29/8/19

Engineer Mechanic

* **Structural Engineering**

  It deals with construction, designing, surveying

  it covers 60% of weightage in the field of civil engineering

* **Geotechnical Ei**

  It deals with ground, soil strength

* **Transportation**

  It deals with traffic, roads, runways

* **Environmental**

  It deals with water quality – impurities removal
  air quality
  sewage system

* **Water resources**

  It deals with utilize and supply of water

05/9/19

Structural
↓
Applied Mechanics
↓
Strength of Material
↓
Structural Analysis – I and II
↓
RCC and steel structure design
↓
Prestressed concrete

Textbook : Applied Mechanics — R.C. Hibbler

1) Equilibrium of forces (force system)
2) Centroid and moment of inertia
3) Friction
4) Simple stresses and strains - I
5) Simple stresses and strains - II

5/09/2019

Applied Mechanics

*** Static**

- It is understanding of the force induced by the external body.
- The study is about finding forces or reactions or a resting body.
- Example:
  - ★ A book placed on a table
  - ★ Lift moving up and down

*** Kinematics**

- It is the study of the motion of body or the object.
- Body is in motion.
- Example:
  - ★ Throwing bomb from the aeroplane.

*** Dynamics**

- It is the study about both forces and its motion.
- Body is in motion
- Example:
  - ★ Earthquakes

9/09/2019

* Forces acting on a body $\xrightarrow{\text{rigid body}}$ Coplanar forces, Parallel forces, Collinear forces, concurrent forces

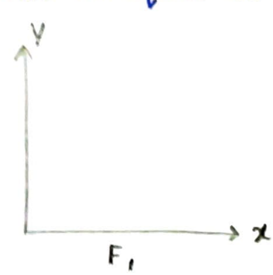
Free body diagram of a body is a diagram where we remove all the supports from the body and replace them with their reaction.

The two approaches available to solve force systems on a rigid body are : (i) Equilibrium of forces
(ii) Lami's theorem

(i) Equilibrium of forces:

The summation of all forces in x-direction must be equal to zero i.e, $\Sigma F_x = 0$

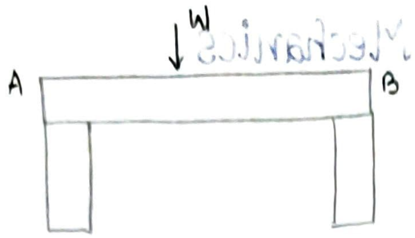
The summation of all forces in y-direction must be equal to zero i.e, $\Sigma F_y = 0$

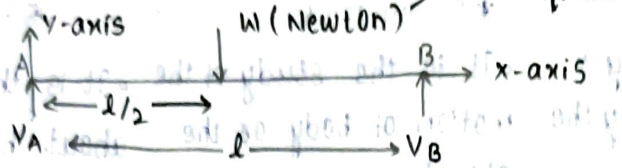


The summation of moment (force × $\perp^{r}$ distance) at a given point must be equal to zero i.e, Σ Moment = 0.

$F \times d$

12/09/2019





V_A and V_B are unknowns

Equilibrium equation.

$\Sigma F_x = 0 \Rightarrow 0$

$\Sigma F_y = 0 \Rightarrow V_A + V_B - W = 0$ —— ①

$V_A + V_B = W$

$\Rightarrow$ Any force or displacement indicated in the direction of axes are considered as positive and opposite direction is negative.

$\Sigma M_A = 0 \Rightarrow -V_B \times l + W \times l/2 + V_A \times 0 = 0$ —— ②

clockwise moment → +ve

Anticlockwise moment → −ve

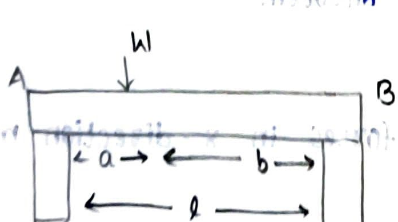
$V_B \times \cancel{l} = W \times \frac{\cancel{l}}{2}$

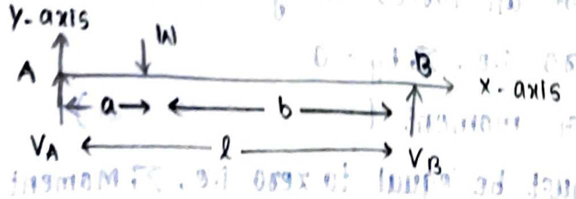
$V_B = \frac{W}{2}$

Putting equation ①,

$V_A + \frac{W}{2} = W$

$V_A = W - \frac{W}{2} = \frac{W}{2}$





$a + b = l.$

$\Sigma F_x = 0 \Rightarrow 0$

$\Sigma F_y = 0 \Rightarrow V_A + V_B - W = 0$

$V_A + V_B = W$ —— ①

$$\Sigma M_A = -V_B \times l + W \times a = 0$$

$$V_B \times l = Wa$$

$$V_B(a+b) = Wa$$

$$V_B = \frac{Wa}{l}$$

By equation ①,

$$V_A + \frac{Wa}{l} = W$$

$$V_A = W\left(1 - \frac{a}{l}\right)$$

$$V_A = W\left(\frac{l-a}{l}\right)$$

$$V_A = \frac{Wb}{l}$$

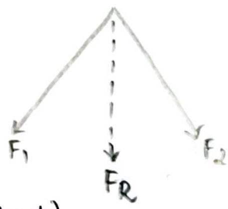
Quantity	Dimensional symbol	Unit	Symbol
Mass	M	kilogram	kg
Length	L	meter	m
Time	T	second	s
Force	F	Newton	N

Basic quantity

* Resultant force

$F_1, F_2 \rightarrow$ component forces

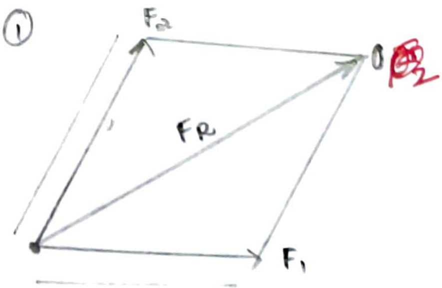
$F_R \rightarrow$ resultant force



Method - 1 : Parallelogram law (Graphical)

Method - 2 : Trigonometry

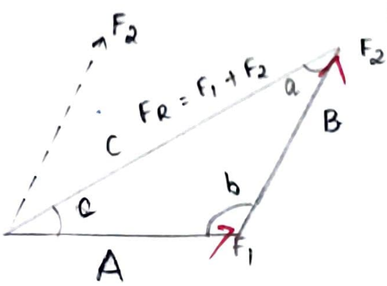
①



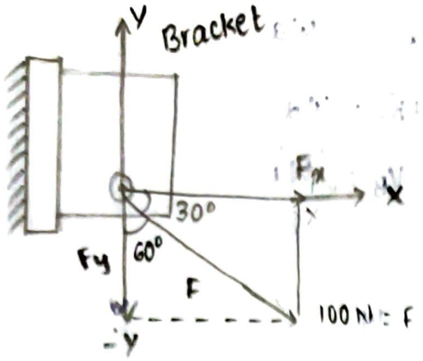
100 N magnitude

② $C = \sqrt{A^2 + B^2 - 2AB\cos b}$

$$\frac{A}{\sin a} = \frac{B}{\sin c} = \frac{C}{\sin b}$$



* Component of forces from resultant



$$\cos\theta = \frac{\text{Base}}{\text{Hypo}}$$

$$\cos 30^\circ = \frac{F_x}{F}$$

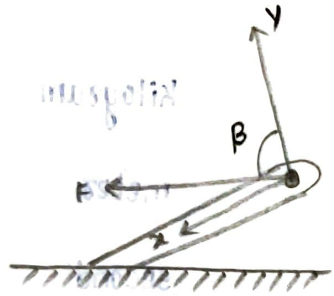
$$F_x = F\cos 30^\circ$$

$$\cos 60^\circ = \sin 30^\circ = \frac{F_y}{F}$$

$$F_y = -F\sin 30^\circ$$

* Component force

1

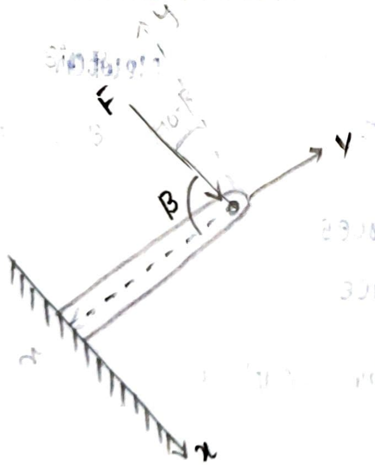


component along x, y directions = ?

