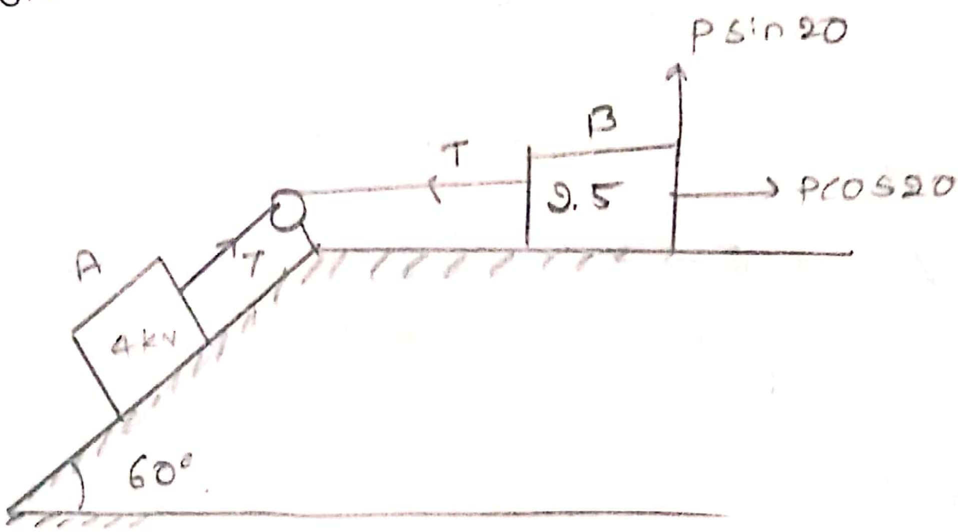
3(a)

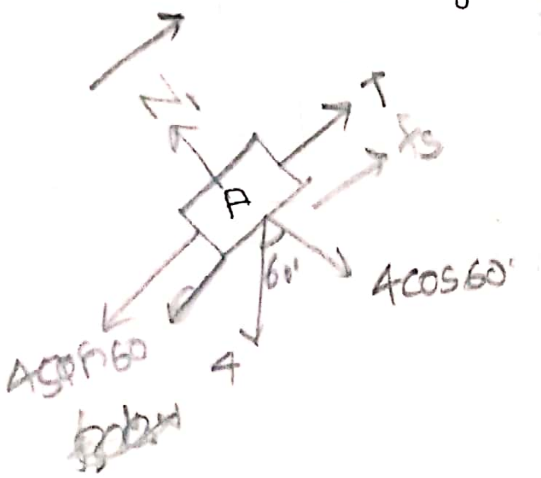
$\mu_s = 0.2$

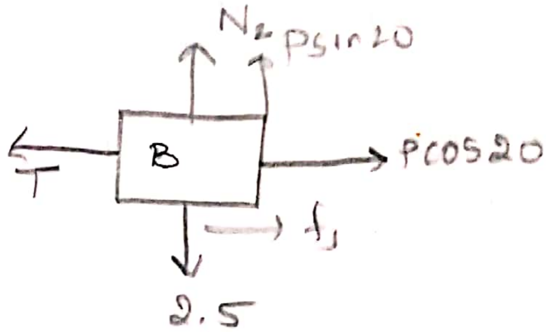


Minimum value of P.

Let us consider block is moving downward.

free body diagram of A





Case(i) Let us consider the given system is in equilibrium
block is moving downward

For block A

$\Sigma F_y = 0$

$N_1 = 4\cos 60°$

$N_1 = 4 \times \frac{1}{2}$

$\boxed{N_1 = 2\,KN}$

$\Sigma F_x = 0$

$T = 4 \times \sin 60 - \mu_s N$

$T = 4 \times \frac{\sqrt{3}}{2} - 0.2 \times 2$

$T = 2\sqrt{3} - 0.4$

$\boxed{T = 3.064\,KN}$

for block B.

