03/10/2023

Engineering Mechanics:-

- Branch of physics
- that ~~dies~~ deals with physical state of Rigid Bodies, when acted upon by External force. (System of)

Statics:-

- Branch of mechanics, that deals with effects of system of forces on a rigid body under the state of rest.

Dynamics:-

- Branch of mechanics, that deals with effect of system of forces on a rigid body under the state of motion.

Dynamics < Kinematics, Kinetics.

Kinematics:-

- Branch of Dynamics, that deals with only motion parameters of the rigid bodies without considering the cause of motion.
- displacement, velocity, acceleration, time. (s, v, a, t)

Kinetics:-

- Branch of Dynamics, that deals with motion of the rigid bodies by considering the cause of motion.

Rigid Body:- A body that doesn't show any kind of deformation when an external load is applied on it.

Deformable Body:- A body that shows deformation when an external load is applied on it.

04/10/2023

~~System of forces~~

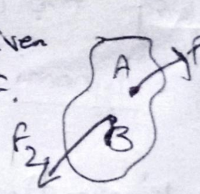
Force:- It is an external factor that tends to change the physical state of the body under rest (or) uniform motion.

Specifications:-

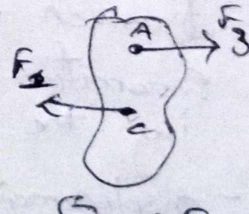
- A force is totally specified by magnitude, direction, point of application.
- **Line of action:-** when the force vector is extended on both sides to ∞ to get the line of action.

System of forces:-

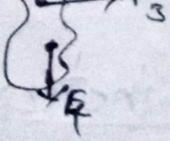
1. **Collinear SOF:-** If the line of action for the given SOF lies in the same line, it is called collinear SOF.



2. **Non-collinear SOF:-** If the line of action for the given SOF doesn't fall in the same line



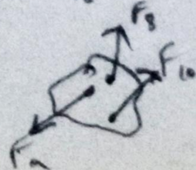
3. **Co-planar SOF:-** If the line of action for the given SOF lies in the same plane.



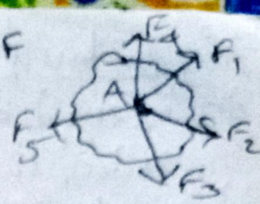
4. **Non Co-planar SOF:-** (or) **Spatial SOF:-** (or) **3-D SOF:-** If the line of action for the given SOF lies on different planes.

5. **$\parallel^{el}$ SOF:-** If the line of action for the given SOF are $\parallel^{el}$ to each other

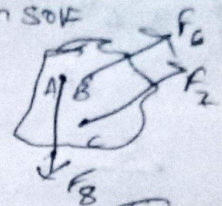
6. **Non $\parallel^{el}$ SOF:-** If the line of action for the given SOF is not $\parallel^{el}$ to each other



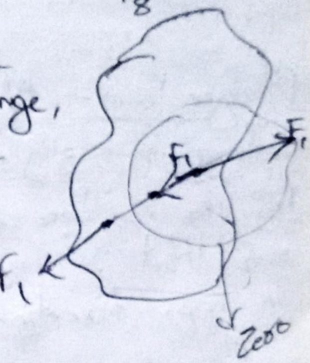
Concurrent SOF:- If the line of action for the given SOF ~~pred~~ meets at a single point



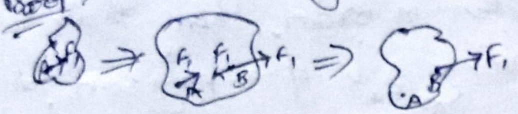
8. Non-concurrent SOF:- If the line of action for the given SOF doesn't meet at a single point.



Law of transmissibility:- It states that, the effects of a force on a rigid body doesn't change, if it is transmitted to any other point on the rigid body along ~~the~~ its line of action.

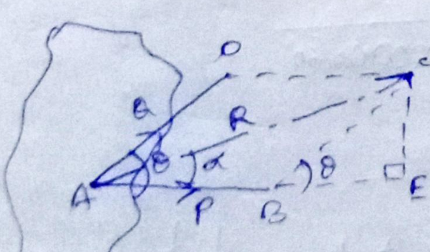


Proof:-



Parallelogram law of forces:- when a rigid body is subjected to a set of coplanar concurrent forces & if these two forces are represented in magnitude & direction by ~~edges~~ adjacent sides of a ~~P~~ ∥gram, then the resultant of these two forces are represented in magnitude & direction by the diagonal passing through the point of application)

06/10/2023.



ΔACE, $AC^2 = AE^2 + CE^2$

$R^2 = AC^2 = (AB+BE)^2 + CE^2$

$AC^2 = (P + Q\cos\theta)^2 + Q^2\sin^2\theta$

$R^2 = P^2 + Q^2 + 2PQ\cos\theta$

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

Rough

$\sin\theta = \frac{CE}{BC}$

$CE = BC\sin\theta$

$\cos\theta = \frac{BE}{BC}$

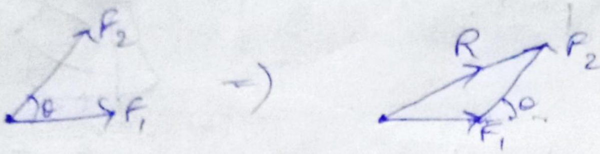
$BE = BC\cos\theta$

ΔACE, $\tan\alpha = \frac{CE}{AE} = \frac{CE}{AB+BE}$

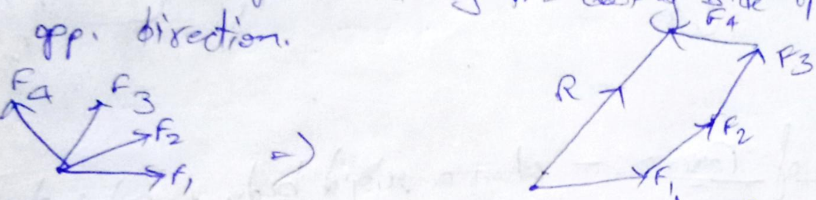
$\tan\alpha = \frac{Q\sin\theta}{P+Q\cos\theta}$

$$\boxed{\alpha = \tan^{-1}\frac{Q\sin\theta}{P+Q\cos\theta}}$$

Triangle law of forces:- If 2 co-planar, con-current forces acting on a rigid body are represented by sides of a Δ^{le} taken in order, then their resultant is represented by closing side of a Δ^{le} taken in opp. direction.



Polygon law:- If a ~~set~~ system of coplanar, con-current forces acting on a rigid body is represented in magnitude & direction by the sides of a polygon taken in order, then their resultant is represented by the closing side of a polygon taken in opp. direction.



Force polygon

09/10/2023

(1) 2 forces are Co-planar & con-current having magnitude of 100N & 200N find the magnitude of their resultant force. If the angle b/w the two forces is 60°

(A) Given, $P = 100\,N$, $Q = 200\,N$, $\theta = 60^\circ$

w.k.T, $R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$

$R = \sqrt{10000 + 40000 + 40000\cos 60^\circ}$

$R = \sqrt{70,000}$

$R = 264.5751$

(2) The resultant of 2 co-planar, con-current forces which are equal in magnitude is equal to the magnitude of the forces find the angle b/w two forces

(A) Given, $R = P = Q$

w.k.T, $R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$

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

$P^2 = 2P^2(1 + \cos\theta)$

$\boxed{\cos\theta = -\frac{1}{2}}$

$\boxed{\theta = 120^\circ}$

Q2 coplanar, concurrent forces P & Q has the magnitude of resultant 40N, & the resultant makes 45° & 30° with forces P & Q resp. Find the magnitude of P & Q.