$F_x = F\sin\beta$

$F_y = F\cos\beta$

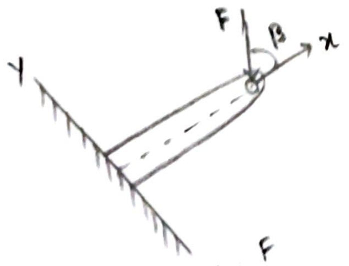
2



$F_x = F\sin\beta$

$F_y = F\cos\beta$

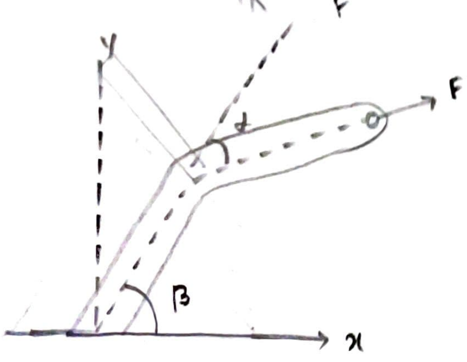
3



$F_x = -F\cos\beta$

$F_y = -F\sin\beta$

4



$F_x = F\cos(\beta-\alpha)$

$F_y = F\sin(\beta-\alpha)$

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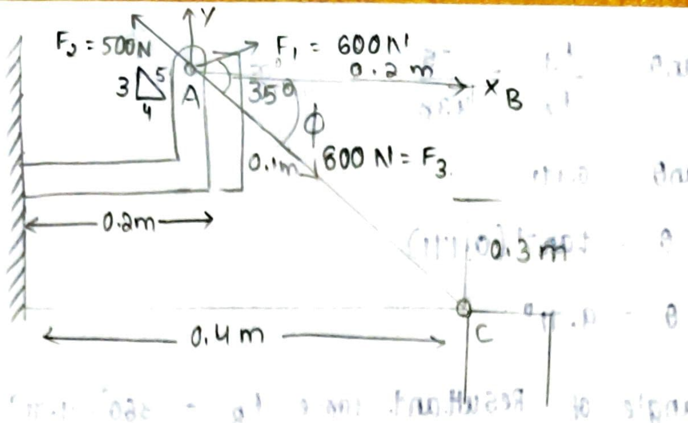
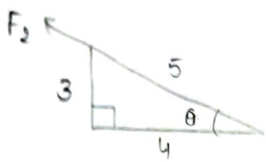
1)



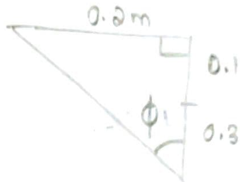
Find component of F_1, F_2, F_3



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

$\theta = \tan^{-1}\left(\frac{3}{4}\right)$

$\theta = 36.85^\circ$



$\tan\phi = \frac{0.1+0.3}{0.4-0.2}$

$\tan\phi = \frac{0.4}{0.2} = 2$

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

$\phi = 63.4^\circ$

$\sin 35^\circ = 0.57$	$\sin 36.85^\circ = 0.59$	$\sin 63.4^\circ = 0.89$
$\cos 35^\circ = 0.81$	$\cos 36.85^\circ = 0.80$	$\cos 63.4^\circ = 0.44$

$F_{1x} = F_1 \cos 35^\circ = 486\,N$

$F_{1y} = F_1 \sin 35^\circ = +342\,N$

$F_{2x} = -F_2 \cos 36.85^\circ = -400\,N$

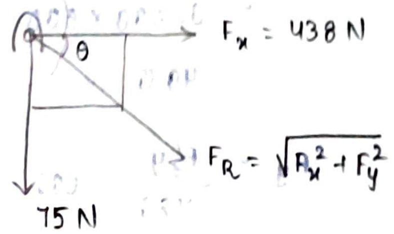
$F_{2y} = F_2 \sin 36.85^\circ = 295\,N$

$F_{3x} = F_3 \cos 63.4^\circ = 352\,N$

$F_{3y} = -F_3 \sin 63.4^\circ = -712\,N$

$F_x = F_{1x} + F_{2x} + F_{3x} = (486 - 400 + 352)\,N = 438\,N \rightarrow$

$F_y = F_{1y} + F_{2y} + F_{3y} = (342 + 295 - 712)\,N = -75\,N \downarrow$



$F_R = \sqrt{F_x^2 + F_y^2}$

$= \sqrt{(438)^2 + (-75)^2}$

$= \sqrt{191844 + 5625}$

$= \sqrt{197469} = 444.34\,N$

0.59 × 500 = 295

0.80 × 500 = 400

0.57 × 600 = 342

0.81 × 600 = 486

$$\tan\theta = \frac{F_y}{F_x} = \frac{75}{438}$$

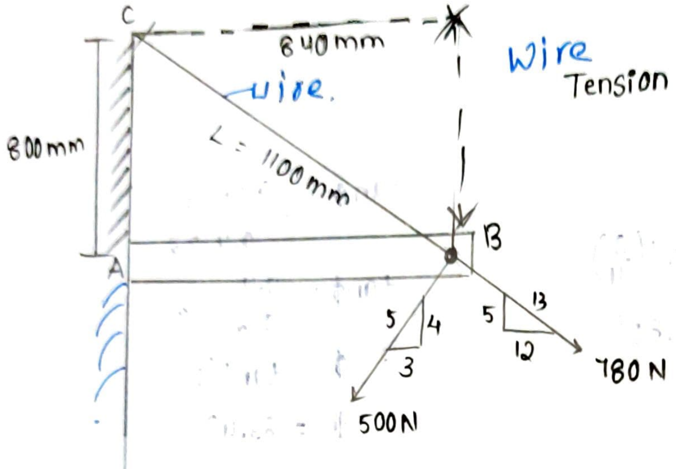
$$\tan\theta = 0.171$$

$$\theta = \tan^{-1}(0.171)$$

$$\theta = 9.71^\circ$$

Actual angle of Resultant force $F_R = 360^\circ - 9.71^\circ$
$= 350.29^\circ$

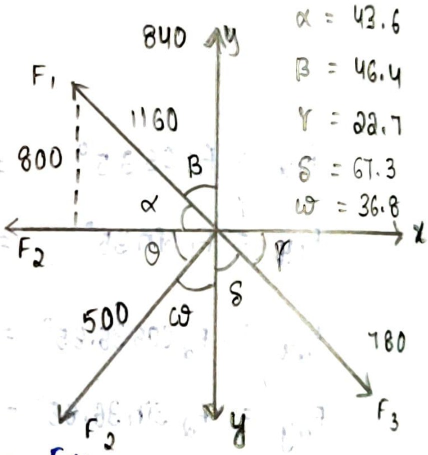
2)



Wire
Tension in BC = 725 N

Find the resultant force F_R.

$\theta = 53.2$
$\alpha = 43.6$
$\beta = 46.4$
$\gamma = 22.7$
$\delta = 67.3$
$\omega = 36.8$



$\cos 53.2 = 0.599$
$\sin 53.2 = 0.800$

$\cos 46.4 = 0.689$
$\sin 46.4 = 0.724$

$\cos 36.8 = 0.800$
$\sin 36.8 = 0.599$

$\cos 43.6 = 0.724$
$\sin 43.6 = 0.689$

$\cos 22.7 = 0.922$
$\sin 22.7 = 0.385$

$\cos 67.3 = 0.385$
$\sin 67.3 = 0.922$

$$F_x = \frac{F_{1x}}{1160} = \cos 43.6$$

$$F_{1x} = \cos 43.6 \times 1160$$
$$= 0.724 \times 1160$$
$$= 839.84 \text{ N}$$

$$F_y = \frac{F_{1y}}{1160} = \cos 46.4$$

$$F_{1y} = \cos 46.4 \times 1160$$
$$= 0.689 \times 1160$$
$$= 799.24 \text{ N}$$

