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Applied Mechanics : It is a part of applied science of engineering wit which deals with the responce of particles or rigid bodies to any mechanical disturbance.

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- Idealization / Assumption in Applied Mechanics:

Mathematical description of real engineering problem can becomes very complex. thus, idealization & assumptions are used in mechanics in order to simplify the application of theory

#) Idealization of particle:

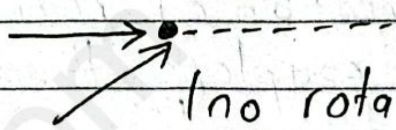
1) It is an idealized body of negligible dimension whose total mass is ~~concentrated~~ considered to be concentrated at point. (we often choose a particle as a differential element of a body)

2) We may treat a body as a particle when its dimensions are irrevelant to the description of its position or the action of forces applied to it. for eg: heavinly bodies

3) A particle has mass, but not shape & dimensions in considering so, the principle of mechanics are reduced to a simplified form since the geometry of a body will not be involved in the analysis of problem

The line of action of all the forces applied to the body must passes through point.

If a force is applied to a point mass, then force will be push or pull only since there is no geometry in consideration.



(no rotational force).

Idealization of rigid bodies:
(Rigid body):
It is an idealized body composed of large no. of particle all of which always remains at fixed distance from each other when acted by a force system i.e. there will be no deformation under the action of force

The idealization is very important because the material properties of any rigid bodies is not considered while studying the effect of force acting on it because no matter whatever load is being applied, the distance betn particles always remains same.

- ~~If a force is applied to a rigid body, their will be a push, pull or~~

- In addition to the tendency to move a body in direction of its applied, a force also tends to rotate a body about an axis.

Idealization of point force:

Point force: It is an idealized force assumed to act at a point on a body.

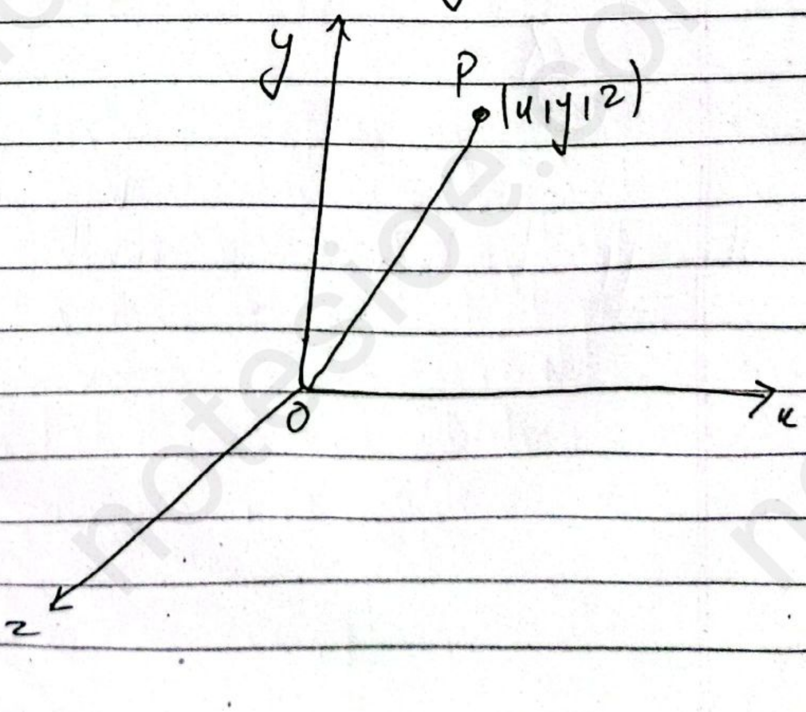
→ If the area of contact is relatively small, the contact force bet^n two bodies may be considerd as point or concentrated force.

Fundamental concept of applied mechanics:

→ The fundamental concept used in the field of mechanics are: space, time, mass & force.

In Newtonian mechanics, these are absolute quanties which ~~ar~~ means they are independent to each other which is not true in case of relativistics mechanics where the time of an event depends on its position & mass of body varies with velocity.

Space: It can be defined as the geometric region occupied by the body or particles whose position are described by linear or angular measurements relative to a specific coordinate system from an origin.



Time: It can be defined as the concept of measuring the succession

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Laws & principle of mechanics:

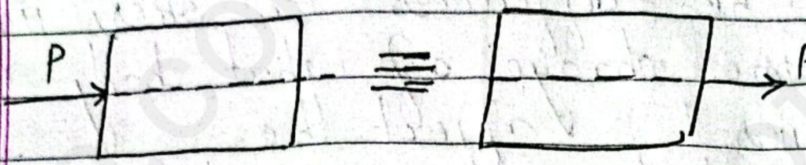
Parallelogram law of vector addition:
It states that, the resultant vector of a parallelogram is given by the addition of two adjacent sides of a parallelogram.

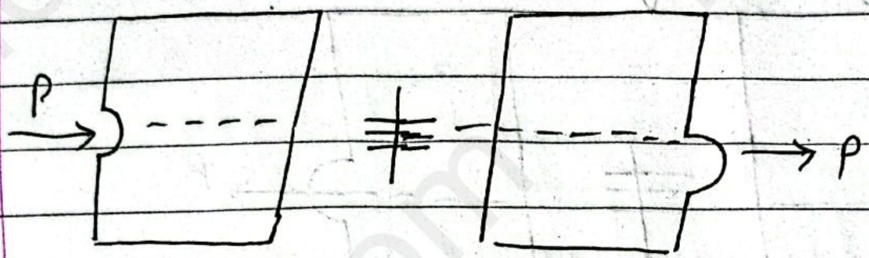
Newton's 1st law of motion:
It states that, every body remains in the state of rest or motion until & unless any external force is applied on it.

