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Assignment - 01 | "Theory portion"

① Diff. betn particle & rigid body ? and explain why the idealization of rigid body is important while studing the effect of extrnal force in mechnics.

=> A rigid body where the particles inside that body are assumed to be completely stationary & the particle distance or distance betn the particles is fixed.

The particle is something we assume to have no internal structure where as a rigid body does have as internal structure or composite particles.

We idealized a body as a rigid body because as rigid body has zero deformation and it's particle distance is alway fixed the effect of external forces doesnot change its structure & its makes easy for us to study about the effect of external force the material property of any body that is assumed to be rigid will not have to be considered.

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2. Explain the law of mechanics. And why do you think it is important to know about the law of mechanics?

=> The study of elementary mechanics rest on six fundamental principle based on experimental evidence.

1) Parallelogram law of forces.

It is used to determine the resultant of two forces acting at a point in a plane. It states that "If two forces, acting at a point be represented in magnitude & direction by two adjacent sides of a parallelogram, then their resultant is represented in magnitude & direction by the diagonal of the parallelogram passing through that point.

2) Principle of transmissibility of forces.

It states, when the point of application of force acting on a body is shifted to any other point on the line of action of the force without changing its direction there occurs no change in the equilibrium of the body.

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3) Netwon's 1st law:

Every body contines in its states of rest of uniform motion in a st. line if there is no unbalanced force acting upon it.

4) Netwon's 2nd law.

Rate of change of linear momentum is directly proportional to the applied force & its take place in the direction of the applied force.

5) Netwon's 3rd law.

To every action, there is equal & oppo. reaction

6) Netwon's law of gravitation.

Every body in the universe attracts every bod with a force directly proportional to the product of their mass & inversely proportional to the sq. of the distance betn them.

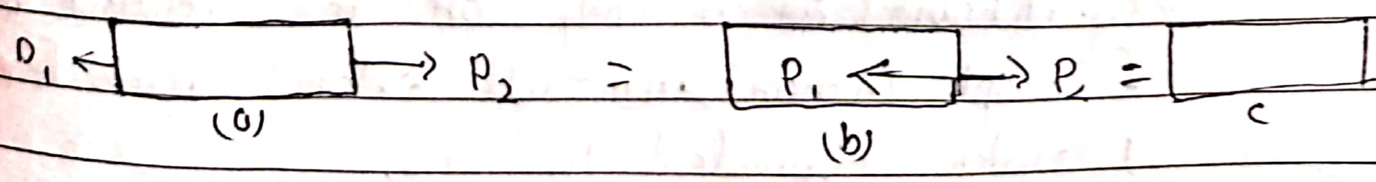
It is important to know because these law gives complete information about the external force & helps to deal to find out the unknown force or equillibrant & this law perfectly described about the force acting on a body.

③ Which newton's law speaks about the equilibrium condition of a body ? & states that law.

⇒ Netwons 1st law of motion speaks about the equilibrium condition of a body. It states that " Every body continue in it rest or of uniform motion in a st. line if there is no unbalanced acting upon it."

④ State the principle of transmissibility of force with simple sketch & comment about the vilidity of this principle.

⇒ When the point of application of force acting a body is shifted to any other point on the line action of the force without changing its direction, there occurs no change in the equilibrum of the body.



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Here, P_1 & P_2 are equal force action on the body & the body is in equilibrium. In there sketch the body is in equilibrium. I think as force is a vector quantity as long as its magnitude & direction are not disturb it can be easily transfer from one point to another & its is perfectly valid.

(5) Why do you think we call force as an sliding ~~vectorce~~ Vector?

=> Vector has specific magnitude & direction but they do not have a specific position so any vector can be slide parallel to its original without changing its value. As force is also a vector quantity so it can be called as a sliding vector.

6) State the necessary & sufficient condition for static equilibrium of a rigid body in two dimension.

=> The necessary & sufficient condition for static equilibrium of a body are the resultant force & couple (moment) from all external forces from 1 system equivalent to zero,

$$\Sigma f_x = 0 \, , \; \Sigma f_y = 0 \; \& \; \Sigma M = 0$$

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(7) What is free body diagram ? And why it is important:?

:) A free body diagram is a sketch of the selected system consisting of a body, a portion of a body or a collection of inter connected bodies completely isolated or free from all other bodies, showing the interaction of all other bodies by forces on the one being considered.

FBD is important because it make a clear way to study about the external force & helps to find out required equilibrant. required force for the equilibrium.

(8) Describe about the equation of static equation equilibrium for 2-D & 3-D analysis of a particles & a rigid body.

For 2-D.

Consider a body is acted upon by no. of coplanar & non-concurrent force. Because of these force the body may have one of following states.

(a) A body may move in any one direction.
(b) The body may rotated itself without moving

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c) The body may move in any one direction & rotate about itself at same time

d) The body may be completely at rest.

Case A:

The equilibrium eq^n be ~~completely at rest~~.

(1) $\Sigma f(x) = 0$ ie $\Sigma x = 0$

(2) $\Sigma fy = 0$ ie $\Sigma y = 0$

Case b:

The equilibrium eq^n be will be

$\Sigma M = 0$

Case C:

The equilibrium eq^n be will be

(i) $\Sigma f_x = 0$

(ii) $\Sigma f_y = 0$

(iii) $\Sigma M = 0$

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case d:

They are:

(i) $\Sigma f_x = 0$

(ii) $\Sigma f_y = 0$

(iii) $\Sigma M = 0$

lly for 3-D eq^n are

$\Sigma \vec{F} = 0$

$\Sigma M = 0$

which further expanded as

$\Sigma f_x = 0$ $\Sigma f_x = 0$ $\Sigma f_z = 0$

$\Sigma M_x = 0$ $\Sigma M_y = 0$ $\Sigma M_z = 0$

where

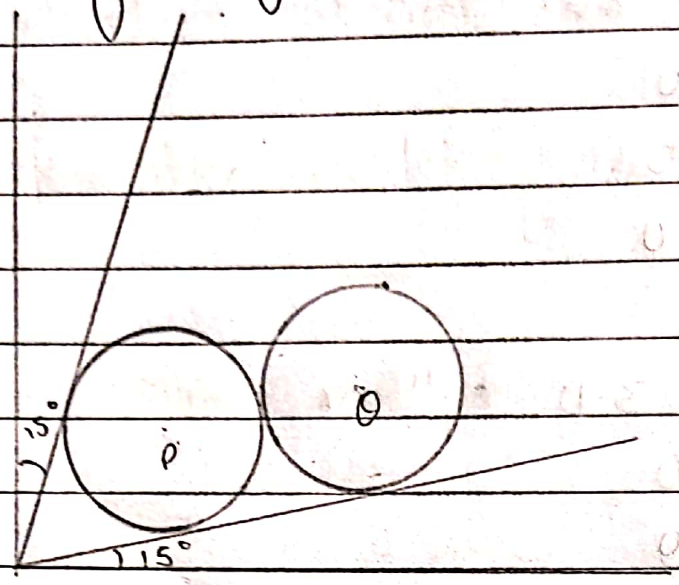
Σf_x & ΣM_x = algebric sum of force & moment respectively in x-axis.

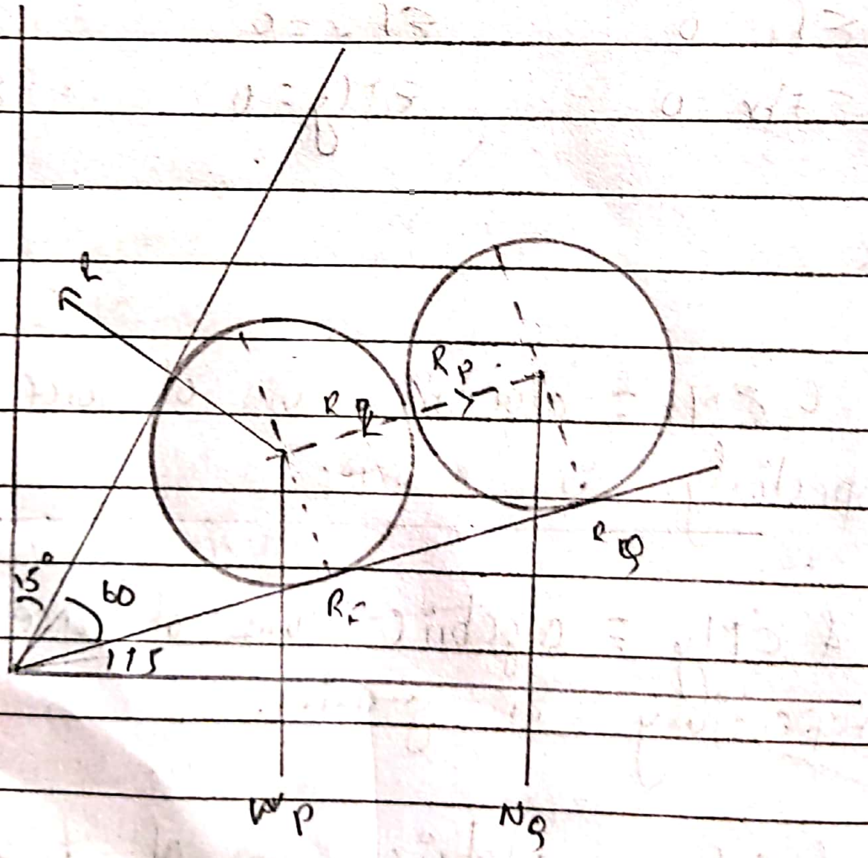
Σf_y & ΣM_y = algebric sum of force & moment repectively in y-axis.