$\Sigma F_x = 0$

$P\cos 20^\circ = -\mu N_2 + T$

$\boxed{P\cos 20^\circ + 0.2N_2 = 3.064}$

$\boxed{0.93 P + 0.2N_2 = 3.064}$ — (2)

$\Sigma F_y = 0$

$N_2 + P\sin 20 = 2.5$

$\boxed{N_2 + 0.34 P = 2.5}$ → (1)

by Equation (1) & (2)

$0.93P + 0.2N_2 = 3.064$

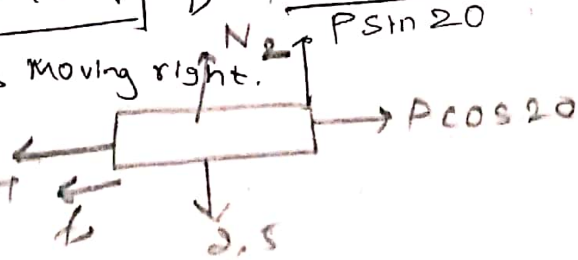
$0.34P + N_2 = 2.5$

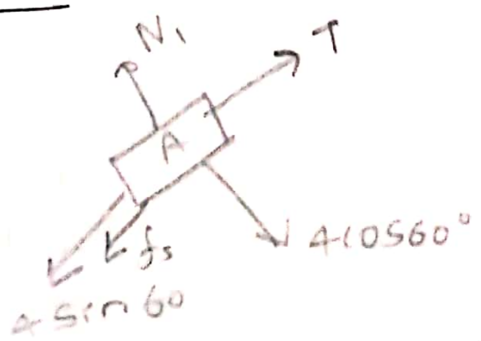
$P_{min} = \mu_s N$
$= 0.2 \times 1.4886$
$= 0.297$

$\boxed{P = 2.974\ KN}$ $\boxed{N_2 = 1.4886\ KN}$

There $\boxed{P_{max} = 2.974\ KN}$ & $\boxed{P_{min}\ is\ 0.297\ KN}$

Case(ii) when the block system is moving right.





for block A

$\Sigma F_y = 0$

$\boxed{N_1 = 2\ KN}$

$\Sigma F_y = 0$

$T = 4\sin 60^\circ + \mu N$

$T = 2\sqrt{3} + 0.2 \times 2$

$\boxed{T = 3.864\ KN}$

$\boxed{P_{min} = 0.20264\ KN}$

for block B

$\Sigma F_x = 0$

$P\cos 20^\circ = T + \mu N$

$\boxed{0.93P - 0.2N_2 = 3.864}$ — (1)

$\Sigma F_y = 0$

$P\sin 20 + N_2 = 2.5$

$\boxed{0.34P + N_2 = 2.5}$

by equat (1) & (2)

$\boxed{P_{max} = 4.372\ KN}$ $\boxed{N_2 = 1.0132\ KN}$

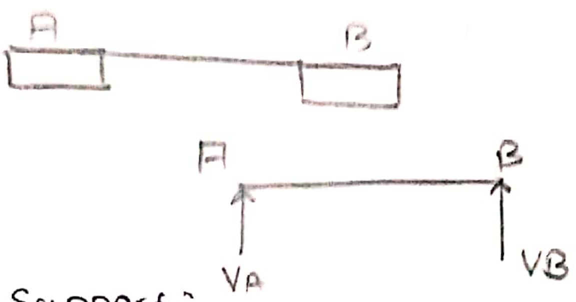
4(a) List & Explain type of Supports & loads.

Types of Supports.

1 Simple Support.
2 roller Support
3 hinge Support
4. fixed Support

* Simple Support:

Simple Support is the type of Support in which Exerts Reactions perpendecular to the plane of Support. They restrict translation of the body in one direction only. They donot restrict rotation.