$$F_x = \frac{F_{2x}}{500} = \cos 53.2$$

$$F_{2x} = \cos 53.2 \times 500$$
$$= 0.599 \times 500$$
$$= 299.5 \text{ N}$$

$$F_y = \frac{F_{2y}}{500} = \cos 36.8$$

$$F_{2y} = \cos 36.8 \times 500$$
$$= 0.800 \times 500$$
$$= 400 \text{ N}$$

$$F_x = \frac{F_{3x}}{780} = \cos 22.7$$

$$F_{3x} = \cos 22.7 \times 780$$
$$= 0.922 \times 780$$
$$= 719.16 \text{ N}$$

$$F_y = \frac{F_{3y}}{780} = \cos$$

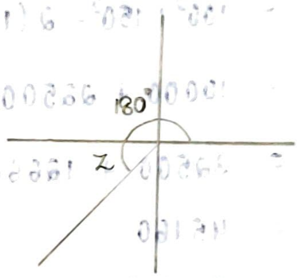
$$F_{3y} = \cos 67.3 \times 780$$
$$= 296.4 \text{ N}$$

$$F_{Rx} = -F_{1x} - F_{2x} + F_{3x}$$
$$= -839.84 - 299.5 + 719.16$$
$$= -420.18\ N$$

$$F_{Ry} = F_{1y} - F_{2y} - F_{3y}$$
$$= 799.24 - 400 - 296.4$$
$$= 102.84\ N$$

$$F_R = \sqrt{F_{Rx}^2 + F_{Ry}^2}$$
$$= \sqrt{(-420.18)^2 + (102.84)^2}$$
$$= \sqrt{176551.23 + 10576.06}$$
$$= \sqrt{187127.29}$$
$$= 432.58\ N.$$

$$\tan(z) = \frac{F_{Rx}}{F_{Ry}}$$
$$\tan(z) = \frac{420.18}{102.84}$$
$$\tan(z) = 4.08$$
$$z = \tan^{-1}(4.08)$$
$$= 76.22^{\circ}$$



$180 + 76.22$
$= 256.22$

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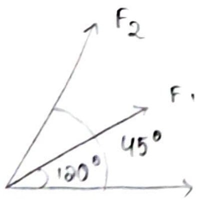
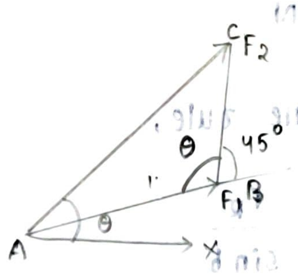
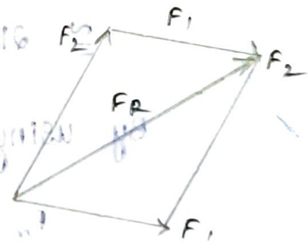


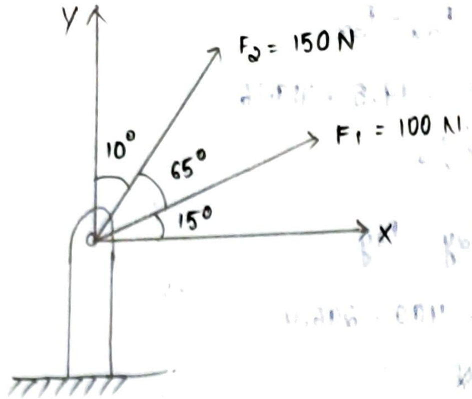




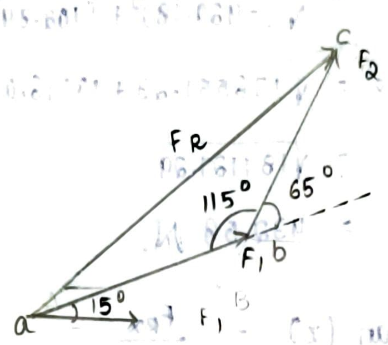
cosine rule : $AC^2 = F_A^2 = F_1^2 + F_2^2 - 2F_1F_2\cos B$

Sine rule : $\frac{F_1}{\sin c} = \frac{F_2}{\sin a} = \frac{F_R}{\sin b}$

1)



Find the magnitude and directions of resultant force by using the cosine and sine rule



$F_1 = 100$ N $\quad F_2 = 150$ N

$\angle b = 115°$

By using cosine rule,

$F_R^2 = F_1^2 + F_2^2 - 2F_1F_2\cos\theta$

$= 100^2 + 150^2 - 2(100)(150)\cos 115°$

$= 10000 + 22500 - 2(15000)(-0.422)$

$= 32500 + 12660$

$= 45160$

$F_R = \sqrt{45160}$

$= 212.508$ N

$\cong 212.6$ N

By using sine rule,

$$\frac{F_2}{\sin a} = \frac{F_R}{\sin b}$$

$$\frac{150}{\sin a} = \frac{212.6}{\sin 115}$$

$$\sin a = \frac{150}{212.6} \times \sin 115$$

$$= \frac{150}{212.6} \times 0.906 = \frac{135.9}{212.6} = 0.639$$

$\sin a = 0.639$

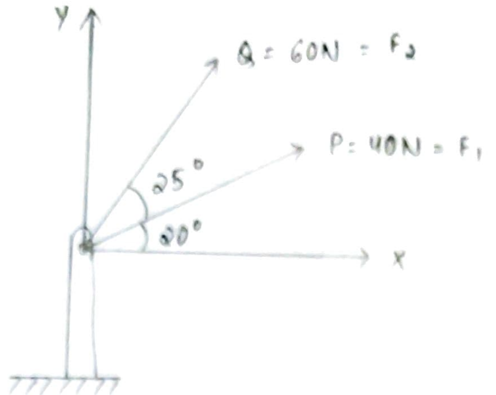
$a = \sin^{-1}(0.639)$

$a = 39.711$

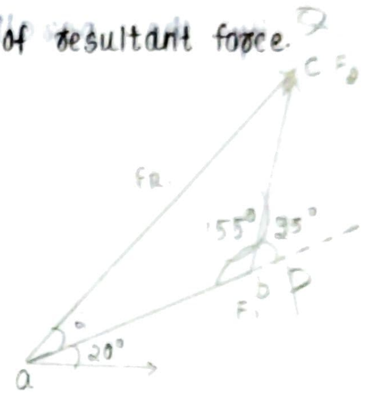
$a \cong 39.8$

Resultant of F_R has direction of , $39.8° + 15°$
$= 54.8°$

2)



Find the magnitude and directions of resultant force.



$F_1 = 40\,N$ $F_2 = 60\,N$ $\angle b = 165°$

By using cosine rule,

$F_R^2 = 40^2 + 60^2 - 2(40)(60)\cos 165$

$= 1600 + 3600 - 2(2400)(-0.90)$

$= 5200 + 4320$

$= \cancel{9580}\ 9550$

$F_R = \sqrt{9520}$

$= \cancel{97.51}\ N\ 97.73\ N$

By using sine rule,

$$\frac{F_2}{\sin a} = \frac{97.57}{\sin b}$$

$$\sin a = \frac{F_2 \times \sin 155°}{97.57}$$

$$\sin a = \frac{60 \times 0.422}{97.57} = 0.259$$

$a = \sin^{-1}(0.259)$

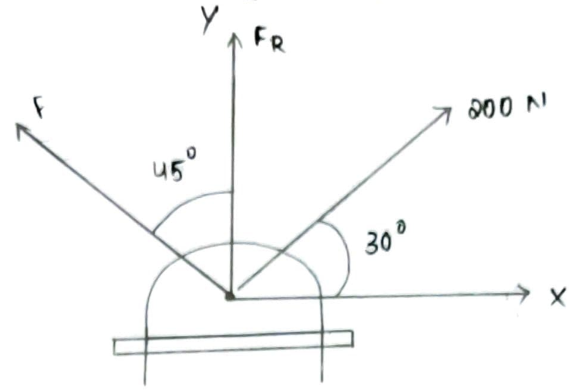
$a = 15.0107°$

Resultant of F_R has direction of,

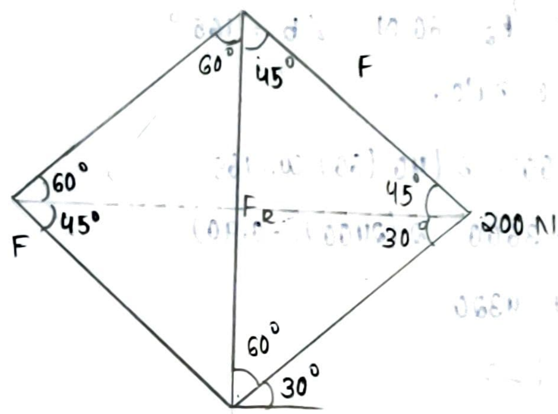
$= 15.01° + 20°$

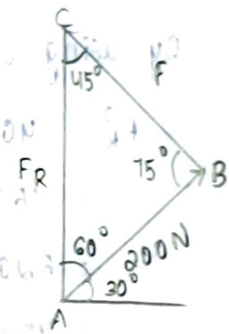
$= 35.01°$

3) Determine the magnitude of the component force F and magnitude of the resultant force F_R. If F_R is directed along the positive y-axis.