Sol:- Given, $R = 40N$; $\alpha_1 = 45°$; $\alpha_2 = 30°$

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

$$1600 = P^2+Q^2+0.517PQ$$

$$1600 = P^2+Q^2+2PQ\cos 75 \quad (2)$$

~~$\alpha = \tan$~~

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

$$P+Q\cos\theta - Q\sin\theta = 0$$

~~$P+Q\cos 75 - Q\sin 75 = 0$~~

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

$$P = Q(\cos 75 - \sin 75) \quad (1)$$

$$P = Q(0.7071)$$

Sub (1) in (2)

$$1600 = Q^2(0.495)+Q^2+\cancel{40Q}\ Q(0.3623)$$

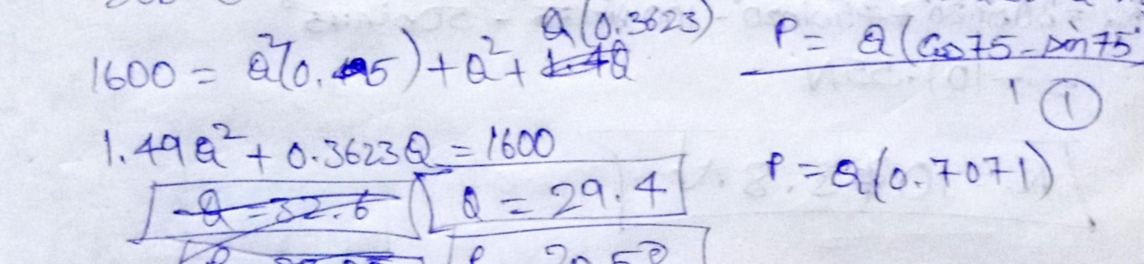
$$1.49Q^2+0.3623Q = 1600$$

$\boxed{\cancel{Q = 32.6}}$ $\boxed{Q = 29.4}$

$\boxed{\cancel{P = 23.05}}$ $\boxed{P = 20.58}$

10/10/2023

Resultant Force:- A force acting on a rigid body can be horizontal (or) vertical (or) inclined. An inclined force is to be resolved into x component (horizontal) & y component (vertical). An inclined force acting on a rigid body can be in Q_1, Q_2, Q_3 (or) Q_4

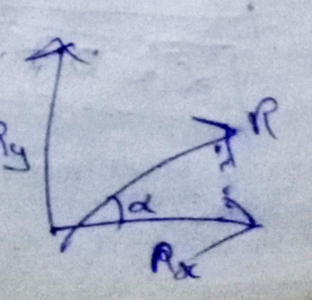


- when a rigid body is subjected to a system of forces :
  - resolve all the inclined forces in horizontal & vertical directions
  - Add all the H-components & Add all the V-components
  - Add all the x-components will give the x-component of Resultant force
  - Add all the y-components will give the y-component of Resultant force

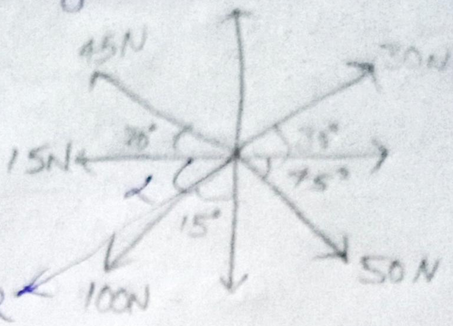
$$\Sigma F_x = R_x \quad ; \quad \Sigma F_y = R_y$$

$$\boxed{R = \sqrt{R_x^2+R_y^2}}$$

$$\boxed{\alpha = \tan^{-1}\frac{R_y}{R_x}}$$



1) Determine the resultant force for the given ~~set~~ system of coplanar con-current forces.



$R_x = 30\cos 30° + 45\cos 20° - 15 - 100\cos 75° + 50\cos 45°$

$= \cancel{15 - 45 \quad 15}$

$= \cancel{17.13N}$

$= -21.83N$

$R_y = 30\sin 30° + 45\sin 20° - 100\sin 75° - 50\sin 45°$

$= -101.55N$

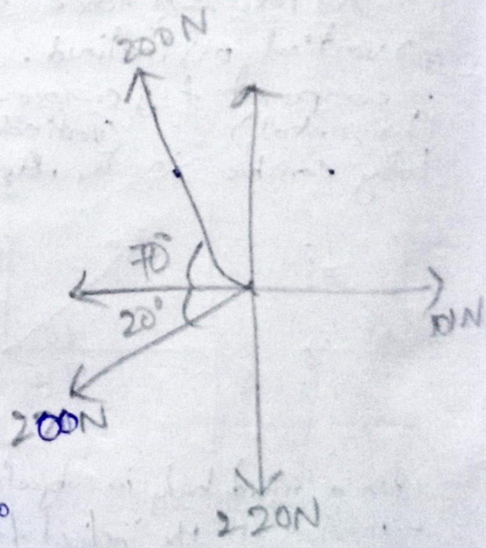
$\boxed{R = 1043.8N}$

~~tan~~ $\alpha = \tan^{-1}\frac{R_y}{R_x}$

$\boxed{\cancel{\alpha = 78°}}$

$\boxed{\alpha = 77.7°}$

2



Sol:- $R_x = 101 - 200\cos 70° - 200\cos 20°$

$= -155.32N$

$R_y = 200\sin 70° - 220 - 200\sin 20°$

$= -100.4N$

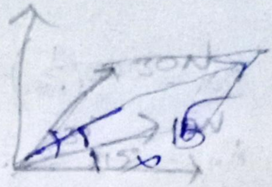
$\boxed{R = 184.97N}$

$\boxed{\alpha = 57.1°}$

~~Determine~~ 11/10/2023

(3) Determine the resultant force of given coplanar & con-current forces & compare the result with IInd law of forces.

Sol:- (1)



$R_x = 15\cos 15^\circ + 30\cos 45^\circ$

$R_x = 35.70$

$R_y = 15\sin 15^\circ + 30\sin 45^\circ$

$R_y = 25.09$

$\boxed{\alpha = 35.1034}$

$R = \sqrt{R_x^2 + R_y^2} = 43.6348$

from IInd law,

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

$R = \sqrt{15^2 + 30^2 + 2(15)(30)\cos 30^\circ}$

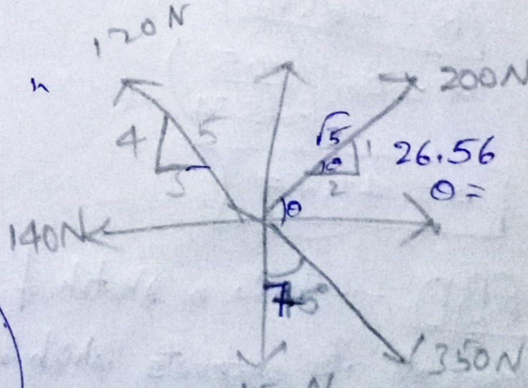
$\boxed{R = 43.6393}$

$\alpha = \cancel{22.6307}$ 20.1

~~87.6307~~

$\boxed{35.1}$

(4) " " " " "