Σf_z & Σf_z = algebric sum of force & moment respectively in z-axis

"Conceptual questions"

Draw free body diagram.





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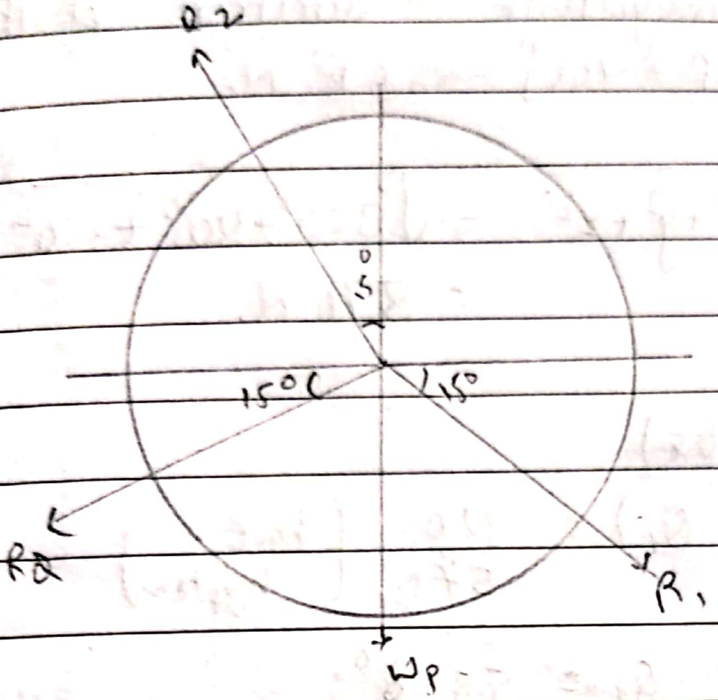
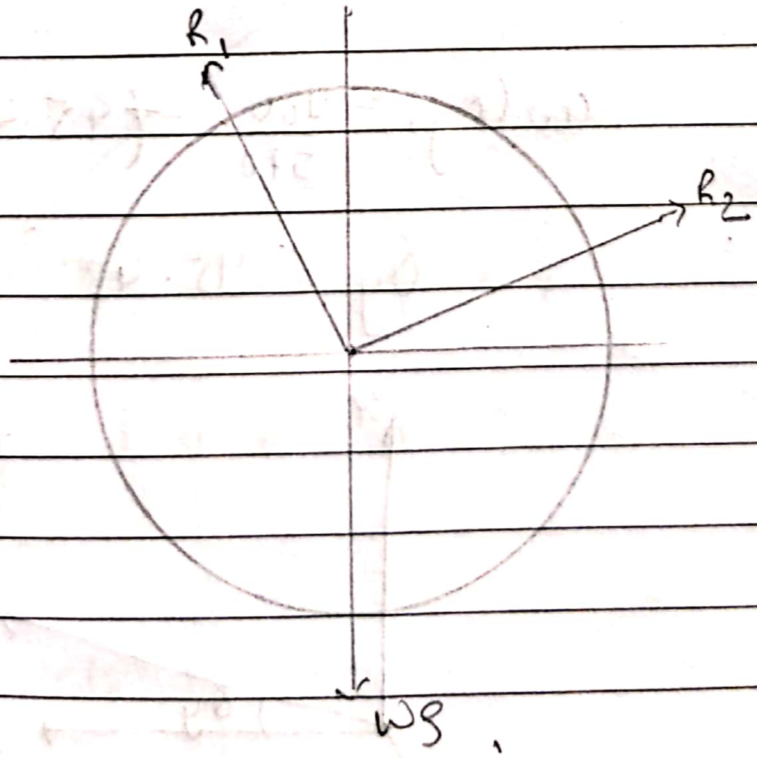
Body (P)



Body (Q)



Determine the magnitude & direction of the force $\vec{F} = 320\hat{i} + 400\hat{j} - 250\vec{k}$ N.

Here

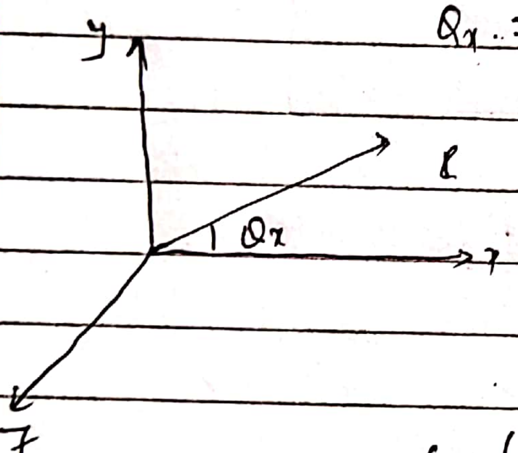
$$|F| = \sqrt{x^2+y^2+z^2} = \sqrt{320^2+400^2+250^2}$$
$$= 570 \text{ N.}$$

now,

~~$\tan^{-1}(\theta_x)$~~

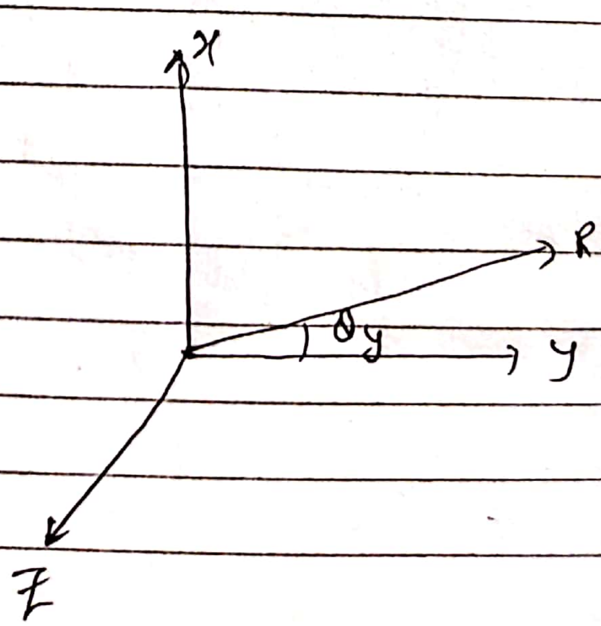
$$\cos(\theta_x) = \frac{320}{570} \quad \left(\frac{\text{base}}{\text{hypton}}\right)$$

$$\theta_x = 55.8^\circ.$$



$$\cos(\theta_y) = \frac{400}{570} = \cancel{45.43}$$

$$\theta_y = 45.43$$



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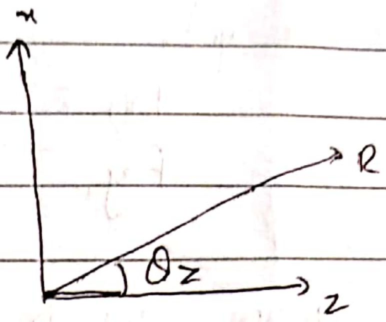
For θ_z