By the parallelogram law of forces,





$$\frac{F}{\sin 60^\circ} = \frac{200}{\sin 45^\circ} = \frac{F_R}{\sin 75^\circ}$$

$$F = \frac{200 \times \sin 60^\circ}{\sin 45^\circ}$$

$$F = \frac{200 \times \sqrt{3}/2}{1/\sqrt{2}}$$

$$F = 244.94$$

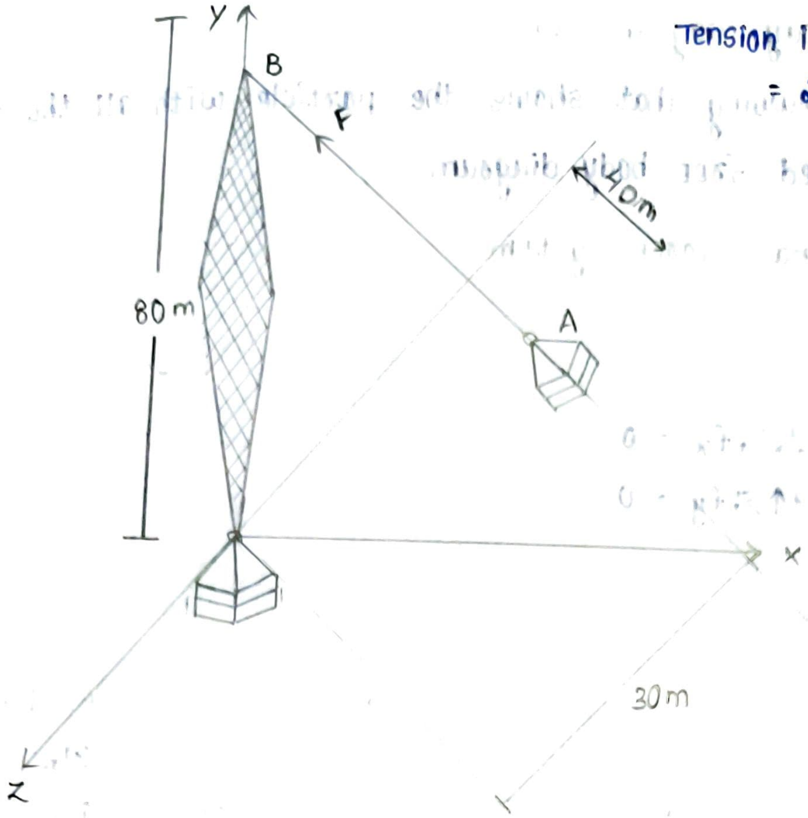
$$\frac{F_R}{\sin 45^\circ} = \frac{244.94}{\sin 60^\circ}$$

$$F_R = \frac{244.94 \times \sin 45^\circ}{\sin 60^\circ}$$

$$F_R = \frac{244.94 \times 1/\sqrt{2}}{\sqrt{3}/2}$$

$$F_R = 273.19$$

* Component of forces in space



Tension in the wire = 2500 N = F

Determine F_x, F_y, F_z at bolt A

$AB = -40i + 80j + 30k$

$|AB| = \sqrt{40^2 + 80^2 + 30^2}$

Resultant magnitude

$= \sqrt{1600 + 6400 + 900}$

$= \sqrt{8900} = 94.3$

$\lambda = \frac{AB}{|AB|}$

$= \frac{-40i}{94.3} + \frac{80j}{94.3} + \frac{30k}{94.3}$

$= -0.424i + 0.848j + 0.318k$ — components of forces

Actual force, $F = F \times \lambda$ Tension in the wire

$= 2500(-0.424i + 0.848j + 0.318k)$

$= -1060i + 2120j + 795k$

$F_x = -1060$ N

$F_y = 2120$ N

$F_z = 795$ N

19/09/2019

Equilibrium of force system

* Free body diagram (FBD)

A drawing (or diagram) that shows the particle with all the forces act on it is called free body diagram

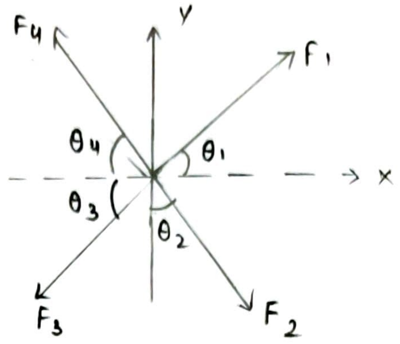
Co-planar force system

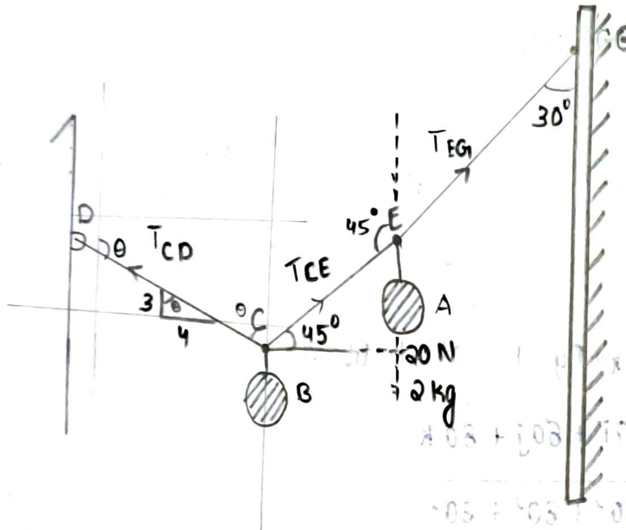
↓

All the forces of a body are in one plane

$\overset{+}{\rightarrow} \Sigma f_x = 0$

$+\uparrow \Sigma f_y = 0$





Find or determine,

W_B

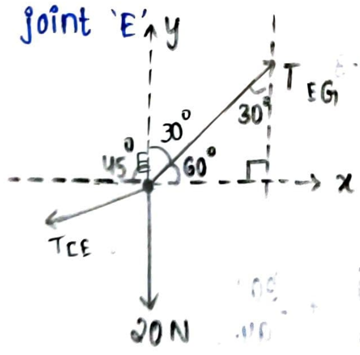
T_{CD}

T_{EG}

$T_{CE} = T_{EC}$

Consider equilibrium of joint 'E'

FBD of joint 'E'



$\overset{+}{\rightarrow} F_x = 0 \Rightarrow T_{EG} \sin 30° - T_{EC} \cos 45° = 0$

$+\uparrow F_y = 0 \Rightarrow T_{EG} \cos 30° - T_{EC} \sin 45° - 20 = 0$

$T_{EG} \sin 30° = T_{EC} \cos 45°$

$T_{EG} \cos 30° - T_{EG} \sin 30° = 20$

$$T_{EG} = \frac{20}{\cos 30° - \sin 30°}$$

$$= \frac{20}{\frac{\sqrt{3}}{2} - \frac{1}{2}}$$

$$T_{EG} = \frac{20 \times 2}{0.610} = \frac{40}{0.732}$$ $\sqrt{3} = 0.732.$

$$= 54.64\ N$$

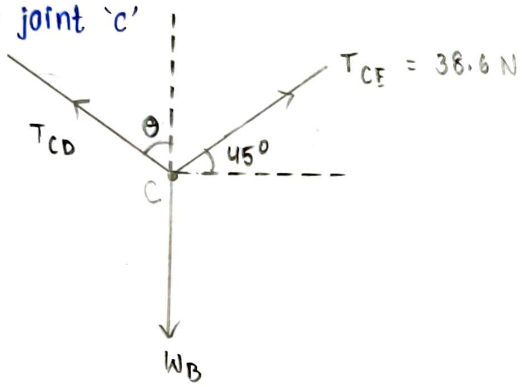
$$T_{EC} = \frac{T_{EG} \sin 30^\circ}{\cos 45^\circ}$$

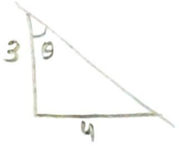
$$= \frac{54.6 \times \frac{1}{2}}{1/\sqrt{2}}$$

$$= 38.6\ N.$$

Consider equilibrium of joint 'c'

FBD of joint 'c'