(4) $R_x = 200\frac{2}{\sqrt{5}} - 120\left(\frac{3}{5}\right) - 140 + 350\cos 45^\circ$

$R_x = 214.37$

$R_y = 200\frac{1}{\sqrt{5}} + 120\left(\frac{4}{5}\right) - 150 - 350\sin 45^\circ$

$= -212.04$

$R = \sqrt{R_x^2 + R_y^2} = 301.52$

$\boxed{\alpha = 44.68}$

$R_x = 200\left(\frac{2}{\sqrt{5}}\right) - 120\left(\frac{3}{5}\right) - 140 + 350\cos 15^\circ$

$R_x = 304.95$

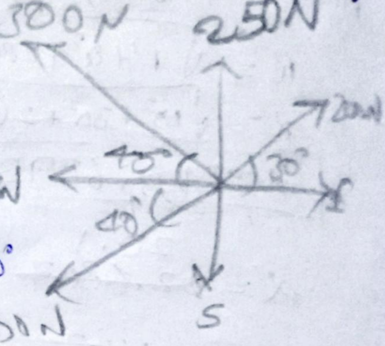
$R_y = 200\left(\frac{1}{\sqrt{5}}\right) - 120\left(\frac{4}{5}\right) - 150 - 350\sin 15^\circ$

$R_y = -239.65$

$R = \sqrt{R_x^2 + R_y^2} = 387.\cancel{84}\,N$

$\alpha = 37.9$

(5)



$R_x = 200\cos 30^\circ - 300\cos 45^\circ - 400\cos 40^\circ$

$R_x = \cancel{154.42}$ $-345.34\,N$

$R_y = 200\sin 30^\circ + 250 + 300\sin 45 - 400\sin 40^\circ$

$R_y = 305\,N$

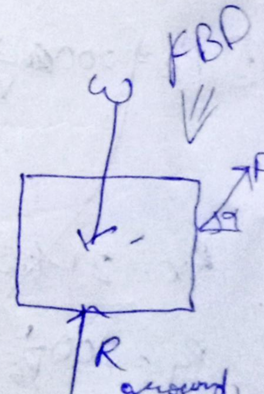
$R = \sqrt{R_x^2 + R_y^2}$

$\boxed{R = 460.75}$

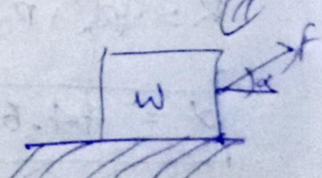
$\alpha = \tan^{-1}\left(\frac{305}{345.34}\right)$

$\boxed{\alpha = 41.45}$

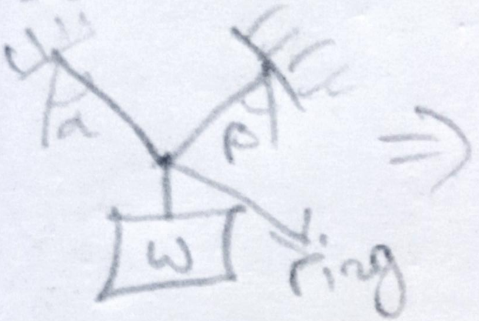
FBD: – It is a sketch of an isolated body from all its supports which represents all the acting & reactive forces on it.



- All the external forces acting on the body including the weight of the body comes under the active forces.
- The force exerted by the support on the body is called reactive force (or) support reaction.

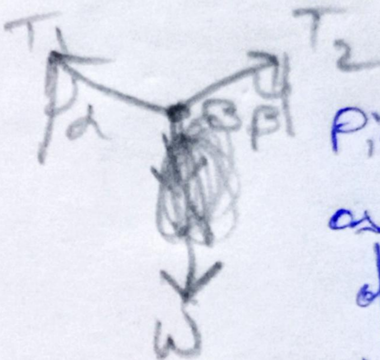


Ex:-



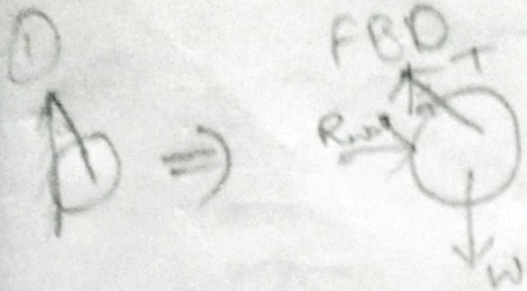
FBD - Block

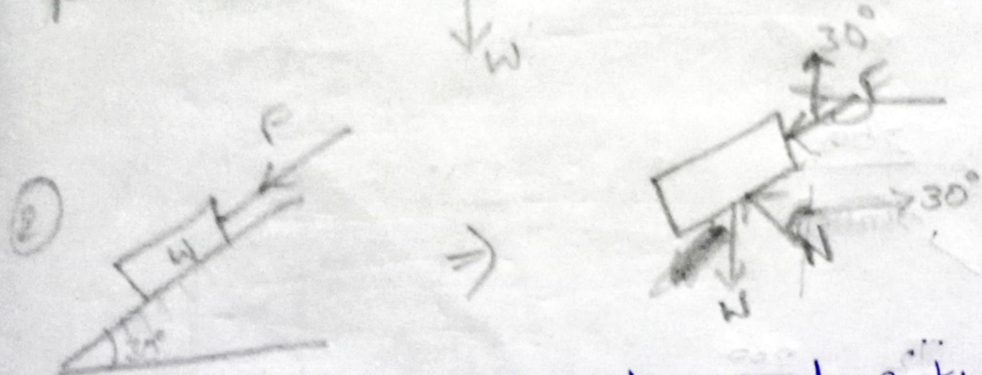
FBD - Ring



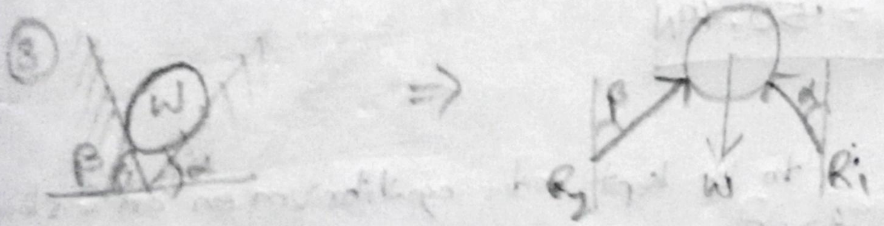
Ring weight is negligible as compared to weight of block. So ring weight is neglected.
So, no active force & 3 reactive force