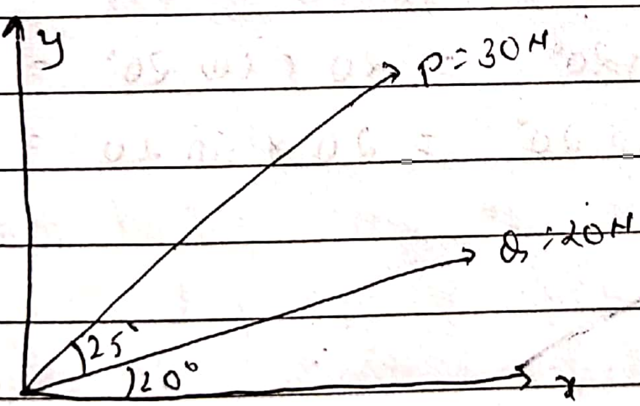


$$\cos\theta_z = \frac{-250}{570} = 116.01$$

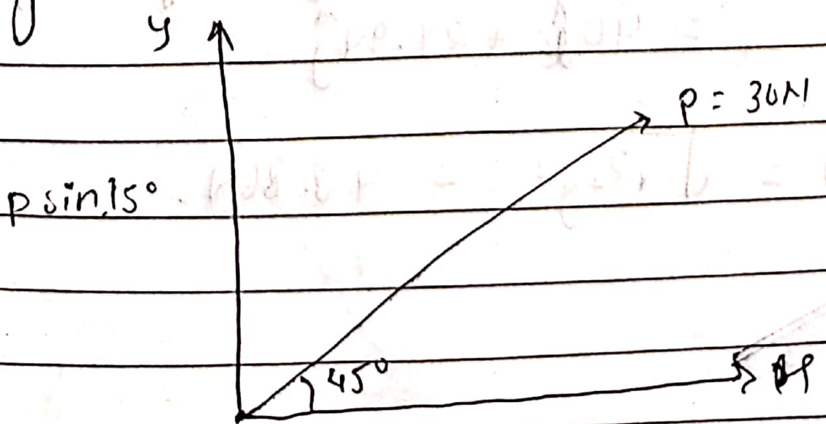
$$\theta_z = 116.01$$

Q Two force P & Q act at a point. Determine resultant of these two force & angle that it make with x-axis.

⇒ Solⁿ.



considering P force at 1st

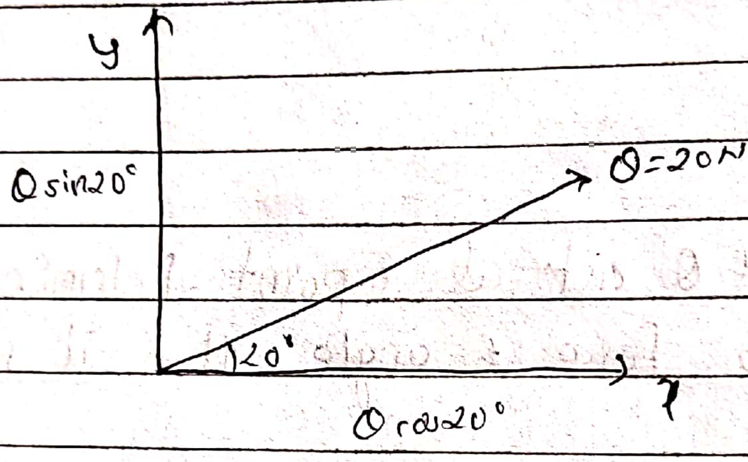


we get,

$F_{x_1} = P\cos 45^\circ = 30\times\cos 45^\circ = 21.27\hat{i}$

$F_{y_1} = P\sin 45 = 30\times\sin 45 = 23.27\hat{j}$

Now, for Q.



$F_{x_2} = Q\cos 20^\circ = 20\times\cos 20^\circ = 18.79\hat{i}$

$F_{y_2} = Q\sin 20^\circ = 20\times\sin 20 = 6.84\hat{j}$

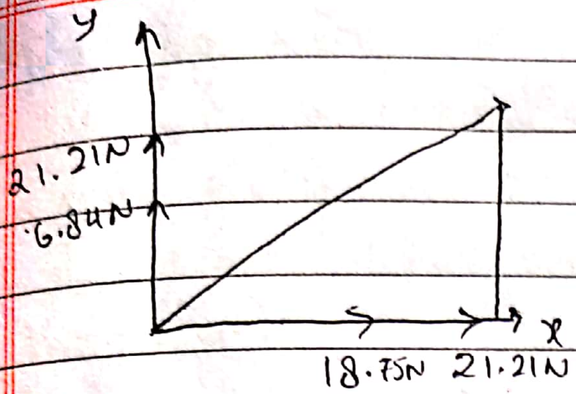
Now finally,

total force $= f_{x_1} + f_{x_2} + f_{y_1} + f_{y_2}$

$= 21.21\hat{i} + 18.75\hat{j} + 21.21\hat{j} + 6.68\hat{j}$

$= 40\hat{i} + 27.94\hat{j}$

$|F| = \sqrt{x^2+y^2} = 48.86N.$



Now,

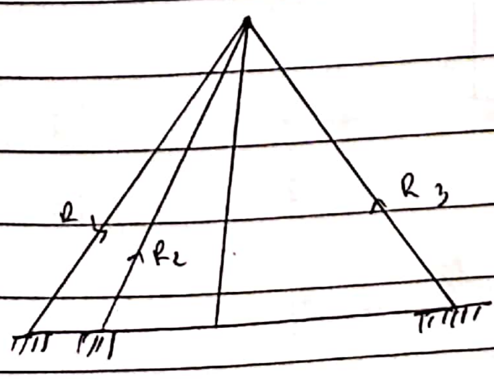
$$\tan \theta_x = \frac{\Sigma_y}{\Sigma_x}$$

$$= \frac{27.94}{40}$$

$$\theta_x = 34.93 \approx 35^\circ$$ #

Q. A camera having a mass of 1.8 kg rest on a tripod with leg equally spaced & each having an angle of 20° with verticle. Assume the system is concurrent at a point 1200mm above level ground. Find the force in each leg

⇒ Soln



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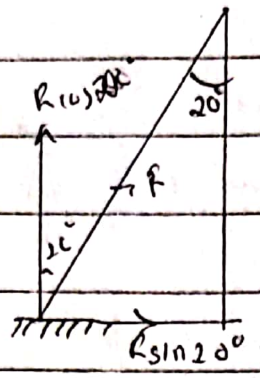
Now,



So, Required force (vertical comp.) R cos 20 for three legs is

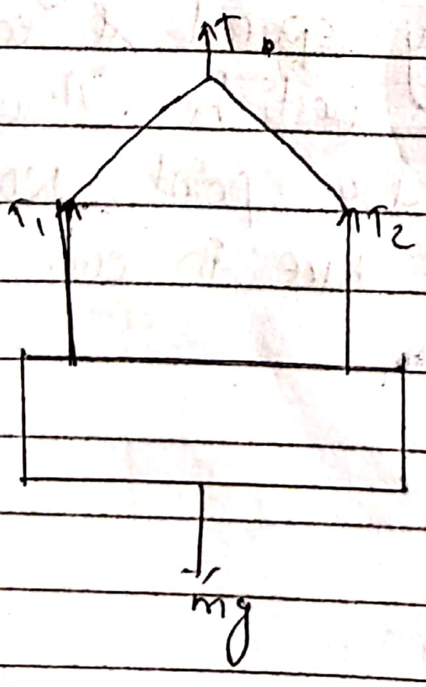
$$3R\cos 20^\circ = m \times 10$$

$$3 \times R \times \cos 20 = 1.8 \times 10$$

$$R = 6.385\ N.$$

So, $R_{required} = 6.385\ N.$ #

Draw FBD.



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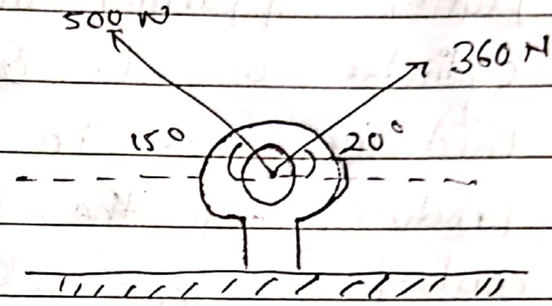
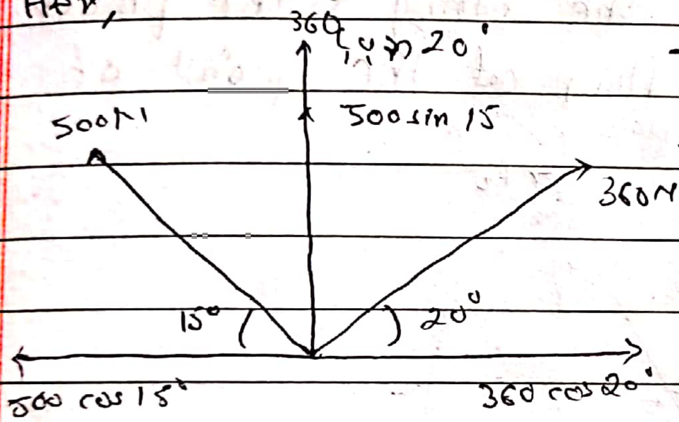
5) Two guy wire are fastened to an anchor bolt in a foundation as shown in the figure given below.