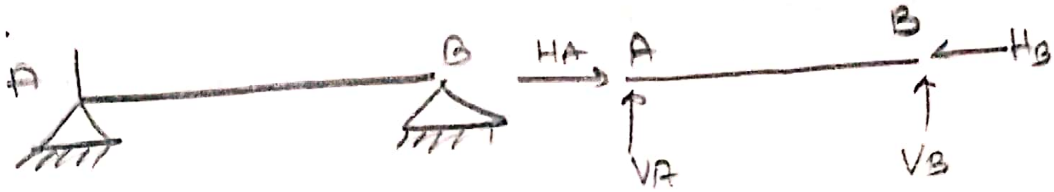


* roller Support:

roller Support is the type of Support in which Exerts. Reactions perpendecular to the plane of Support. They restrict translation of the body along one direction. which allows rotation.

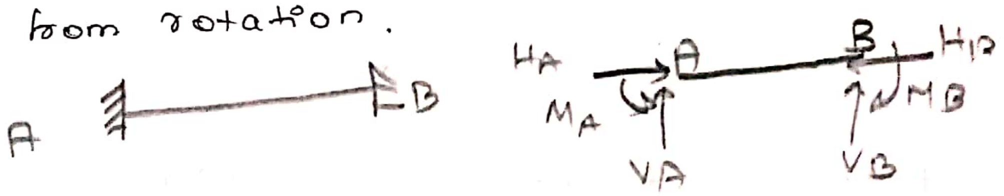
③ Hinge Support.

The hinge Support is the Support in which Exerts Reactions in all any possible direction, which ~~restrits~~ restricts translation of the body. which allows members to Rotate.



④ fixed Support:

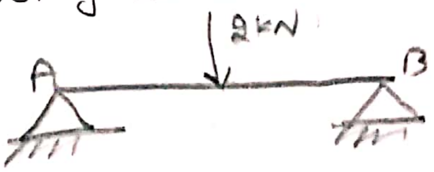
fixed support is the Support which restricts both translation & rotation of the body. Fixed support have internal moment which prevent ~~body~~ ~~to~~ the body from rotation.



⑥ Types of loads.

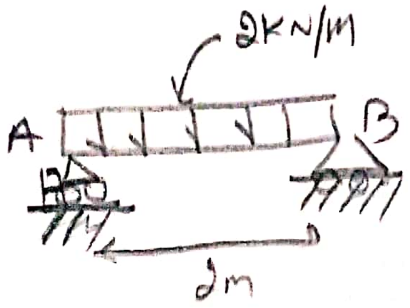
① Pointed load:

Pointed load is the type of load in which the load intensity concentrated at one point.



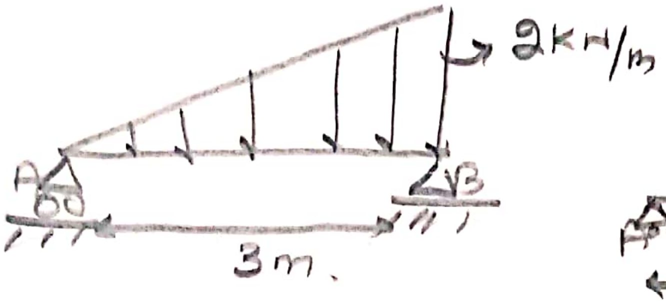
② Uniformly distribution load:

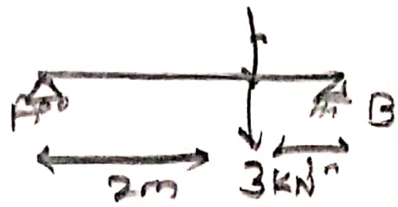
It is the type of the load in which the load intensity distributed uniformly along the length of the beam.



(3) Uniformly varrying load:

It is the type of the load in which the load intensity is uniformly varrying along the length of the beam.