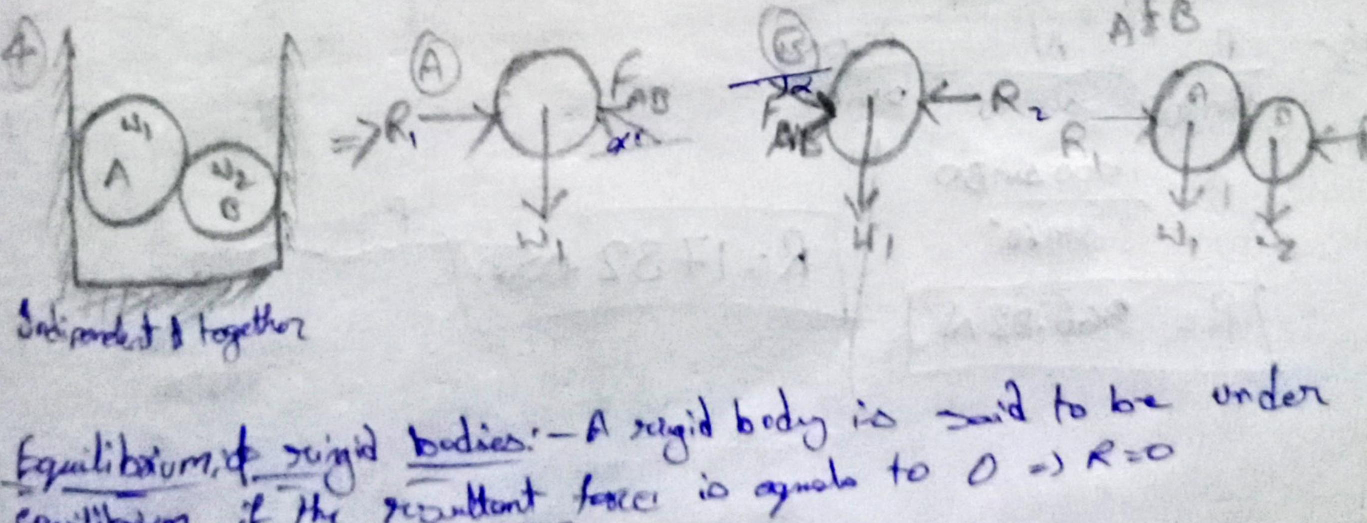
So, no active force
& 3 reactive force





* If two lines make an angle θ, their Normals make the same angle θ.





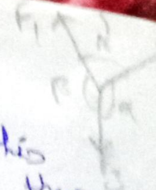
Independent & together

Equilibrium of rigid bodies:- A rigid body is said to be under equilibrium, if the resultant force is equals to 0 => R=0

$$\text{equilibrium} \Leftrightarrow R=0 \begin{cases} R_x & \Sigma F_x = 0 \\ R_y & \Sigma F_y = 0 \end{cases} \text{Equilibrium conditions}$$

Lami's theorem - If 3 coplanar, concurrent forces are in equilibrium, then magnitude of each force is proportional to sin. of the angle b/w other two forces.

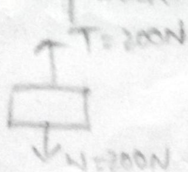
$$\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{F_3}{\sin\gamma}$$



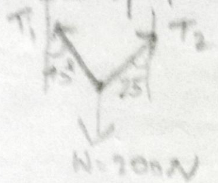
- a FBD having 3 forces can be solved using this theorem.

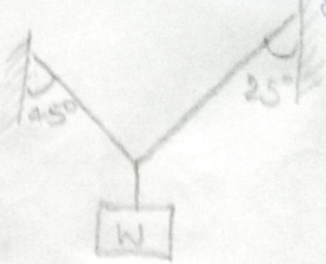
① A block weight 200 N is supported using 2 cables as shown in fig. Find the tension in both the cables.

FBD of block

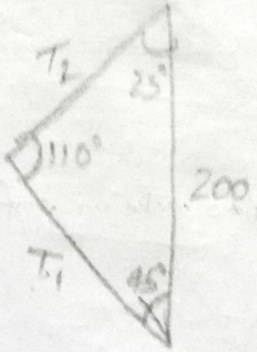


FBD of pin





$$\frac{T_1}{\sin 25} = \frac{T_2}{\sin 45} = \frac{200}{\sin 110^\circ}$$



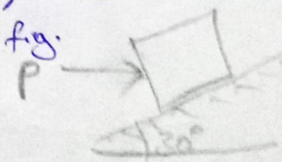
$$\frac{T_1}{\sin 25} = \frac{200}{\sin 110^\circ}$$

$$\boxed{T_1 = 89.94\text{ N}}$$

$$\frac{T_2}{\sin 45} = \frac{200}{\sin 110^\circ}$$

$$\boxed{T_2 = 150.49\text{N}}$$

② A block weight 1500N is to be kept under equilibrium on an inclined slope with a horizontal force as shown in fig. find the magnitude of force.



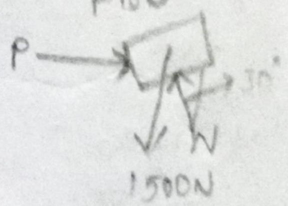
Sol:-
$$\frac{P}{\sin 30^\circ} = \frac{N}{\sin 90^\circ} = \frac{1500}{\sin 60^\circ}$$

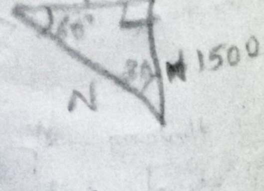
$$P = \frac{1500 \sin 30}{\sin 60^\circ}$$

$$\boxed{P = 866.02\text{ N}}$$

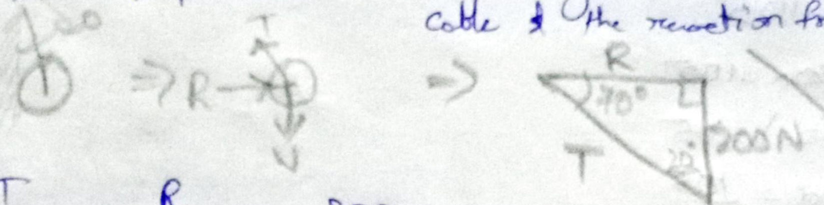
$$\boxed{R = 1732.05\text{N}}$$

FBD





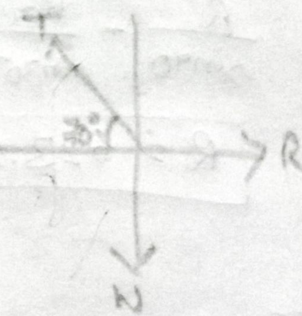
③ A solid sphere weighting 200N is supported against a vertical wall with the help of cable as shown in fig. calculate the tension in the cable & the reaction from the wall.



$$\frac{T}{\sin 90^\circ} = \frac{R}{\sin 20^\circ} = \frac{200}{\sin 70^\circ}$$

$$\boxed{T = 212.83N}$$

$$\boxed{R = 72.79N}$$



$$\Sigma F_x = -T\cos 70^\circ + R.$$

$$\boxed{R - T\cos 70^\circ = 0} \quad \text{--- ①}$$

$$\Sigma F_y = T\sin 70^\circ - 200$$

$$T\sin 70^\circ = 200$$

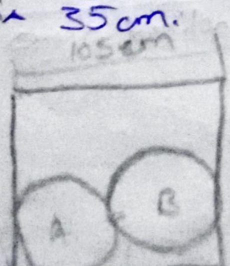
$$\boxed{T = 212.83N}$$

from ①,

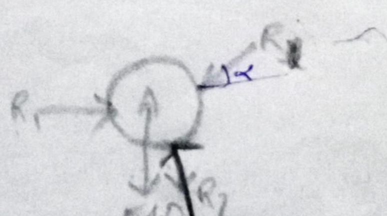
$$R - 72.79 = 0$$

$$\boxed{R = 72.79}$$

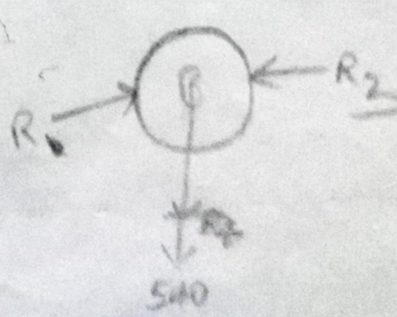
④ 2 solid spheres weighing 540N each are under equilibrium as shown in fig. Det. all the support reaction. radius of each sphere is 35cm.