What a pull does the bolt exert on the foundations.



=> Here,



Now, force along x-axis

$$f_x = 500 \cos 15° - 360 \cos 20°$$
$$= -144.65 \, N \hat{i}$$

$$f_y = 360 \sin 20 + 500 \sin 15$$
$$= 252.53 \hat{j}$$

$$\vec{F} = -144.67 \hat{i} + 252.53 \hat{j}$$
$$|F| = \sqrt{x^2 + y^2} = 291.04 \, N$$

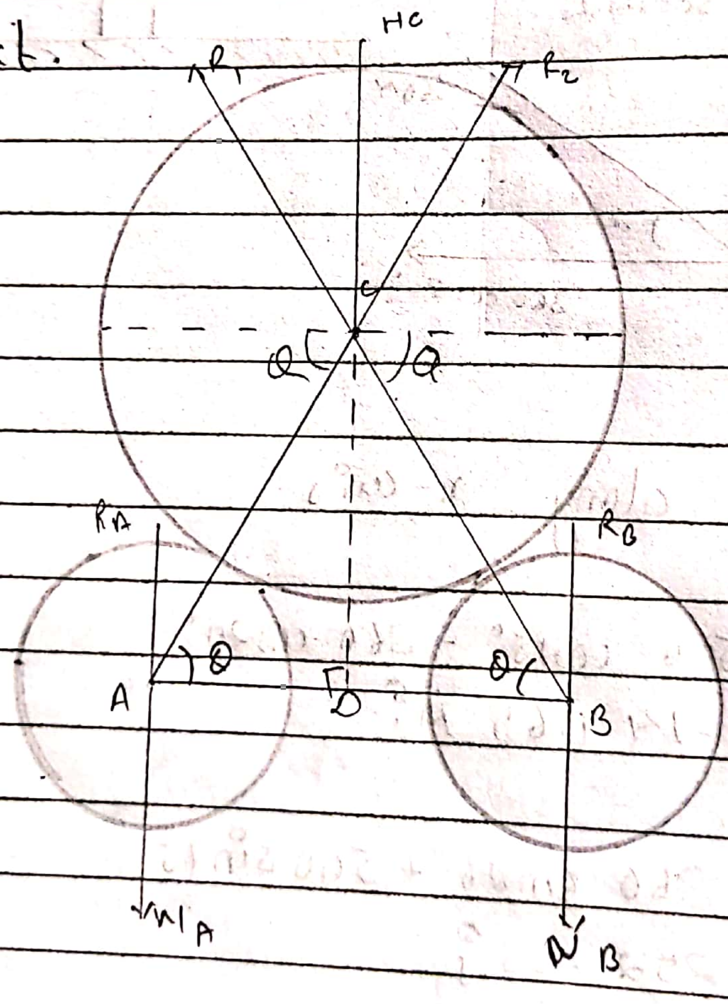
Now,

$$\tan\theta = \left|\frac{\Sigma y}{\Sigma x}\right| = \left(\frac{252.53}{144.67}\right) = 60.19$$ with negative x-axis.

Numerical problem.

Q1 Two smooth circular cylinder each of wt. $W = 445 N$ & radius $= 152 mm$ are connected at their centers by on string AB of length $l = 406 mm$ & rest upon a horizontal plane, supporting above them a third cylinder of wt. $Q = 890 N$ & radius $r = 152 mm$. Find the force in the string & the pressure produced on the floor at the point of contact.

=> Here,



Now,

$$\sin\theta = P/H = \frac{\sqrt{(152\times2)^2 - (203)^2}}{2\times152}$$

$$= 0.74$$

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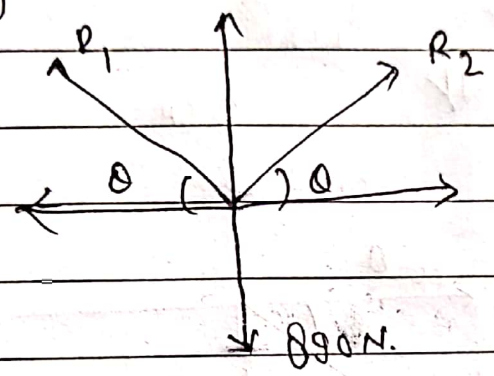
$\cos\theta = b/h = \frac{203}{h}$

$= \frac{203}{226.28} = 0.89.$

now, for cylinder (C)



$\Sigma f_x = 0$

$R_1 \cos\theta = R_2 \cos\theta$

$\therefore \boxed{R_1 = R_2}$

$\Sigma f_y = 0$

$R_1 \sin\theta + R_2 \sin\theta = 890$

$2R\sin\theta = 890 \quad (R_1 = R_2 = R)$

$R\sin\theta = \frac{890}{2}$

$R = \frac{890}{2\sin\theta} = \frac{890}{2 \times 0.74} = 601.35N$

So, $R_1 = R_2 = 601.35N$

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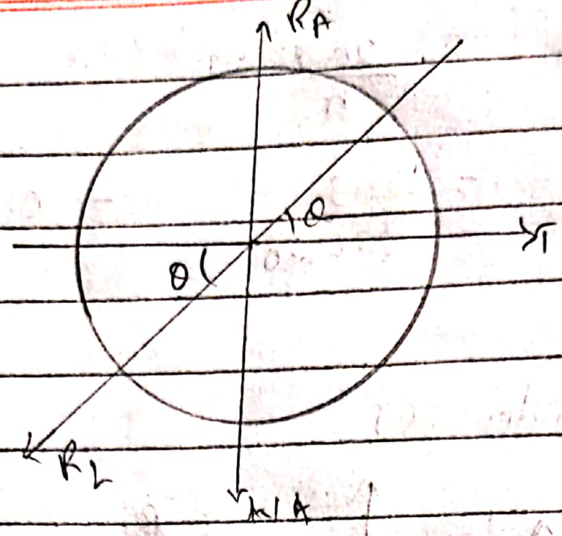
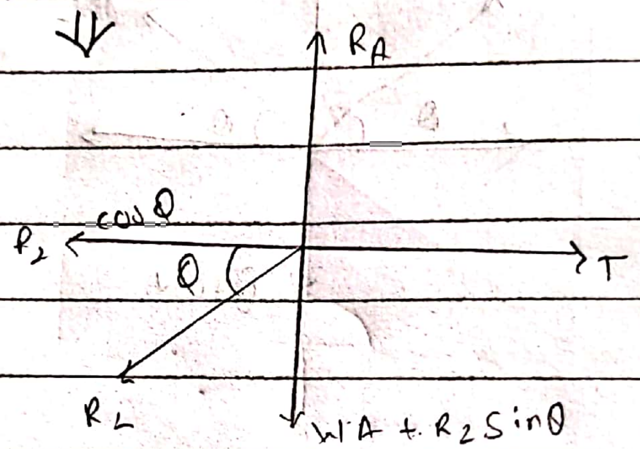


$\Downarrow$



now,

$$\text{Tension} = R_2 \cos\theta = 601.35 \times 0.89$$
$$= 535.2015 \text{ N}$$

now, for pressure (P_1) = $W_A + Q_2 \sin\theta$
r/- force at point of contact = $445 + 601.35 \times 0.74$
of cylinder A. $= 889.99$ N