$\tan\theta = 4/3$

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

$= 53.1^\circ$

$\overset{+}{\rightarrow} \sum F_x = 0 \Rightarrow T_{CE} \cos 45^\circ - T_{CD} \sin\theta = 0$

$$T_{CE} \cos 45^\circ = T_{CD} \sin 53.1^\circ$$

$$T_{CD} = \frac{38.6 \times \frac{1}{\sqrt{2}}}{\sin 53.1^\circ}$$

$$T_{CD} = \frac{4.174 \cdot 27.29}{0.799}$$

$$= 34.15 \simeq 34.2\ N$$

$+\uparrow \sum F_y = 0 \Rightarrow T_{CD} \cos 53.1 + 38.6 \sin 45^\circ - W_B = 0$

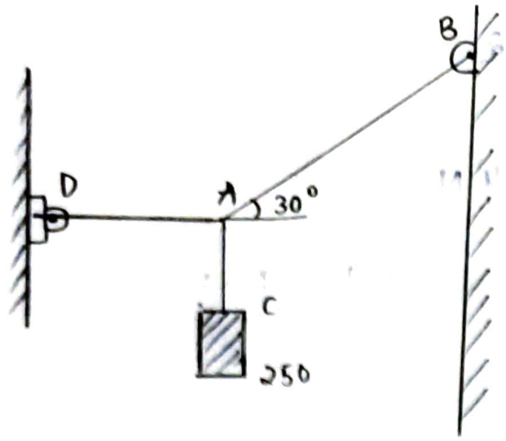
$$34.2 \cos 53.1 + 38.6 \sin 45^\circ = W_B.$$

$$W_B = 34.2 \times 0.600 + 38.6 \times \frac{1}{\sqrt{2}}$$

$$= 20.52 + 27.29$$

114.54.

$$= 47.81$$



Find

T_{AB}

T_{AD}

$\xrightarrow{+} F_x = 0$

$T_{AB} \cos 30^\circ - T_{AD} \sin 30^\circ = 0$ — ①

$+\uparrow F_y = 0$

$T_{AB} \sin 60^\circ - T_{AD} \cos 60^\circ - 250$

① $\Rightarrow$ $T_{AB} \cos 30^\circ = T_{AD} \sin 30^\circ$

② $\Rightarrow$ $T_{AB} \sin 60^\circ = T_{AD} \cos 60^\circ + 250$

① $\Rightarrow$ $T_{AB} \left(\frac{\sqrt{3}}{2}\right) = T_{AD} \left(\frac{1}{2}\right)$

② $\Rightarrow$ $T_{AB} \left(\frac{\sqrt{3}}{2}\right) - T_{AD}\left(\frac{1}{2}\right) - 250 = 0$

① + ② $\Rightarrow$ $T_{AB}\left(\frac{\sqrt{3}}{2}\right) - T_{AD}\left(\frac{1}{2}\right) - 250 = 0$

$$T_{AB} = \frac{250 + \frac{T_{AD}}{2}}{2/\sqrt{3}}$$

$$= \frac{500 + T_{AD}}{2} \times \frac{\sqrt{3}}{2}$$

$$= \frac{500 + T_{AD}}{4} \times \sqrt{3}$$

① $\Rightarrow$ $T_{AB}\left(\frac{\sqrt{3}}{2}\right) - T_{AD}\left(\frac{1}{2}\right) = 0$

$\frac{500 + T_{AD}}{4} \sqrt{3}\left(\frac{\sqrt{3}}{2}\right) - T_{AD}\left(\frac{1}{2}\right) = 0$

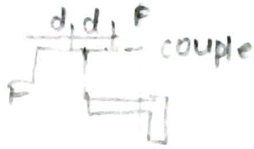
$T_{AD} = 1500$

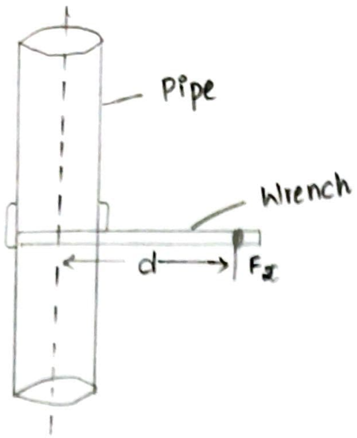
① $\Rightarrow$ $T_{AB}\left(\frac{\sqrt{3}}{2}\right) - \frac{1500}{2} = 0$

$$T_{AB} = \frac{1500}{\sqrt{3}}$$

$$T_{AB} = 866.02$$

* Moment of forces



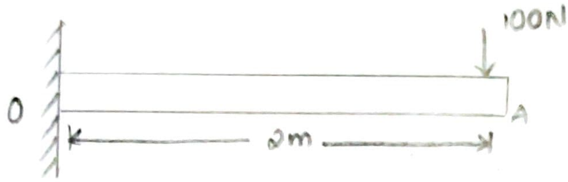


Moment = Force × distance (⊥r)

↓ N-m ↓ N

↺ +M ↻ −M

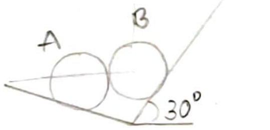
↓ A.C.W ↓ C.W



$M_0 = -100 \times 2 = -200$ N-m ↻

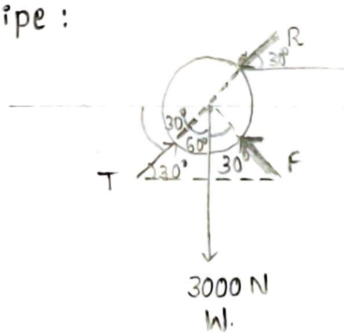
24/09/2018

Two smooth pipes each having a mass of 300 kg are supported by forks of tractor. Draw free body diagram for each pipe and both pipe together.

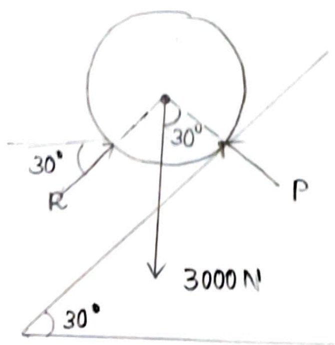


300 kg = 300 × 10 N
= 3000 N

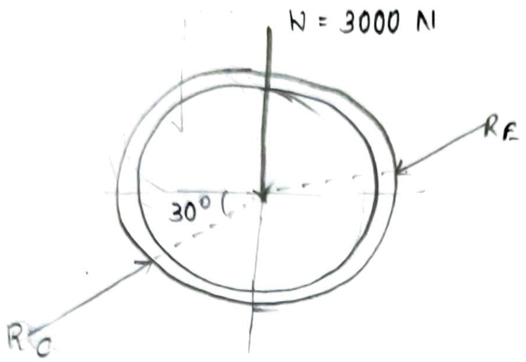
FBD of 'A' pipe :



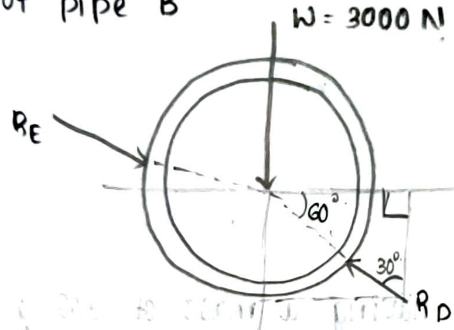
FBD of 'B' pipe :



FBD of pipe A

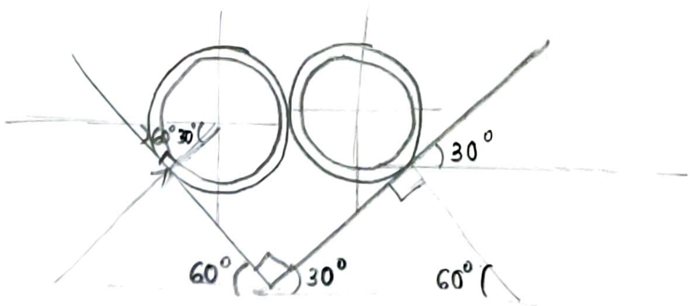


FBD of pipe B

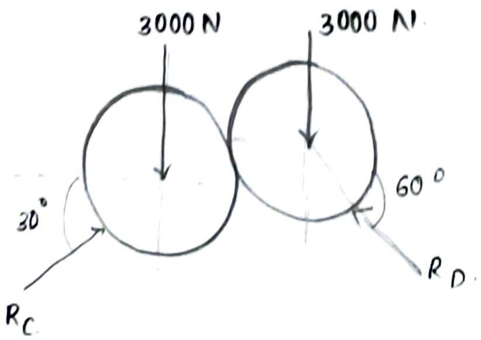


Whenever we need to draw the FBD of balls or pipes it is good to draw local x-axis & y-axis passing through the centre of circle.