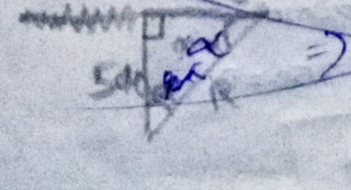
FBD of A



FBD of B



for B:-



$$\Rightarrow \frac{R}{\sin 90^\circ} = \frac{R_3}{\sin\alpha} = \frac{540}{\cos\alpha}$$

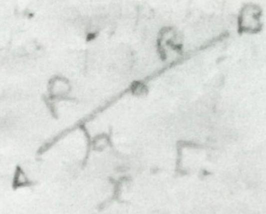
ACC to diagram

$R+R+x=105$

$2R+2R\cos\alpha=105$

$2R(1+\cos\alpha)=105$

$1+\cos\alpha=\dfrac{105}{2R}$



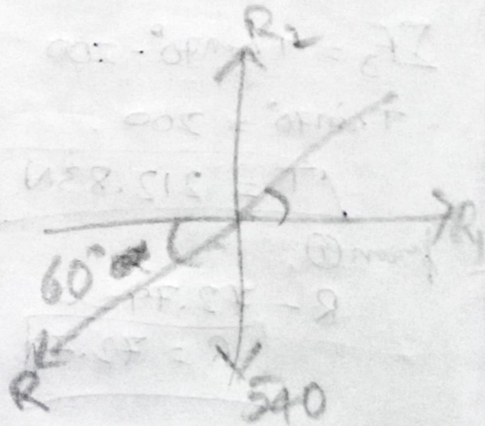
$\therefore x = 2R\cos\alpha$

$\cos\alpha=0.5$

$\boxed{\alpha=60^\circ}$

$$\frac{R}{\sin 90}=\frac{R_3}{\sin 30^\circ}=\frac{540}{\sin 60^\circ}$$

$\boxed{R=623.53N}$ $\boxed{R_3=311.76N}$



$\sum F_x=0$

$R_1-623.53\cos 60^\circ=0$

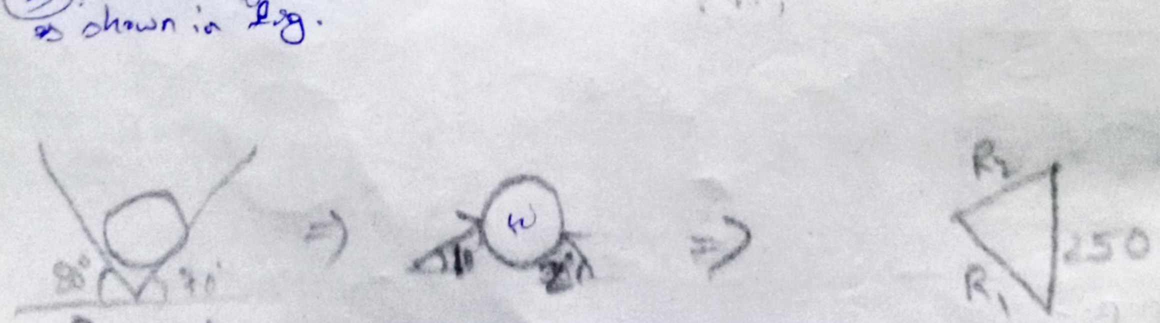
$\boxed{R_1=311.76N}$

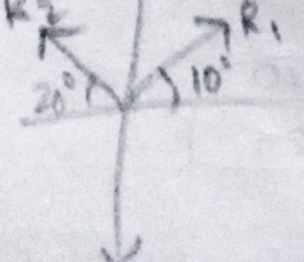
$\sum F_y=0$

$R_2-623.53\sin 60^\circ-540=0$

$\boxed{R_2=1079.99\ N}$

(5) A solid cylinder, is under equilibrium b/w two inclined planes as shown in fig.





$-R_2\cos 20^\circ+R_1\cos 10^\circ=0$ — (1)

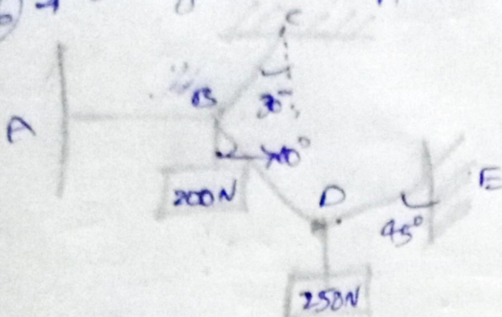
~~$R_1\cos 10^\circ=R_2\cos 20^\circ$~~

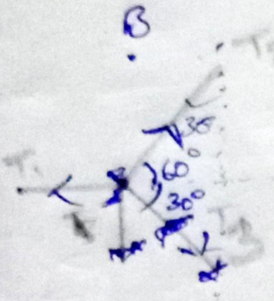
$R_1\sin 10^\circ+R_2\sin 20^\circ-250=0$

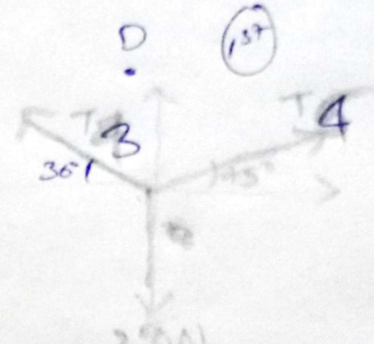
$\boxed{R_1=469.84N}$

18/10/2023

6) If 2 weights are supported by a system of cables as shown in fig. sat in all the pins.