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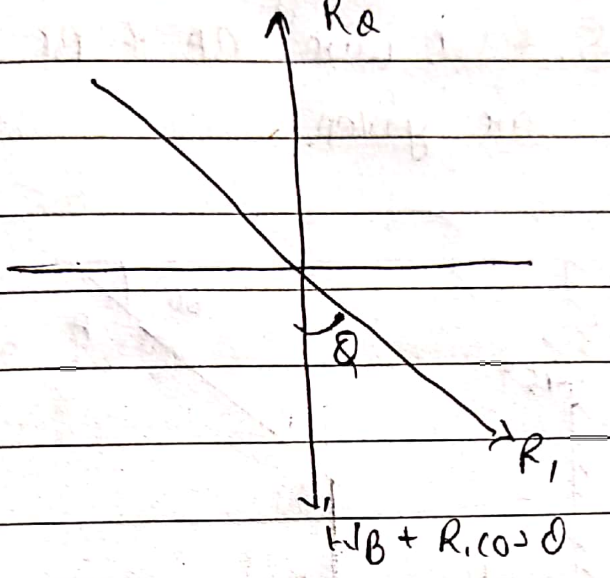
For pressure at cylinder B,



$$P_B = W_B + R_1 \cos\theta$$
$$= 445 + 535.20$$
$$= 980.2N$$

So, Tension $(T) = 535.2N$

$P_A = 889.99N$

$P_B = 980.2N$

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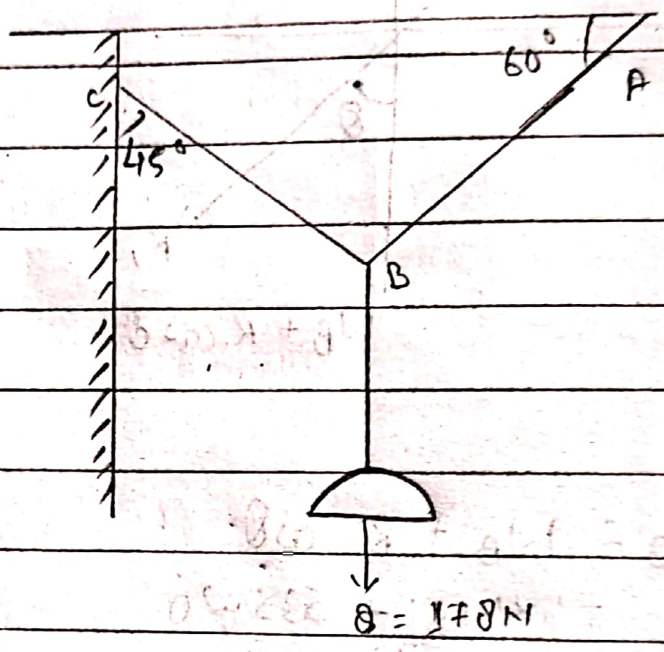
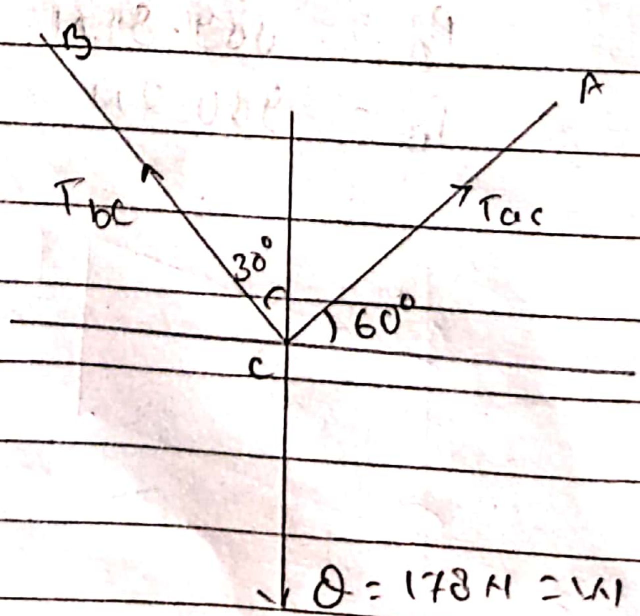
(Q2) An electric light fixture of wt. Q = 178 N is supporte as shown in fig. Determine the tensile force S_1 & S_2 wire BA & BC it this ∡ of indication are given.



Here,



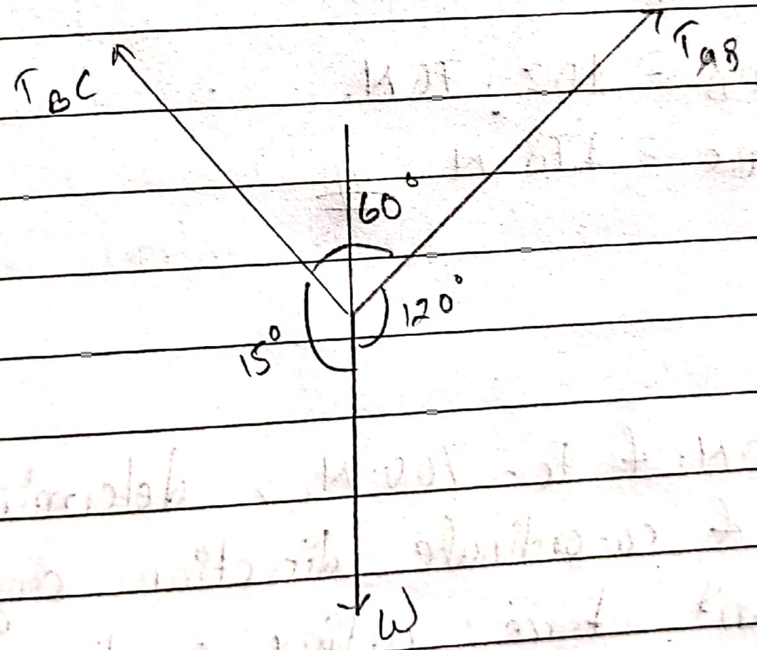
T_{AC} = tension in string AC

T_{BC} = tension in string BC

W = wt. of body.

Here, three force are meeting at point C & are in equilibrium.

now, using lamis therom.



$$\frac{W}{\sin 60} = \frac{T_{AB}}{\sin 15} = \frac{T_{BC}}{\sin 120}$$

now,

$$\frac{17d}{\sin 60^\circ} = \frac{T_{AB}}{\sin 150^\circ}$$

(1) $T_{AB} = \sin 150° \times \frac{178}{\sin 60}$

$= 102.76 N.$

also,

$$\frac{178}{\sin 60} = \frac{T_{BC}}{\sin 120}$$

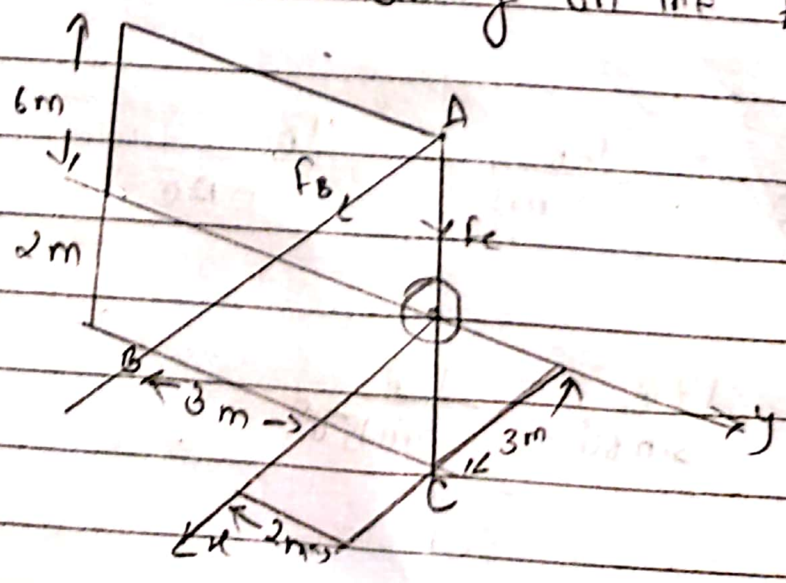
$$T_{BC} = 178 \times \frac{\sin 120°}{\sin 60}$$

$$= 178 N.$$

$T_{AB} = 102.76 N.$

& $T_{BC} = 178 N$ #

Q.3. If $F_B = 560 N$ & $F_C = 700 N$, determine the magnitude & co-ordinate direction angles for the resultant force acting on the flag pole.



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Here, assingning the co-ordinate of points A, B, & C.

$$\vec{A} = 0\hat{i} + 0.\hat{j} + 6\hat{k}$$
$$\vec{B} = 2\hat{i} + 3\hat{j} + 0\hat{k}$$
$$\vec{C} = 3\hat{i} + 2\hat{j} + 0\hat{k}$$

$$\vec{AB} = (B_x - A_x)\hat{i} + (B_y - A_y)\hat{j} + (B_z - A_z)\hat{k}$$
$$= (2\hat{i} - 3\hat{j} - 6\hat{k})$$

$$|A| = \sqrt{4+9+36}$$
$$= \sqrt{49} \quad = 7m$$

now,

limit vector along AB $(\hat{AB}) = \frac{\vec{AB}}{|AB|}$

$$= 0.285\hat{i} - 0.429\hat{j} - 0.857\hat{k}$$

simillarly

$$\vec{AC} = 3\hat{i} + 2\hat{j} - 6\hat{k}$$
$$|AC| = 7$$

$$\frac{\vec{AC}}{|AC|} = \hat{AC} = 0.429\hat{i} + 0.286\hat{j} - 0.857\hat{k}$$