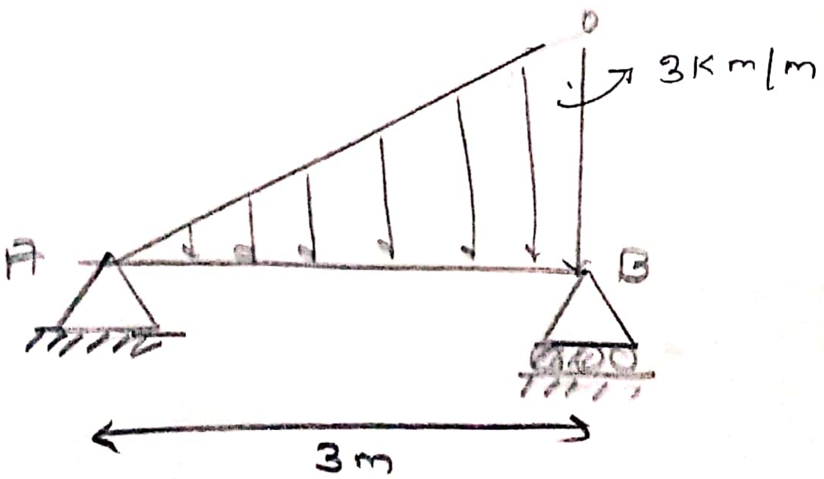


(b) Procedure to convert a (UVL) and trapezoidal loads into point loads.

Ans Uniformly varrying load!

It is the type of load in which the load intensity is uniformly varrying along the length of the beam.

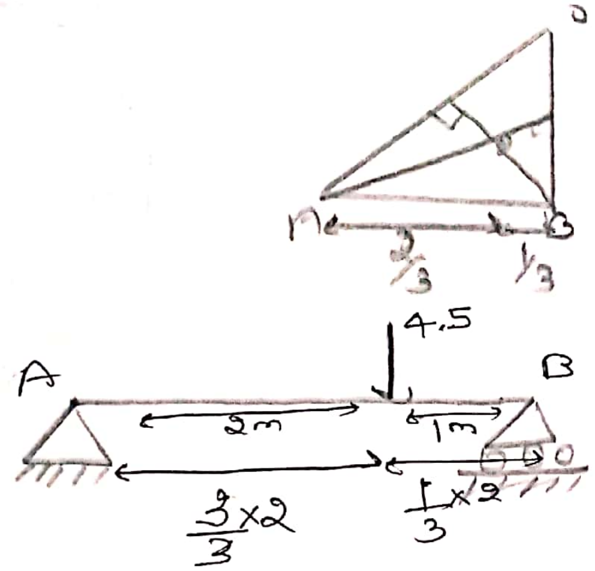
Let us consider a triangular beam of length 3m and 3Km/m is acting on the beam. AB



To convert it into point load

first we have to calculate the centre of mass of that triangle.

we know that the centre of mass of triagal lamina lines $\frac{1}{3}$rd of length from base & $\frac{2}{3}$rd of length from top



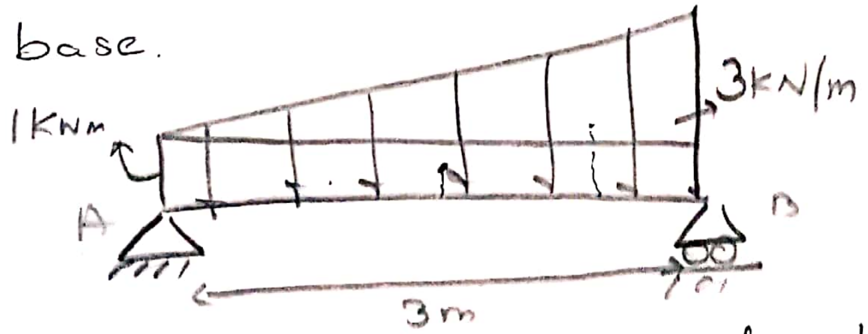
= for force:

$= \frac{1}{2} \times b \times h$

$= \frac{1}{2} \times 3 \times 3$

force $= \frac{9}{2} = 4.5$ KN

for trapezoidal loads first we have to devide the trapezium into rectangle & triangle and then calculate the centre of mass for Rectangle which lies at centre & for $\triangle$le lies $\frac{1}{3}$rd from the base.



for ~~triangle~~ Rectangl

$= l \times b$

$= 1 \times 3$ 1.5m form A

$= 3$ N

for triangle

$= \frac{1}{2} \times b \times (h)$

$= \frac{1}{2} \times 3 \times (3-1)$

$= 3$KN

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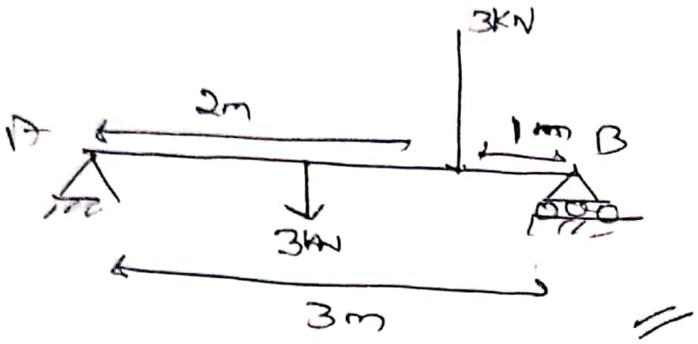
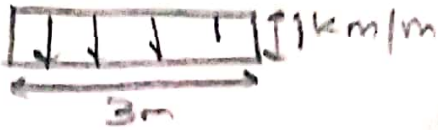
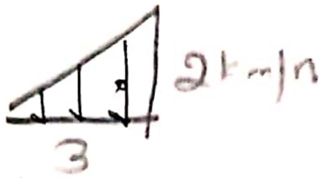