$\Sigma F_x = F_{BC}\cos 60^\circ - F_{AB} + F_{BD}\cos 30^\circ = 0$

$F_{BC} = \dfrac{\cancel{158.49}\, F_{BD}\cos 30^\circ + F_{AB}}{\cos 60^\circ}$

$\Sigma F_y = F_{BC}\sin 60^\circ - 200 - F_{BD}\sin 30^\circ = 0$

$274.5 + F_{AB}\dfrac{\sin 60}{\cos 60} - 200 - 91.505 = 0$

$F_{AB}\tan 60 = 17.005$

$\boxed{F_{AB} = 9.81\,N}$

$\Sigma F_x = T_4\cos 45 - T_3\cos 30^\circ = 0$

$T_3 = \left(\dfrac{\cos 30^\circ}{\cos 45^\circ}\right) T_4$

$T_3 = 0.816\, T_4$

$\Sigma F_y = T_4\sin 45^\circ + T_3\sin 30^\circ - 250 = 0$

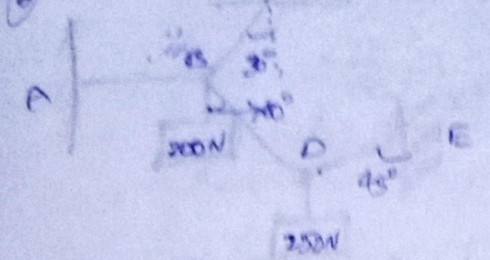
$1.1151\, T_4 = 250$

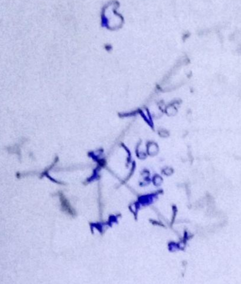
$F_{DE} = \boxed{T_4 = 224.13\,N}$

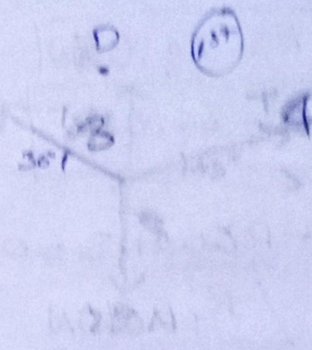
$F_{BD} = \boxed{T_3 = 183.8\,N}$

18/10/2025

(6) 2 weights are supported by a system of cables as shown in fig. and in all the pieces.







$\Sigma F_x = F_{BC}\cos 60^\circ - F_{AB} + F_{BD}\cos 30^\circ = 0$

$$F_{BC} = \frac{\cancel{158.49}\,F_{BD}\cos 30^\circ + F_{AB}}{\cos 60^\circ}$$

$\Sigma F_x = T_4\cos 45 - T_3\cos 30^\circ = 0$

$$T_3 = \left(\frac{\cos 30^\circ}{\cos 45^\circ}\right)T_4$$

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$\Sigma F_y = F_{BC}\sin 60^\circ - 200 - F_{BD}\sin 30^\circ = 0$

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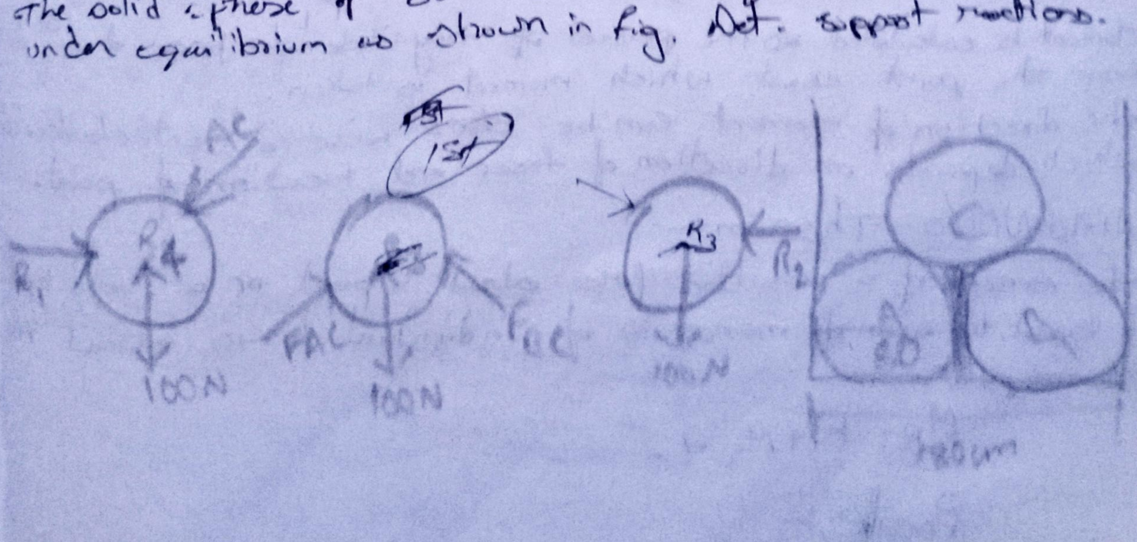
$\Sigma F_y = T_4\sin 45^\circ + T_3\sin 30^\circ - 250 = 0$

$1.1151\,T_4 = 250$

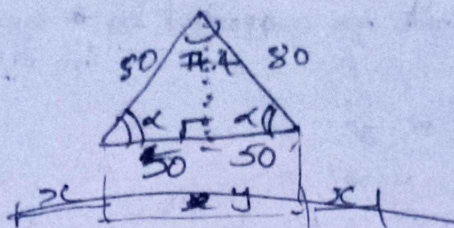
$$F_{DE} = \boxed{T_4 = 224.13N}$$

$$F_{BD} = \boxed{T_3 = 183.84N}$$

The solid spheres of 80mm dia. & weight 100N each are kept under equilibrium as shown in fig. Det. support reactions.



$\cos\alpha =$



$\boxed{\alpha = 51.3}$

$$\frac{R}{\sin 38.7} = \frac{R'}{\sin 38.7} = \frac{100}{\sin 102.6}$$

$\boxed{R = 64.0\,N}$

$\boxed{R' = 64.0\,N}$

$R_1 - R\cos 51.3 = 0$

$\boxed{R_1 = 40N}$

$R_2 - 100 - R\sin 51.3 = 0$

$\boxed{R_2 = 149.9N}$

$-R_2 + R'\cos 51.3 = 0$

$\boxed{R_2 = 40N}$

$\boxed{R_3 = 149.9N}$

$R_3 = R_1$

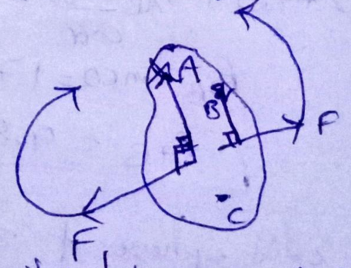
$R_4 = R_2$

30/10/2023

Moment:- when a force applied on a rigid body has a tendency to rotate the rigid body & this rotation is measured in moment.

$M_A = F \times d_1$ Anti-CW

$M_B = F \times d_1$ Anti-CW



Moment by F_1

$M_A = F_1 \times d.$ (CW)

$M_B = F_1 \times d_1$ (CW)

- Moment is calculated as the product of magnitude of force & ⊥ distance from the point about which moment is taken.
- The direction of moment can be clock wise (or) anti clock wise which depends on direction of force and location of point.

VARIGNON'S Theorem:-

The moment of a resultant force about a point on a rigid body is equal to sum of momentum of individual forces about the same point.

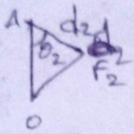
$M_R = M_1 + M_2 + \ldots$

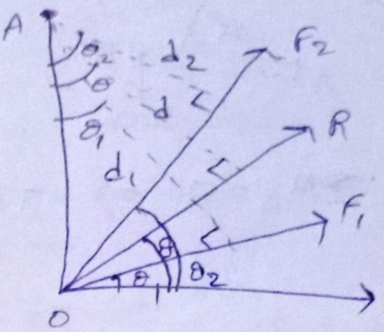
Proof:-

Consider two forces F_1 & F_2 acting on a rigid body at an angle θ_1 & θ_2 resp. $F_1 - \theta_1$, $F_2 - \theta_2$. Let R be the resultant which makes an angle θ.