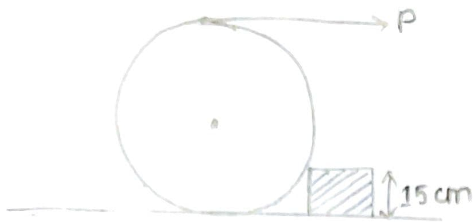
Angles :



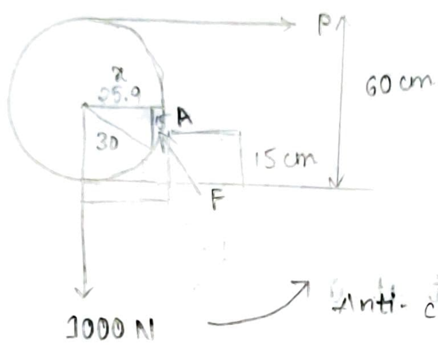
Both pipes FBD



a) Find the minimum value of P which will just make wheel move. Wheel diameter is 60 cm. P is the force applied here. Weight of the wheel is 1000 N.



FBD :



$$x = \sqrt{30^2 - 15^2}$$
$$= 25.9$$

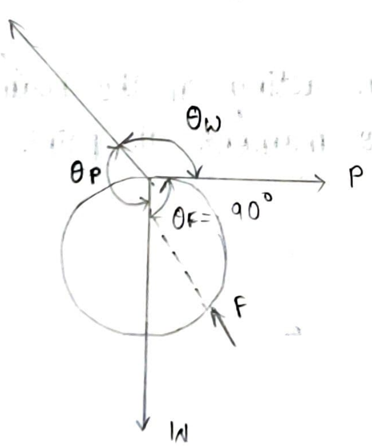
Anti-clock wise (+ve)

Momentum at A ; $-P \times (60-15) + 1000 \times 25.9 = 0$

$$P \times 45 = 1000 \times 25.9$$

$$P = \frac{1000 \times 259}{450}$$

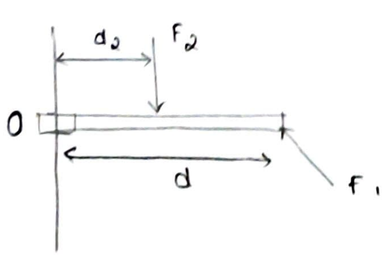
$$P = 575.6 \text{ N}$$



Lami's Theorem

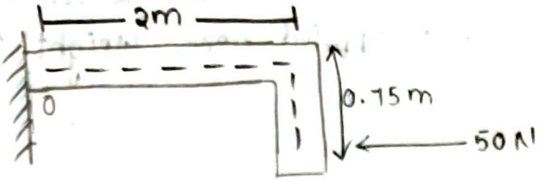
$$\frac{P}{\sin\theta_p} = \frac{F}{\sin\theta_F} = \frac{W}{\sin\theta_w}$$

* Moment of forces / couple



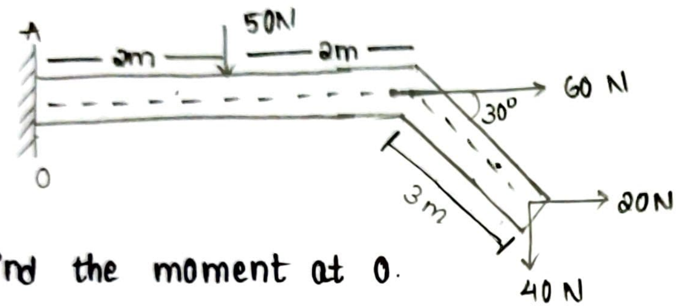
$$M_O = F_2 \times d_2 + F_1 \times d_1$$
$$= \sum F_i d_i$$

*

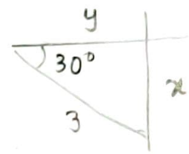


$$M_O = -50 \times 0.75$$
$$= -37.5 \text{ Nm}$$
$$= 37.5 \text{ Nm}$$

*



Find the moment at 0.



$\cos 30 = \frac{y}{3}$

$y = 3\cos 30$

$= 2.59$ m

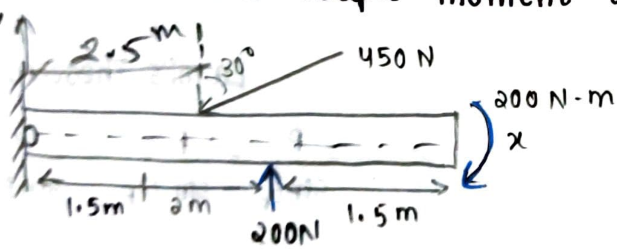
$\sin 30 = \frac{x}{3}$

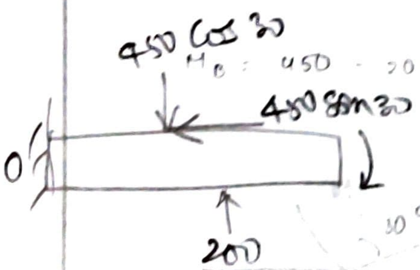
$x = 3\sin 30$

$= \frac{3}{2} = 1.5$ m

$$M_O = -50 \times 2 + 60 \times 0 + 20 \times 1.5 - 40 \times (4 + 2.59)$$
$$= -100 + 0 + 30 - 40 \times (6.59)$$
$$= -100 + 30 - 263.6$$
$$= 334 \text{ N-m}$$

* Replace the loading system acting on the beam by equivalent resultant force and couple moment at point 'O'.



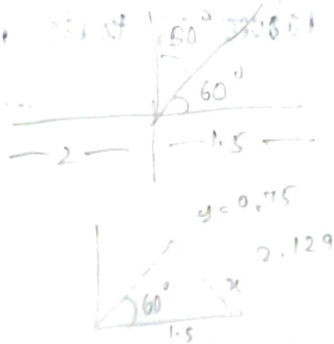


$F_x =$

$F_y =$

$$M_O = -200 + 200 \times 3.5 - 450\cos 30 \times 2.5$$

1.750



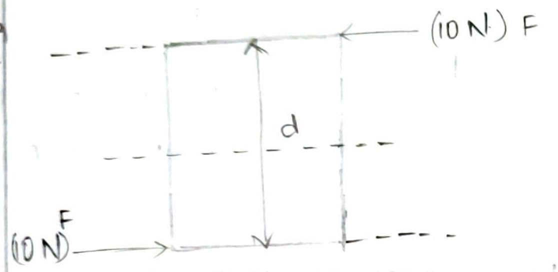
$\sin 60° = \frac{x}{1.5}$

$x = 1.29$

$\cos 60° = y/1.5$

$y = 0.75$

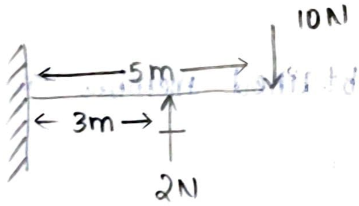
28/09/2019



couple

Moment produced by this couple $= F \times d$

$= 10 \times d$ KNm



Moment $= -10 \times 5 + 2 \times 3$

$= -50 + 6$

$= -44$ N·m

Trusses are of two types :

Roof trusses – used buildings, industries.

used for railways, vehicles — Bridge trusses → Deck type, Through type

Through type

⇒ Provide shelter downward

Deck type.

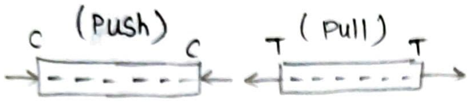
⇒ not safer

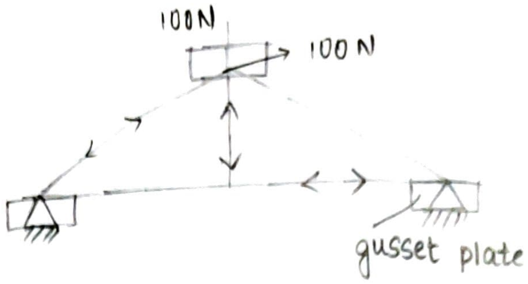
* Roof Trusses : (Analysis) : Finding member forces

Forces in truss members are axial forces. → any force applied along the centroid of the member

Axial Forces

Compressive (Push) | Tensile (Pull)





Finding member forces

Method of joints

(all member forces)

↓

It is the method to find out all member force.