force = $l \times b$
$= 3 \times 1$
force = 3 kN



force = $\frac{1}{\cancel{2}} \times 3 \times \cancel{2}$

$\boxed{\text{force} = 3\text{ kN}}$

force distance
$\cancel{3} \times \frac{2}{\cancel{3}} = 2m$ for A

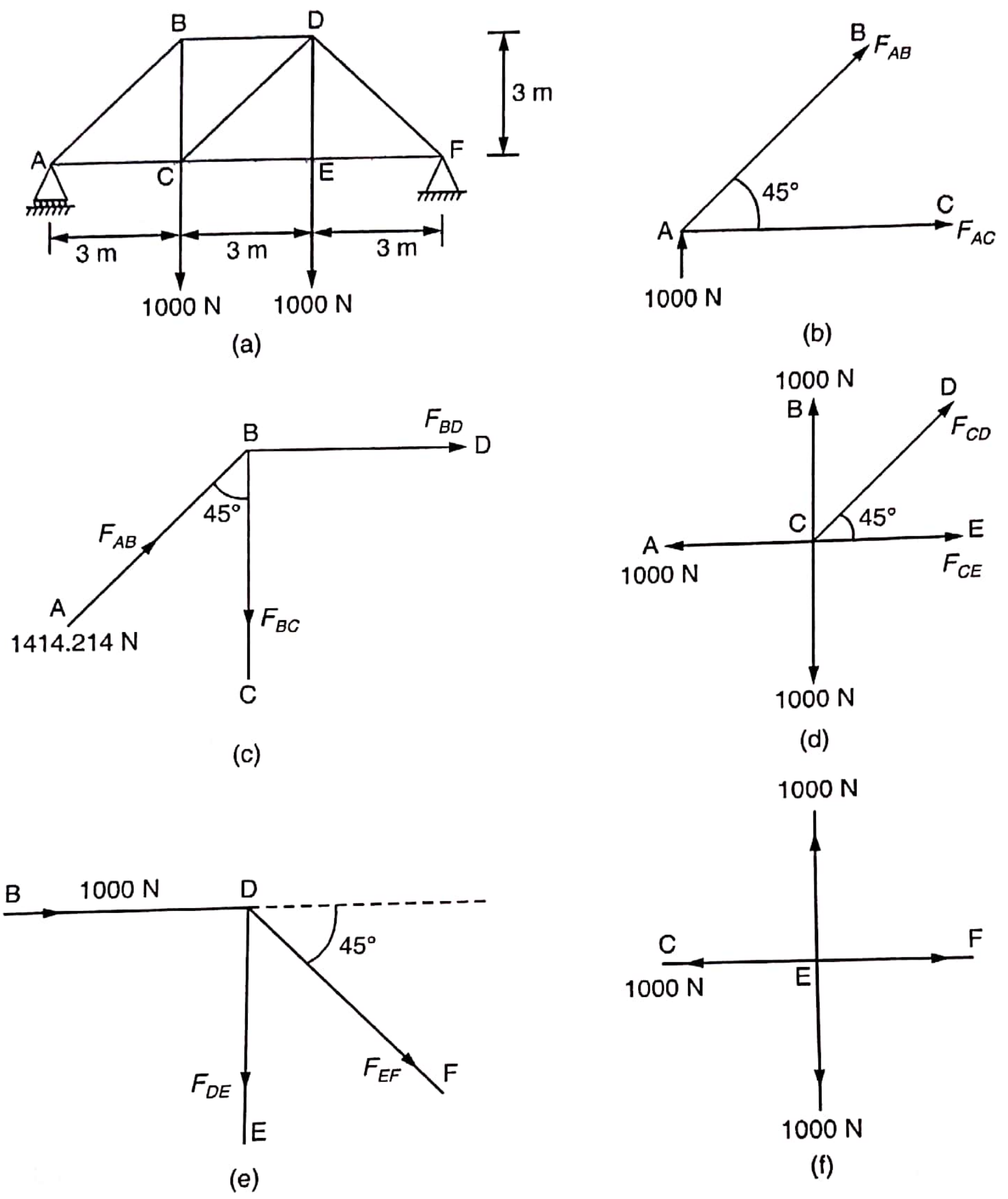


Figure 7.2

$$\Rightarrow \qquad 1000 \times 3 + 1000 \times 6 - R_{F_y} \times 9 = 0$$

$$R_{F_y} \times 9 = 9000$$

$$\Rightarrow \qquad R_{F_y} = 1000 \text{ N}$$

$$\therefore \qquad R_A = 2000 - 1000 = 1000 \text{ N}$$

Consider joint A [Figure 7.2(b)] which has got minimum number of unknowns, i.e. 2

$$\angle BAC = \tan^{-1}\left(\frac{3}{3}\right) = 45°$$

Assume that the members AB & AC are under tension.

Apply the conditions of equilibrium

$$\Sigma F_y = 0$$

$$\Rightarrow \quad 1000 + F_{AB} \sin 45° = 0$$

$$F_{AB} = -1414.214 \text{ N (C)}$$

The negative sign indicates that, the member AB is under compression.

$$\Sigma F_x = 0$$

$$\Rightarrow \quad F_{AC} + F_{AB} \cos 45° = 0$$

$$F_{AC} = 1414.214 \cos 45°$$

$$= 1000 \text{ N (T)}$$

∴ Our assumption is right.

Consider joint B [Figure 7.2(c)]

$$\Sigma F_x = 0$$

$$\Rightarrow \quad 1414.214 \sin 45° + F_{BD} = 0$$

$$F_{BD} = -1000 \text{ N(C)}$$

∴ Member BD is under compression

$$\Sigma F_y = 0$$

$$\Rightarrow \quad 1414.214 \cos 45° - F_{BC} = 0$$

$$F_{BC} = -1000 \text{ N(T)}$$

∴ Our assumption is right.