Consider a point A which about moment is taken

Consider :





$$\cos\theta_2 = \frac{d_2}{OA}$$

$$\boxed{d_2 = OA\cos\theta_2}$$
$$\boxed{d_1 = OA\cos\theta_1}$$
$$\boxed{d = OA\cos\theta}$$
||ly

$$R_x = F_{1x} + F_{2x}$$

||ly

$$R\cos\theta = F_1\cos\theta_1 + F_2\cos\theta_2$$

$$\frac{Rd}{OA} = \frac{F_1 d_1}{OA} + \frac{F_2 d_2}{OA}$$

$$Rd = F_1 d_1 + F_2 d_2$$

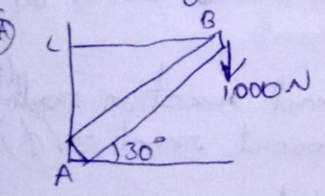
$$\boxed{M_R = M_1 + M_2}$$

Conditions of equilibrium:-

i) $\Sigma F_x = 0$ ii) $\Sigma F_y = 0$ iii) $\Sigma M = 0$

① A rigid bar AB and cable BC together support a vertical load as shown in the fig. find tension in the cable & reaction at the hinge at A.

A)



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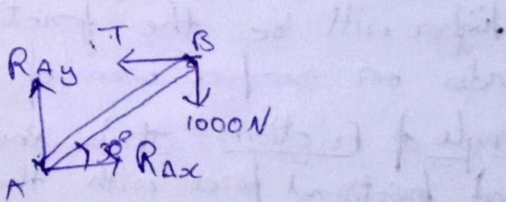


$\Sigma F_x = 0 \Rightarrow R_{Ax} = T$ — ①

$\Sigma F_y = 0 \Rightarrow R_{Ay} = 1000N$

$\therefore R_A = R_{Ax}^2 + R_{Ay}^2$

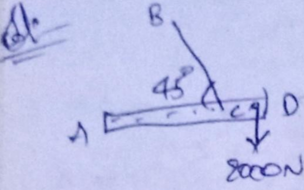
$\Sigma M = 0 \Rightarrow 1000 \times AB\cos 30^\circ = T \times AB\sin 30$

$T = 1000\cot 30^\circ$

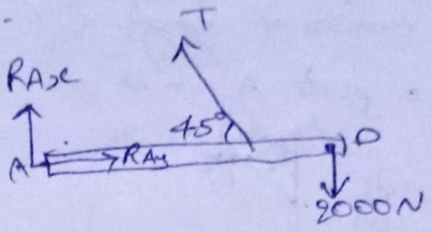
$$\boxed{T = \quad N}$$

(2) A Horizontal beam AD is supported at A by hinge and a bar BC as shown in the figure. Find the tension in the bar BC and reaction at the hinge O.

Sol:



=)



$\Sigma M_A = 0 \Rightarrow T \sin 45° \times \cancel{2} = 2000 \times \cancel{4}^{4}$

$T = 4000\sqrt{2}$

$\boxed{T = 5656.8\,N}$

$\Sigma F_x = 0 \Rightarrow R_{Ax} = T\cos 45 = 5656.8\,(\cos 45°)$

$R_{Ax} =$

$\Sigma F_y = 0 \Rightarrow R_{Ay} = T\sin 45 = 4000$

$\boxed{R_{Ay} = 6000N}$

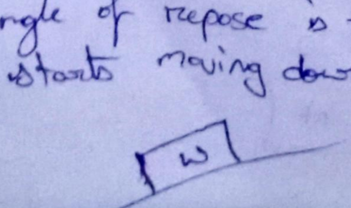
Friction:- When a body slides over another body there exists a force of resistance along around the surface of contact & this force opposes the motion of the body. This force is called frictional force. This force always acts tangential to the contact surface. It depends on roughness, ~~of contact~~ higher will be the frictional force. Friction doesn't depends on surface area of contact.

Angle of Friction:- It is the angle b/w normal reaction resultant (R) and frictional force with the direction of normal reaction (ϕ)

- The tangent of angle of friction (ϕ) is called as coefficient of friction (μ) → $[\tan\phi = \mu]$

$\boxed{F = \mu R}$

Angle of Repose:- Consider a block of weight (w) on an inclined plane. The angle of repose is the angle of inclination at which the block starts moving down.



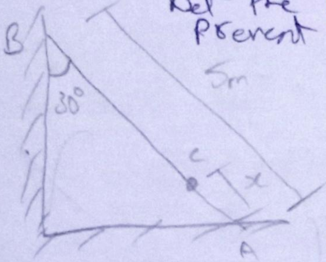
$\Sigma F_x = 0 \Rightarrow R\sin\alpha = \mu R\cos\alpha$

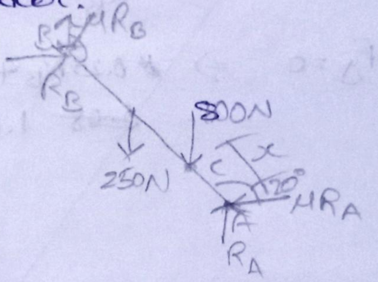
$\Sigma F_y = 0 \Rightarrow \quad \mu = \tan\alpha$

$R\cos\alpha + \mu R\sin\alpha = W$

⇒ When the angle of inclination becomes equal to the angle of friction the block starts moving down the plane.

Q) A 5m long ladder of weight 250N is placed against a vertical wall with an inclination of 30° with vertical. A man of weight 800N is on the ladder (take $\mu = 0.2$) for all contact surfaces. Det the position of the man on the ladder in order to prevent sliding of ladder.





$\Sigma F_x = 0 \Rightarrow \boxed{R_B = 0.2R_A}$

$\Sigma F_y = 0 \Rightarrow 0.2R_B + R_A = 250 + 800$

$1.04 R_A = 1050$

$\boxed{R_A = 1009.6\ N}$

$\boxed{R_B = 201.9\ N}$

$\Sigma M_A = 0 \Rightarrow$ ~~201.9 + 40.38 = 250 + 800~~

$(800 \times x\cos 60) + (250 \times 2.5\cos 60°)$

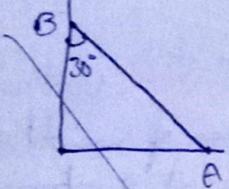
$= (201.9 \times 5\sin 60°) + (0.2R_B \times 5\cos 60°)$

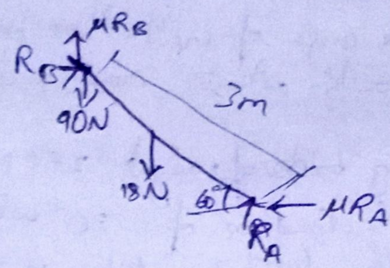
$800 \times \cos 60 = 568.01$

$\boxed{x = 1.65m}$

(2) A 3m long ladder of weight 18N is placed against a vertical wall at an inclination of 30° with wall. coefficient of friction for the wall 0.25. & for the ground 0.35. A man weight 90N is exactly at a top most point of the ladder, Find the horizontal force to be applied at bottom point of the ladder, in order to prevent slipping.