Method of sections

(particular member force)

↓

It is the method to find out particular member force interested only.

★ Assumptions to be made in the analysis of trusses.:

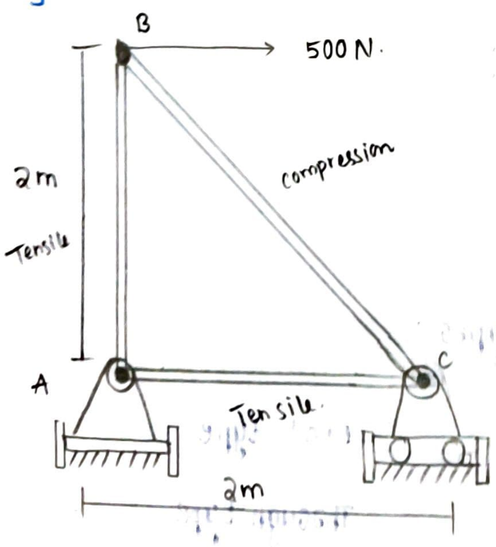
i) All the joints of truss are connected by pin

ii) All the external loads must be applied through the joints only.

iii) Thus the determined forces / obtained member forces will be axial only.

30/09/2019

①



→ Pull (T)

← Push (C)

Find the member forces.

Unknowns : Reactions from supporting — Restrained: A_x, A_y, C_y

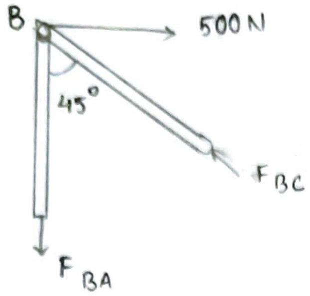
Member forces.

F_{AB}, F_{BC}, F_{AC}

Using method of joints,

take joint 'B' equilibrium.

Draw FBD of joint B.



direction can be any side but the answer is -ve, it should be wrong assumption

$\overset{+}{\rightarrow} \Sigma F_x = 0$

$$-F_{BC} \sin 45^\circ + 500 = 0$$

$$F_{BC} = \frac{500}{\sin 45^\circ}$$

$$= 500 \times \sqrt{2}$$

$$= 707.110 \text{ N}$$

$+\uparrow \Sigma F_y = 0$

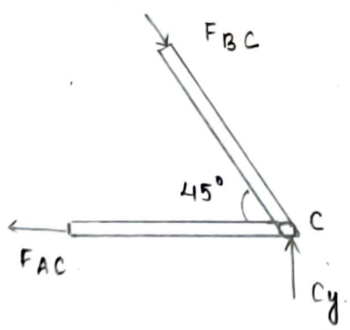
$$F_{BC} \cos 45^\circ - F_{BA} = 0$$

$$F_{BA} = 707 \times \cos 45^\circ$$

$$= 499.9 \cong 500 \text{ N}$$

taking joint 'C'

Draw FBD of joint C



$\Sigma F_x = 0$

$$-F_{AC} + 707 \cos 45^\circ = 0$$

$$F_{AC} = 707 \cos 45^\circ$$

$$= 500 \text{ N}$$

$\Sigma F_y = 0$

$$-F_{BC} \sin 45^\circ + C_y = 0$$

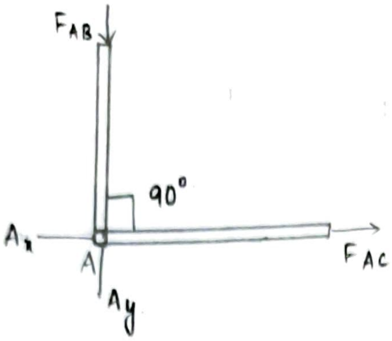
$$C_y = F_{BC} \sin 45^\circ$$

$$= 707 \cdot 1/\sqrt{2}$$

$$= 500 \text{ N}$$

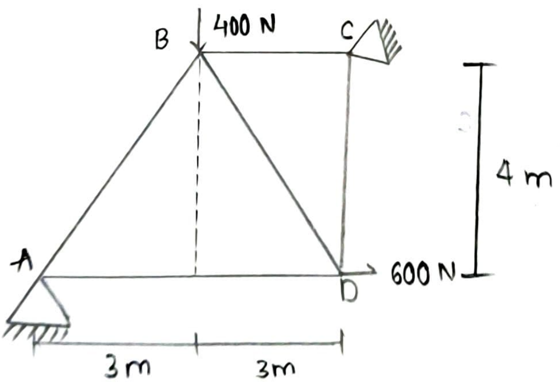
taking joint A,

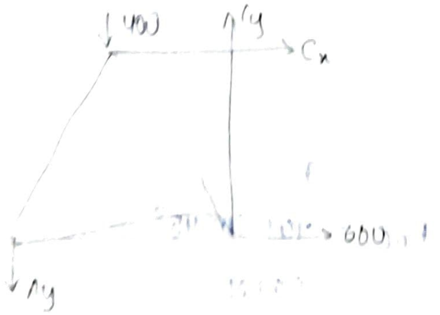
Draw FBD of joint A



Point	Force	Nature
AB	500 N	Tensile
BC	770 N	Compression
AC	500N	Tensile

(2)





$$-A_x + C_x + 600 = 0$$

$$A_y + C_y + 400 = 0$$

$$\Sigma M_{A_y} = 0$$

$$-400 \times 3 + C_y \times 6 - C_x \times 4 = 0$$

$$-1200 + 6C_y - 4C_x = 0$$

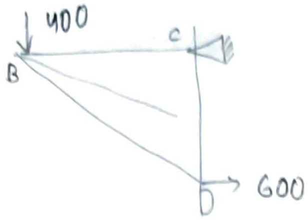
$A_x = 0 \qquad C_x = -600$

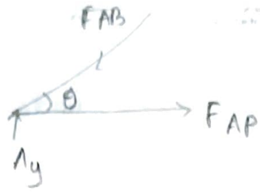
$-1200 + 6C_y - 4(-600) = 0$

$-1200 + 6C_y + 2400 = 0$

$6C_y = -1200$

$C_y = -200\ N$





$\tan\theta = 4/3$

$\theta = 53.2$

$\Sigma F_x = 0$

$F_{AD} - F_{AB}\cos 53.1 = 0$

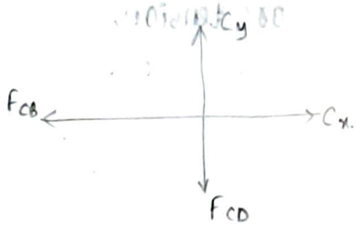
$F_{AB} = 150.16\ N$

$\Sigma F_y = 0$

$A_y - F_{AB}\sin 3.1^\circ = 0$

$F_{AB} = 250\ N$

At point C :



$\Sigma f_x = 0$

$-C_x - F_{CB} = 0$

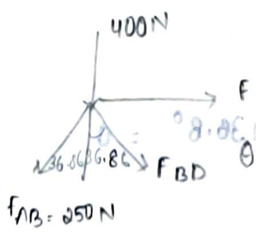
$F_{CB} = -600\ N$

$\Sigma F_y = 0$

$C_y - F_{CD} = 0$

$F_{CD} = 200\ N$

At point B :



$\theta = 36.86^\circ$

$\Sigma f_y = 0$

$-400 - 250\cos 36.86^\circ + F_{BD}\cos 36.86^\circ = 0$

$F_{BD} = 150\ N$

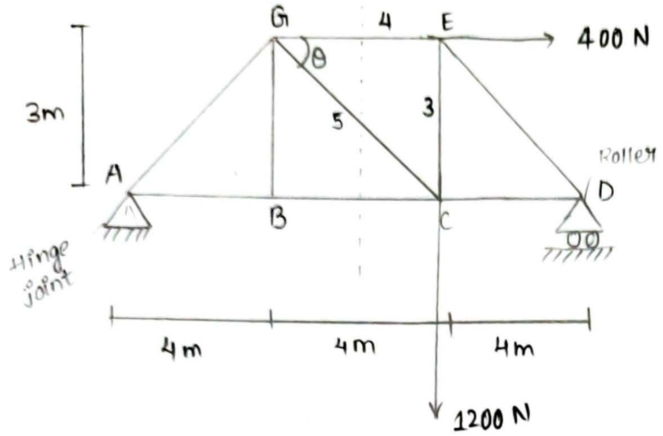
members	force	Nature
AB	250 N	compression
BC	-600 N	Tensile
CD	600 N	Tensile
BD	450 N	compression

* **Method of sections**

⇒ This method is used to find member forces in few members.