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~~mg~~ magnitude of force

$$F_{AB} = |F_{AB}| \cdot u_{AB}$$
$$= 560 \times (0.285\hat{i} - 0.428\hat{j} - 0.857\hat{k})$$
$$= \{160\hat{i} - 240\hat{j} - 480\hat{k}\}\ N$$

$$F_{AC} = |F_{AC}| \times u_{AC}$$

$$= 700 \times (0.429\hat{i} + 0.286\hat{j} - 0.857\hat{k})$$
$$= \{300\hat{i} + 200\hat{j} - 600\hat{k}\}\ N.$$

$$F_R = F_{AB} + F_{AC}$$
$$= \{460\hat{i} - 40\hat{j} - 1080k\}\ N$$

now,

$$|F_R| = \sqrt{460^2 + 40^2 + 1080^2}$$
$$= 1174.5\ N$$

Direction of F_R

$$\alpha = \cos^{-1}\left(\frac{460}{1174.5}\right)$$

$$= 66.97^\circ$$

$$B = \cos^{-1}\left(\frac{-40}{1174.5}\right) = 42^\circ$$

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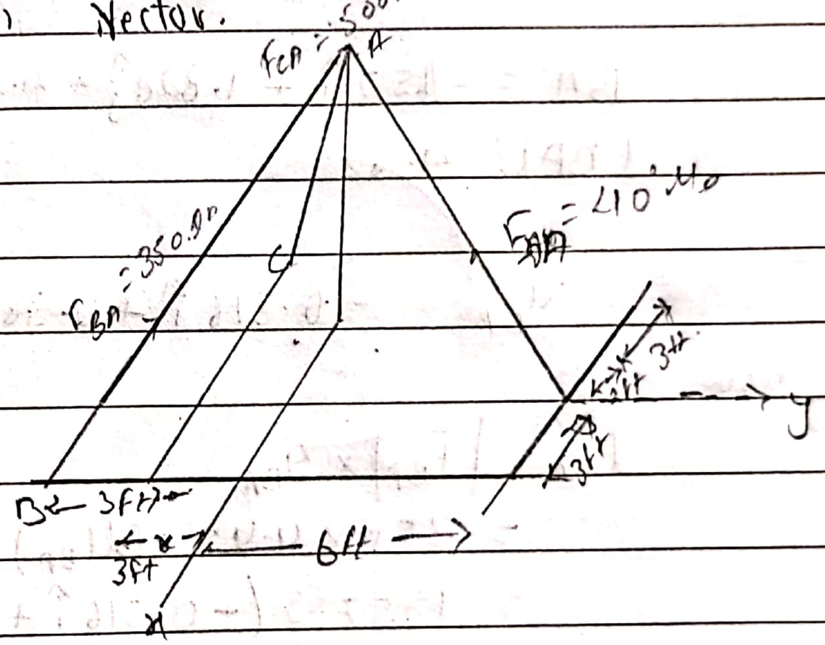
$$r = \cos^{-1}\left(\frac{-1880}{1175.5}\right)$$

$$= 157^{0}$$

The plate is suspended using the three cables which exect the force shown. Express each force as a cartosion vector.



Here, presenting point in vector form

$$\vec{A} = (0\hat{i} + 0\hat{j} + 4.2\hat{k})\,m$$

$$\vec{B} = (1.52\hat{i} - 1.828\hat{j} + 0\hat{k})\,m$$

$$\vec{C} = (-0.91\hat{i} - 0.91\hat{j} + 0\hat{k})\,m$$

$$D = (0.609\hat{i} + 1.82\hat{j} + 0\hat{k})\,m$$

$\vec{AB} = (1.52-0)\hat{i} + (-1.828-0)\hat{j} + (0-4.2)\hat{k}$ m

$= 1.52\hat{i} - 1.82\hat{j} - 4.2\hat{k}$

$|AB| = 4.82$

unit vector along $\vec{AB}$ $(u_{AB}) = \frac{\vec{AB}}{|AB|}$

$= \frac{0.316\hat{i} - 0.38\hat{j} - 0.87\hat{k}}{4.8}$

$\vec{BA} = -1.52\hat{i} + 1.828\hat{j} + 4.2\hat{k}$

$|BA| = 4.82$

$u_{BA} = -0.316\hat{i} + 0.38\hat{j} + 0.875\hat{k}$

now,

$\vec{F_{BA}} = |F_{BA}| \times u_{BA}$

$= 350 \times 4.45 \times (u_{BA})$ N

$= 1557.5(-0.316\hat{i} + 0.38\hat{j} + 0.875\hat{k})$

$= (-492.17\hat{i} + 591.85\hat{j} + 1362.8\hat{k})$ N

simillarly,

$\vec{CA} = (0\hat{i} + 0\hat{j} + 4.2\hat{k}) - (0.91\hat{i} - 0.91\hat{j} + 0\hat{k})$

$= -0.91\hat{i} + 0.91\hat{j} + 4.2\hat{k}$

$|CA| = 4.39$.

unit vector along CA $(u_{CA}) = -0.2\hat{i} + 0.2\hat{j} + 0.95\hat{k}$

$$\vec{F}_{CA} = |T_{CA}| \times u_{CA}$$
$$= 500 \times 4.45 \times u_{CA}$$
$$= 2225\,(-0.2\hat{i} + 0.2\hat{j} + 0.95\hat{k})$$
$$= -445\hat{i} + 445\hat{j} + 2113.75\hat{k} \text{ N}$$

Similarly

$$\vec{DA} = (0\hat{i} + 0\hat{j} + 4.2\hat{k}) - (0.6096\hat{i} + 1.82\hat{j} + 0\hat{k})$$
$$= -0.609\hat{i} - 1.82\hat{j} + 4.2\hat{k}$$

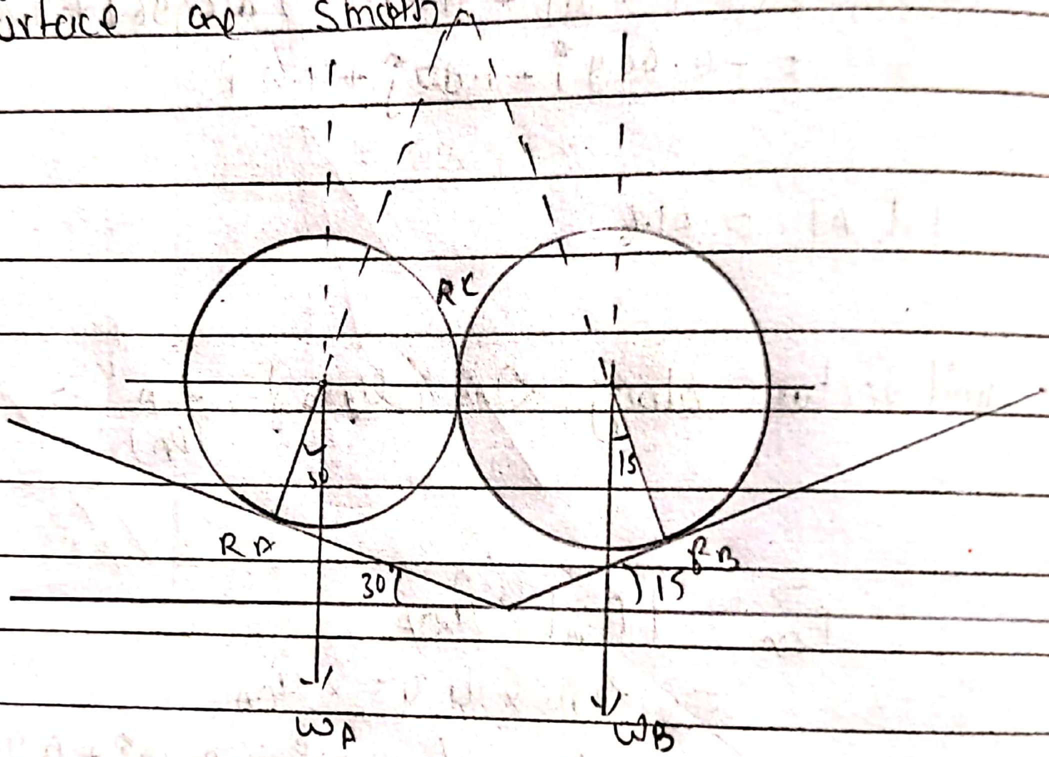
$$|DA| = 4.6$$

unit vector along DA $(u_{DA}) = \dfrac{\vec{DA}}{|DA|} = \dfrac{-0.13\hat{i} - 0.39\hat{j} + 0.91\hat{k}}{4.6}$