Consider joint C [Figure 7.2(d)]

$$\Sigma F_y = 0$$

$$\Rightarrow \quad 1000 - 1000 + F_{CD} \sin 45° = 0$$

$$\Rightarrow \quad F_{CD} = 0$$

$$\Sigma F_x = 0$$

$$\Rightarrow \quad F_{CE} - 1000 + F_{CD} \cos 45° = 0$$

$$F_{CE} = 1000 \text{ N(T)}$$

∴ Our assumption is right.

Consider joint D [Figure 7.2(e)]

$$\Sigma F_x = 0, \; 1000 + F_{DF} \cos 45° = 0$$

$$F_{DF} = -1414.214 \text{ N(C)}$$

$$\Sigma F_y = 0$$

$$\Rightarrow \quad -F_{DE} - F_{DF} \sin 45° = 0$$

$$F_{DE} = 1414.214 \sin 45° = 1000 \text{ N(T)}$$

Consider joint E [Figure 7.2(f)]

$$\Sigma F_x = 0$$

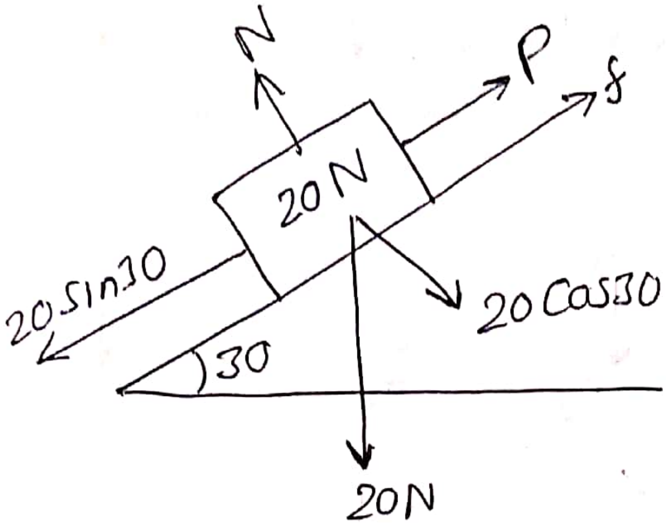
$$\Rightarrow \quad F_{EF} - 1000 = 0$$

$$F_{EF} = 1000 \text{ N(T)}$$

The analysis is tabulated as follows:

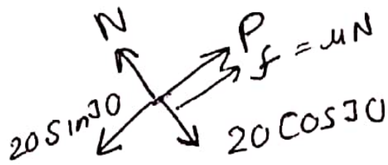
S. no.	Member	Magnitude of force (N)	Nature of force
1	AB	1414.214	Compression
2	BC	1000	Tension
3	AC	1000	Tension
4	BD	1000	Compression
5	CE	1000	Tension
6	CD	0	—
7	DE	1000	Tension
8	DF	1414.214	Compression
9	EF	1000	Tension

(b)



$\mu = 0.24$

When body moves downward



$20\sin 30 - P - 4.15 = 0$

$N = 20\cos 30$

$\boxed{N = 17.32\ N}$

$P = 20\sin 30 - 4.15 = 0$

$\boxed{P = 5.85\ N}$ min

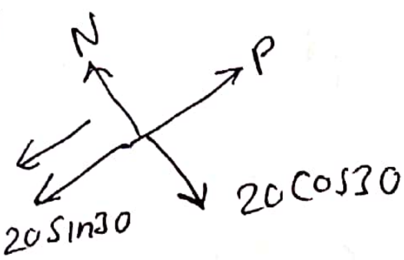
$f = 0.24 \times 17.32$

$\boxed{f = 4.15\ N}$

06

When body moves upward

$P - 20\sin 30 - 4.15 = 0$



$P = 20\sin 30 + 4.15$

$\boxed{P = 14.15\ N}$ max