⇒ This method is based on the principle that if a body is in equilibrium any point (part) of the body is in equilibrium.

1)



*** When section is cut it should not pass more than 3 members.

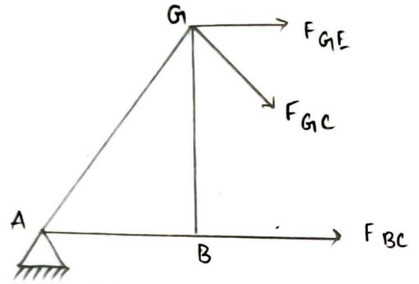
Unknowns :

$\Sigma F_x = 0$ — A_x

$\Sigma F_y = 0$ — A_y

$\Sigma M_A = 0$ — D_y

Determine the forces in members GE, GC, BC. Indicate whether the members are in compression or tension.



Supports

*** Hinge joint - 2 Reaction - A_x, A_y

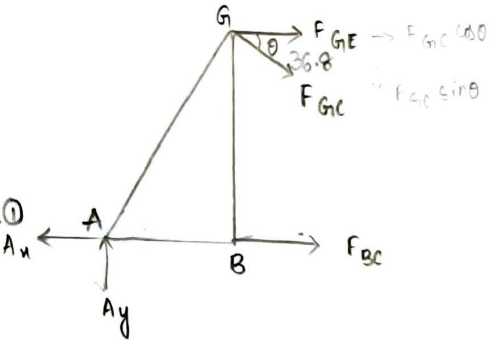
Roller - 1 Reaction - D_y

Fixed - 3 Reaction - B_x, B_y, M_B

01/10/2019

part body in equilibrium

Equilibrium of joint B,



$\Sigma F_x = 0$

Draw FBD of joint B.

$-A_x + F_{BC} + F_{GE} + F_{GC}\cos 36.8^\circ = 0$ —— ①

$\Sigma F_y = 0$

$A_y - F_{GC}\sin 36.8^\circ = 0$ —— ②

$\cos\theta = 4/5$

$\theta = \cos^{-1}(4/5)$

$= 36.8^\circ$

$\Sigma M_A = 0$

$-F_{GC} \times 3 - F_{GC}\cos 36.8^\circ \times 3 - F_{GC}\sin 36.8^\circ \times 4 = 0$ —— ③

$F_{BC} \times 3 - A_y \times 4 - A_x \times 3 = 0.$

For total diagram,

* $\Sigma F_x = 0$

$-A_x + 400 = 0$

$A_x = 400\,N$

* $\Sigma F_y = 0$

$A_y + D_y - 1200 = 0$

$A_y + 900 - 1200 = 0$

$A_y = 300\,N$

* $\Sigma M_A = 0$

$-400 \times 3 - 1200 \times 8 + D_y \times 12 = 0$

$-1200 - 9600 + D_y \times 12 = 0$

$12 D_y = 10800$

$D_y = 900\,N$

From equation ②.

$$300 - F_{GC} \sin 36°8' = 0$$

$$F_{GC} \sin 36°8' = 300$$

$$F_{GC} = \frac{300}{0.599}$$

$$= 500.8 \text{ N}$$

From equation ③,

$$F_{BC} \times 3 - 300 \times 4 - 400 \times 3 = 0$$

$$3F_{BC} - 1200 - 1200 = 0$$

$$F_{BC} = 800$$

From equation ①,

$$-400 + F_{BC} + F_{GE} + F_{GC} \cos 36°8' = 0$$

$$-400 + 800 + F_{GE} + 500.8 \times 0.807 = 0$$

$$400 + F_{GE} + 404.1456 = 0$$

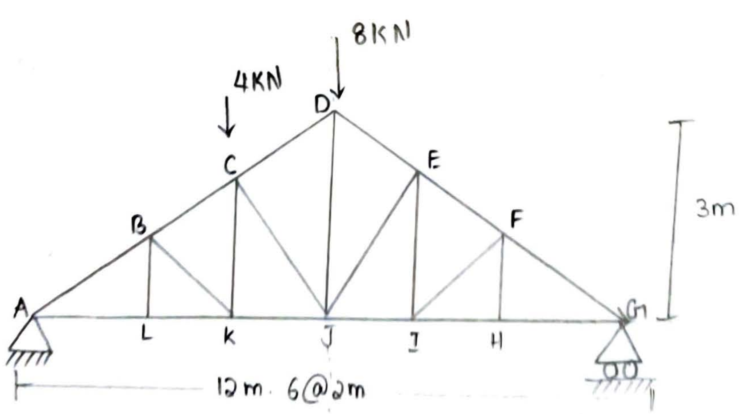
$$F_{GE} + 804.1456 = 0$$

$$F_{GE} = -804.1456 \text{ N}$$

Member	Force	Nature
GC	500.8 N	Tension
GE	804.1 N	Compression
BC	800 N	Tension

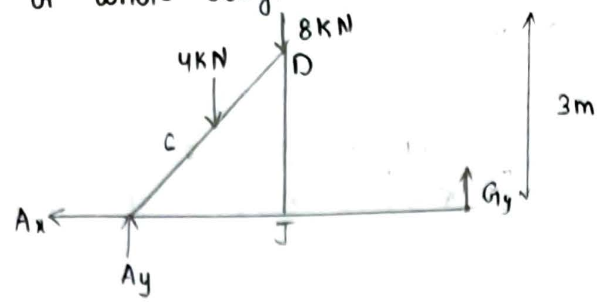
- 801.01 N

2) Find the member forces in a truss BC, CK and KJ



Indicate whether the members are in compression or tension.

FBD of whole body,



$\Sigma F_x = 0 \Rightarrow -A_x = 0$

$A_x = 0$

$\Sigma F_y = 0 \Rightarrow A_y + G_y - 4000 - 8000 = 0$

$A_y + G_y = 12000$ — ⓐ

$\frac{y_1}{4} = \frac{3}{6} \Rightarrow y_1 = 2m$

$\frac{y_2}{2} = \frac{3}{6} \Rightarrow y_2 = 1m$

$\Sigma M_A = 0$

$\Rightarrow G_y \times 12 - 8000 \times 6 - 4000 \times 4 = 0$

$G_y \times 12 - 48000 - 16000 = 0$

$12 G_y - 64000 = 0$

$G_y = \frac{64000}{12}$

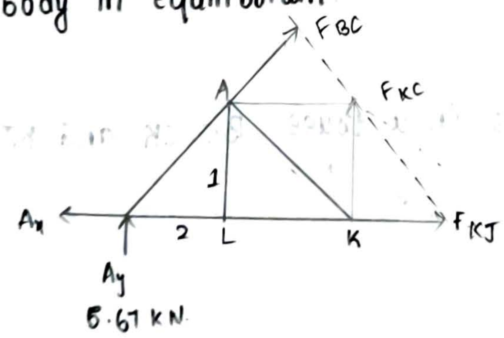
$= 5333.33 \text{ N}$

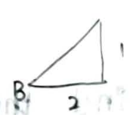
From ⓐ, $A_y = 12000 - 5333.33$

$= 6666.67 \text{ N}$

$A_y = 6666.67 \downarrow \text{N} \Rightarrow 6.67 K \downarrow \text{N}$

Part body in equilibrium





$\tan\theta = 1/2$

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

$= 26.56^\circ$

$\Sigma F_x = 0 \Rightarrow F_{KJ} + F_{BC} \cos 26.56^\circ = 0$ — ①

$\Sigma F_y = 0 \Rightarrow F_{CK} + F_{BC} \sin 26.56^\circ + 6.67 = 0$ — ②

$\Sigma M_A = 0 \Rightarrow F_{KJ} \times 0 + F_{BC} \times 0 + F_{CK} \times 4 = 0$ — ③

$F_{CK} = 0$

from ② $\Rightarrow 0 + F_{BC}\, 0.452 + 6.67 = 0$

$F_{BC} = -6.67$

$F_{BC} = \frac{-6.67}{0.452}$

$= -14.917 \text{ KN}$

From (1) => $F_{KJ} + 16.46$

$F_{KJ} + F_{BC} \times 0.894 = 0$

$F_{KJ} = 14.917 \times 0.894$

$= 13.33$ KN

Member	Force	Nature
BC	-14.917 k	Compressive
CK	0	Tensile
KJ	13.33 K	Tensile