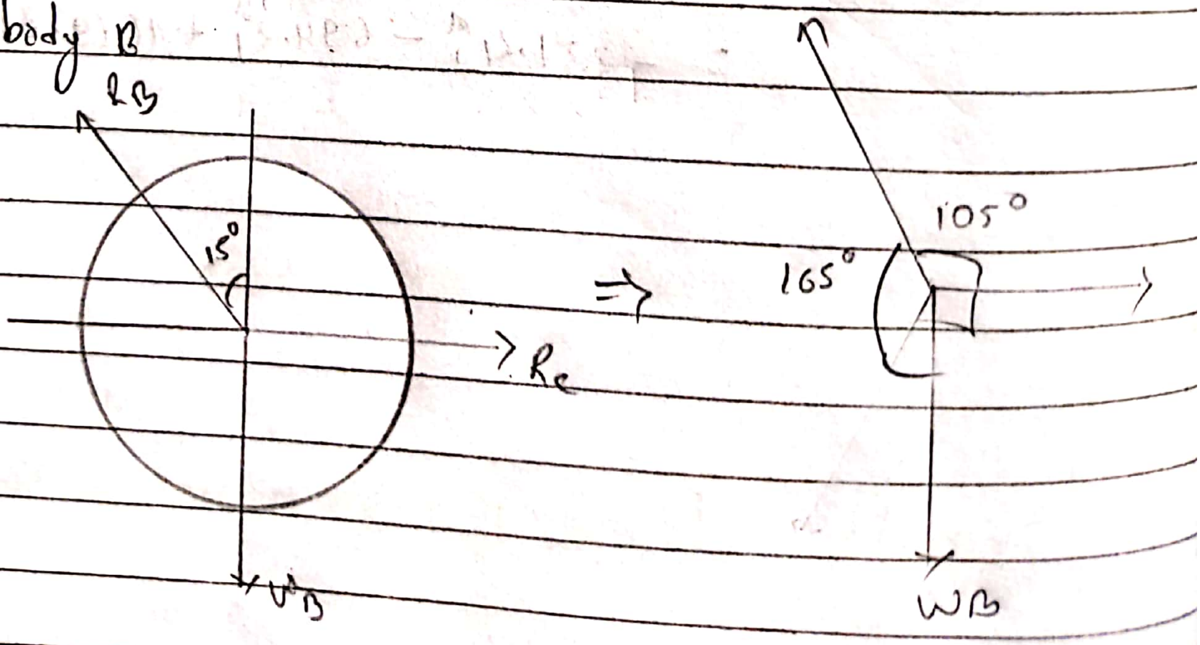
$$\vec{F}_{DA} = |F_{DA}| \times \hat{u}_{DA}$$
$$= 400 \times 4.45 \times \hat{u}_{DA}$$
$$= 1780 \times (-0.13\hat{i} - 0.39\hat{j} + 0.91\hat{k}) \text{ N}$$
$$= -231.4\hat{i} - 694.2\hat{j} + 1619.8\hat{k}$$

Q. The masses of cylinder A & B of figure are 40 kg & 75kg respectively. Determine the force on the cylinder by the inclined surface & the magnitud & direction of the force exerted by cylinder A on cylinder B when the cylinder are in equilibrium Assum that all surface are smooth.

⇒



for body B



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using lamins theorem

$$\frac{R_B}{\sin 90^\circ} = \frac{R_C}{\sin 165^\circ} = \frac{W_B}{\sin 105^\circ}$$

or $$R_B = \frac{W_B}{\sin 105^\circ} \times \sin 90^\circ$$

$$= \frac{75 \times 10}{\sin 105} = 776.45 N$$

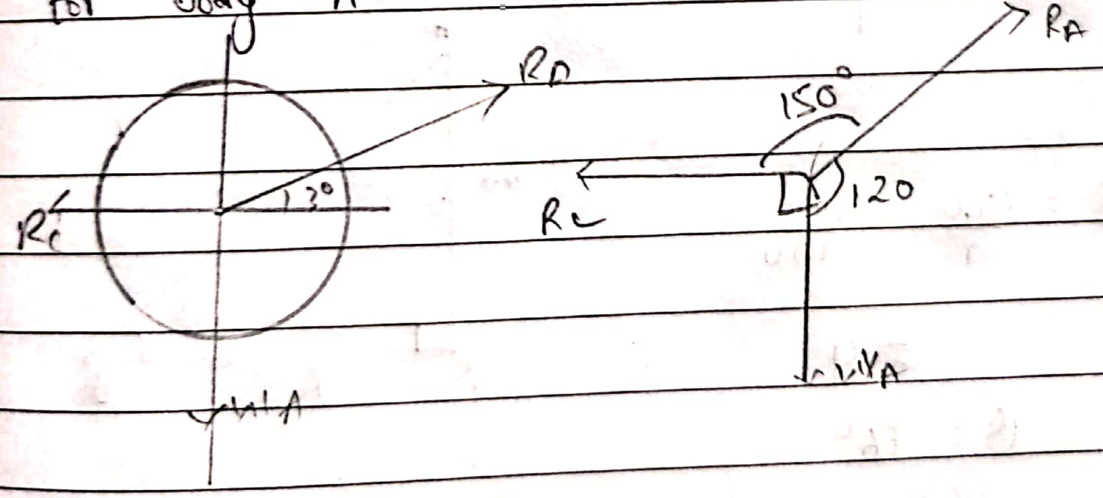
$$R_B = 776.45 N.$$

again,

$$\frac{R_C}{\sin 165} = \frac{75 \times 10}{\sin 105}$$

$$R_C = 200.96 N.$$

for body A



From lamis theorem,

$$\frac{R_A}{\sin 90} = \frac{R_C}{\sin 120^\circ} = \frac{W_A}{\sin 150^\circ}$$

$$R_A = \frac{W_A}{\sin 150} = \frac{40 \times 10}{\sin 150}$$

$$= 800 N$$ ans

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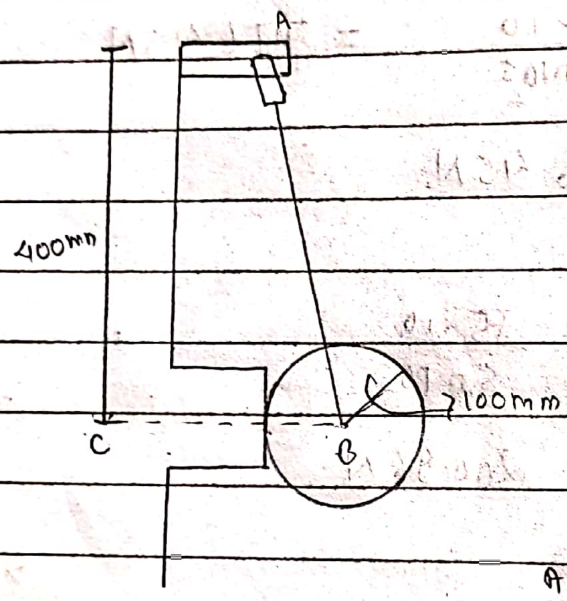
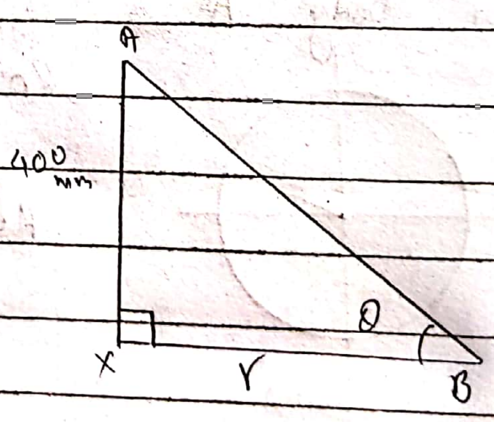
Q A homogenous cylinder with a mass of 250kg is supported against a smooth surface by a cable as shown in fig. Determine the force exerted on the cylinder by the cable & by the smooth surface at the point of contact C



Sol^n.