Sol:-





$\Sigma F_x = 0 \Rightarrow R_B = 0.35 R_A$

$\Sigma F_y = 0 \Rightarrow 0.25 R_B + R_A = 90 + 18$

$1.0875 R_A = 108$

$\boxed{R_A = 99.3N}$

$\boxed{R_B = 34.7N}$

~~ΣM=0 ⇒ (34.7×3×sin60°) + (8.675×3cos60°)~~

~~= (90 cos60°×3) + (18×1.5×cos60°)~~

~~ΣM=0 ⇒~~

$\Sigma M = 0 \Rightarrow$

$\Rightarrow (R_B \times 3 \sin 60°) + (0.25 R_B \times \cos 60° \times 3)$

$= (90 \times 3 \times \cos 60°) + (18 \times 1.5 \times \cos 60°)$

$\Rightarrow 2.5 R_B + 0.375 R_B = 146.7$

$R_B = \frac{146.7}{2.875}$

$\boxed{R_B = 51.02N}$

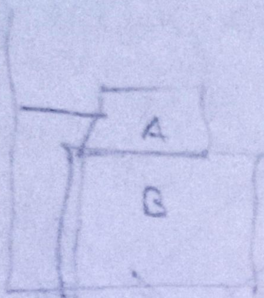
$F + 0.35 R_A = 51$

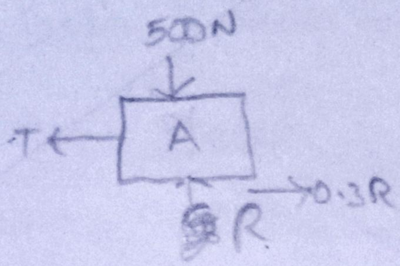
$R_A + 12.75 = 108$

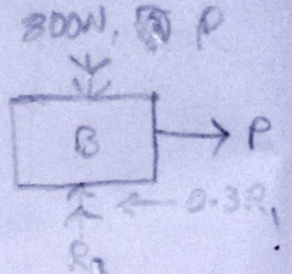
$\boxed{R_A = 95.25}$

$\boxed{F = 17N}$

(3) Find the force 'P' required to start the motion of the lower block. $\mu = 0.3$ for all contact surfaces. weight of A = 500N, weight of B = 800N. Also find the tension in the cable attached to the upper block.







For A

$\Sigma F_x = 0 \Rightarrow T = 0.3R$

$\Sigma F_y = 0 \Rightarrow \boxed{R = 500N}$

$\boxed{T = 150N}$

FOR B

$\Sigma F_x = 0 \Rightarrow P = 0.3R + 0.3R_1$

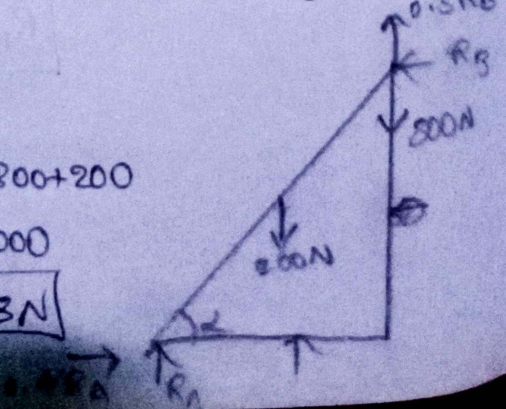
$P = 150 + 0.3R_1$

$\Sigma F_y = 0 \Rightarrow R + 800 = R_1$

$\boxed{R_1 = 1300N}$

$\boxed{P = 540N}$

(4) A 3m long uniform ladder of weight 200 N is placed against a wall at an angle with ground the ladder supports, A man of weight 800N at it upper end. The $\mu = 0.3$ for the wall & 0.4 for the ground. what should be the angle alpha in order to prevent slipping.



Sol:- $\Sigma F_x = 0$

$\Rightarrow 0.4R_A = R_B$

$\boxed{R_B = 357.1N}$

$\Sigma F_y = 0$

$R_A + 0.3R_B = 800 + 200$

$1.12\,R_A = 1000$

$\boxed{R_A = 892.8N}$

$$\Sigma M = 0$$

$$200 \times 1.5 \times \cos\alpha + 0.4R_A \times 3\sin\alpha = R_A \times 3\cos\alpha$$

$$300\cos\alpha + 1071.36\sin\alpha = \cancel{88}\ 2678.4\cos\alpha$$

$$\tan\alpha = 2.21$$

$$\boxed{\alpha = 65.7^\circ}$$

(5) A uniform ladder of 5m weight 20 N is placed against a smooth vertical wall with its lower end 4m away from the wall. In order to prevent slipping find the μ of the ground: Also find the frictional force.

Sol:- $\Sigma F_x = 0 \Rightarrow R_B = \mu R_A \Rightarrow \boxed{R_B = 20\mu}$

$\Sigma F_y = 0 \Rightarrow \boxed{20 = R_A}$

$$\Sigma M = 0$$

$$\Rightarrow 20 \times 2.5 \times \left(\frac{4}{5}\right) + \mu R_A \times 5 \times \left(\frac{3}{5}\right) = R_A \times \cancel{5} \times \left(\frac{4}{\cancel{5}}\right)$$

$$40 + 60\mu = 80$$

$$60\mu = 40$$

$$\mu =$$

$$\boxed{\mu = 0.67\,N}$$

$$\boxed{R_B = F = 13.3\,N}$$

(6) A wooden block of weight W rests on a horizontal plane. In order to move the block towards right a pulling force P_1 at angle θ is required. In order to push the block towards left a force P_2 at an angle θ is required. If the coefficient of friction is μ, derive formula for P_1 and P_2

$$R_A = \frac{P_1\cos\theta}{\mu}$$

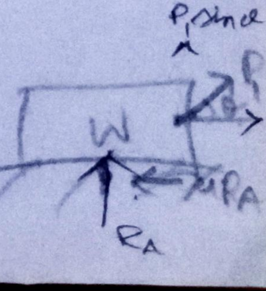
$$P_1\cos\theta = \mu R_A$$

$$R_A + P_1\sin\theta = W.$$

$$\cancel{\tan\theta = \frac{W}{\mu R_A}}$$

$$\frac{P_1\cos\theta}{\mu} + P_1\sin\theta = W$$

$$\boxed{P_1 = \frac{\mu W}{\cos\theta + \mu\sin\theta}}$$



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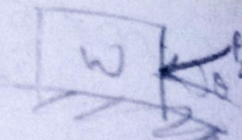
$$P_2\cos\theta + \mu R_2 = 0$$

$$R_2 = \frac{-P_2\cos\theta}{\mu}$$



$$W + P_2\sin\theta = R_2$$

$$W + P_2\sin\theta = -\frac{P_2\cos\theta}{\mu}$$

$$P_2(\mu\sin\theta + \cos\theta) = -\mu W$$

$$\boxed{P_2 = \frac{+\mu W}{\cos\theta - \mu\sin\theta}}$$

Q) in the above problem pulling force is 24 N, pushing force is 30 N. ~~weight of the block is~~ angle of $\theta = 30°$. Det weight of the body & coefficient of friction b/w ground & block.

Sol:- w.k.T $P_1 = \frac{\mu W}{\cos\theta + \mu\sin\theta}$ | $P_2 = \frac{\mu W}{\cos\theta - \mu\sin\theta}$

$$\frac{24}{30} = \frac{\cancel{\mu W}}{0.86 + 0.5\mu} \times \frac{0.86 - 0.5\mu}{\cancel{\mu W}}$$

$$0.8 =$$

$$0.688 + 0.4\mu = 0.86 - 0.5\mu$$

$$\boxed{\mu = 0.199N}$$

$$\boxed{W = 120.8 N}$$