$\tan\theta = \frac{400}{r} = \frac{400}{100}$

$= 4$

$\theta = 76^\circ$

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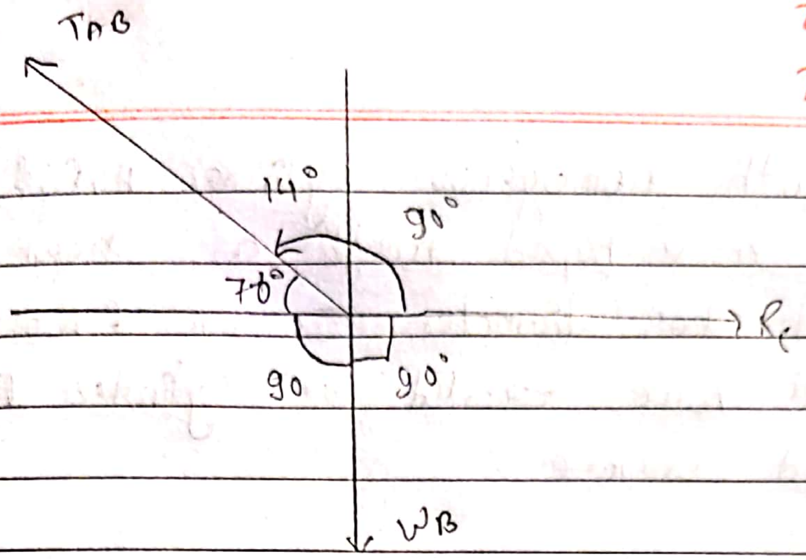

Now, from lami's theorem

$$\frac{T_{AB}}{\sin 90} = \frac{R_c}{\sin(76-90)} = \frac{W_B}{\sin(14+90)}$$

$$\frac{T_{AB}}{\sin 90} = \frac{250 \times 10}{\sin 104}$$

$$T_{AB} = 2500 \times \frac{\sin 90}{\sin 104}$$

$$= 2576.53\,N.$$

also,

$$R_c = \frac{W_B}{\sin 104} \times \sin 166$$

$$= \frac{2500}{\sin 104} \times \sin 166$$

$$= 623.3\,N$$

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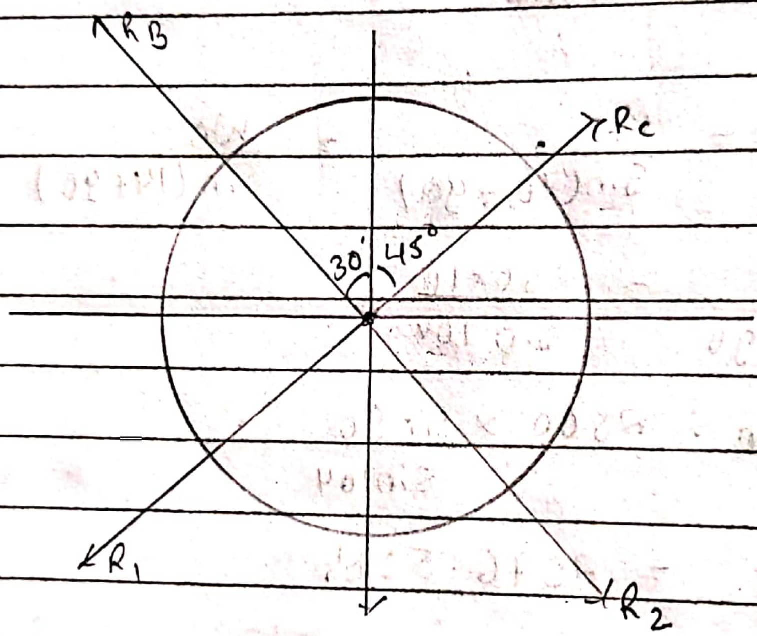
Q. Three smooth homogenous cylinder A, B, & C are stacted in a v-shaped trough as shown in figure. Each has diameter 500 mm & mass of 100 kg. Find force exerted on cylinder A by the inclined surface.

→

For cylinder A.



To be equilibrium

$$R_1 = R_C = Wg \cos 45 = 100 \times 10 \times \cos 45$$

$$= 100 \times \frac{1}{\sqrt{2}}$$

$$= 707.107\ N.$$

$$R_2 = R_B = Wg \cos 90^\circ = 866.025\ N$$

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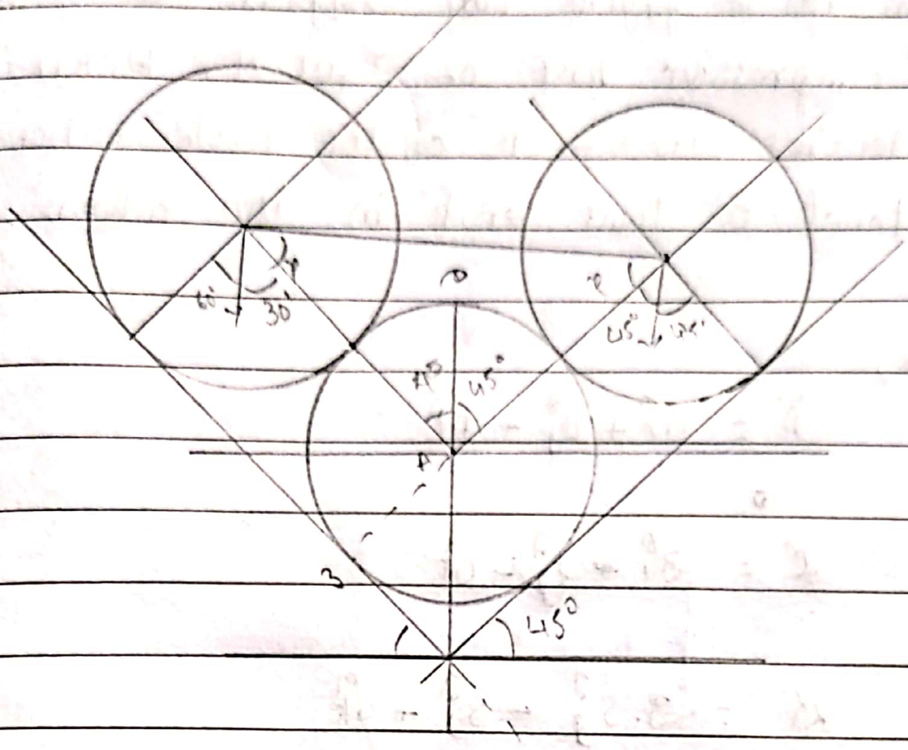

$\angle BAO = 30°$ (corresponding $\angle$)
$\angle CAO = 45°$ (" $\angle$)

also,

$\angle BAC = 75°$

Now

$x + x + 75 = 180$ (angle of isolet Δ's)
$2x = 180 - 75$
$x = 26.25°$

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(*) Column AB of figure can support a maximum axial compressive force of 7500 N. Determine the tension in each of the cables when the level of load exist in the column.

Soln,

Here,

$$\vec{A} = 0\hat{i} + 0\hat{j} + 7\hat{k}$$

$$\vec{C} = 3\hat{i} - 2\hat{j} + 0\hat{k}$$

$$\vec{B} = -3.5\hat{i} - 5\hat{j} + 0\hat{k}$$

$$\vec{E} = -2\hat{i} + 3\hat{j} + 0\hat{k}$$

now,

$$\vec{CA} = -3\hat{i} + 2\hat{j} + 7\hat{k}$$

$$|\vec{CA}| = 7.87$$

now,

$$\text{unit vector } (u_{CA}) = -0.38\hat{i} + 0.27\hat{j} + 0.5\hat{k}$$

now,

$$\hat{u}_{AE} = 0.38\hat{i} - 0.25\hat{j} - 0.88\hat{k}$$

now,

$$\vec{AB} = -3.5\hat{i} - 5\hat{j} - 7\hat{k}$$

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$|\vec{AB}| = 9.28.$

$\hat{u}_{AD} = -0.377\hat{i} - 0.588\hat{j} - 0.75\hat{k}$

now,

$\vec{AF} = -2\hat{i} + 3\hat{j} - 7\hat{k}$

$|\vec{AF}| = 7.87$

now,

$\vec{u}_{AF} = -0.25\hat{i} + 0.38\hat{j} - 0.88\hat{k}$

now

$\Sigma f_x = 0.38\ AC - 0.377\ AD - 0.25\ AF = 0$

$\Sigma f_y = -0.25\ AC - 0.538\ AD + 0.38\ AF = 0$

$\Sigma f_z = -0.88\ AC - 0.75\ AD - 0.88\ AF = \cancel{7500}N$

$\Rightarrow -0.88\ AC - 0.75\ AD - 0.88\ AF$

$= 7500N$

again

$$A = \begin{bmatrix} 0.38 & -0.377 & -0.25 \\ -0.25 & -0.538 & 0.38 \\ -0.88 & -0.75 & -0.88 \end{bmatrix}$$

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$$B = \begin{bmatrix} 0 \\ 0 \\ -7500 \end{bmatrix}$$

now,

$$AX = B$$

$$X = A^{-1}B$$

$$X = \begin{bmatrix} 3.66 \times 10^3 \\ 1.08 \times 10^3 \\ 3.94 \times 10^3 \end{bmatrix}$$

$$T_{AC} = 3.66 \times 10^3 \, N$$

$$T_{AD} = 1.08 \times 10^3 \, N$$

$$T_{AE} = 3.94 \times 10^3 \, N.$$