Newton's 2nd law of motion:
"The rate of change of linear momentum is directly porportional to applied force & it takes place in the direction of applied force.

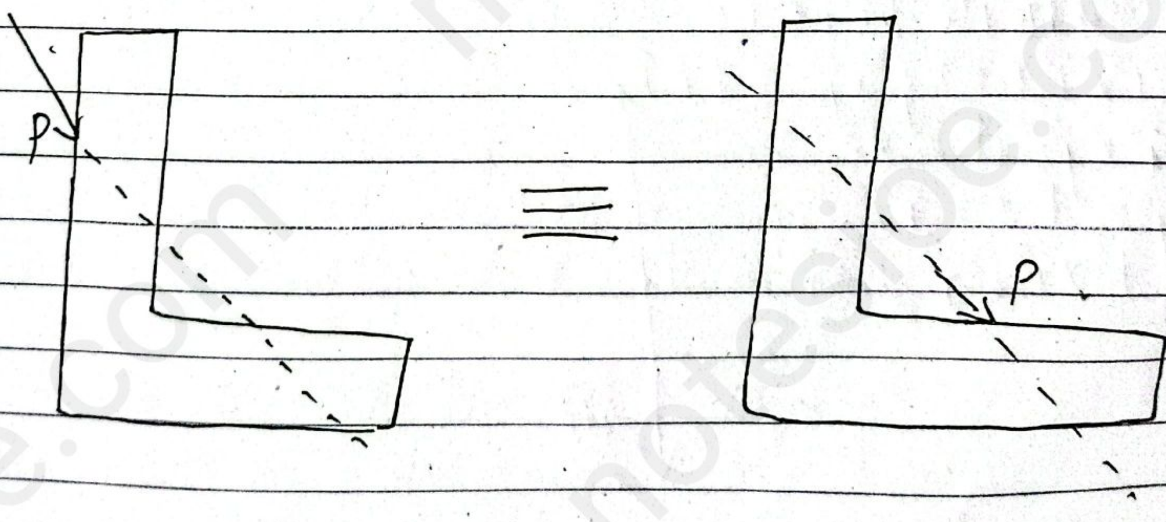
Newton's third law:
"To every action, there is equal & opposite reaction."

5> Principle of transmissibility of forces:

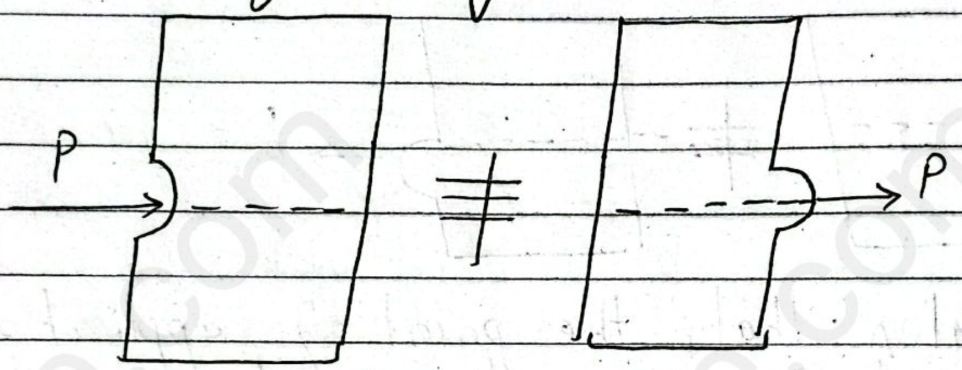




→ It states that, the point of application of a external force can be moved any where along its line of action without changing the external reaction ~~process~~ forces on rigid bodies without changing equilibrium condition of that body.



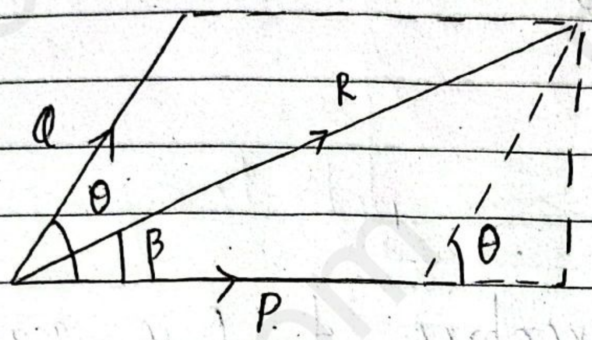
But, while analyzing the stresses in a body, the exact point of application of forces matters because the differences in stress may result the geometric change of that body which in turns affect the equilibrium of a body.



So, principle of transmissibility should only be used while examining external forces on bodies that are assumed to be rigid.

Parallelogram law of forces:

→ It is used to determine the resultant of two forces acting at a point in a plane & inclined to each other at an angle.



$$\therefore \vec{R} = \vec{P} + \vec{Q}$$

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

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

Vector Algebra

1) Dot product

If $\vec{A}$ & $\vec{B}$ are two vectors and 'θ' is angle betn them, then the dot product is defined as,

$$\vec{A}\cdot\vec{B} = |\vec{A}|\cdot|\vec{B}|\cos\theta = AB\cos\theta$$

The result of dot product of two vector is scalar.

- Properties of scalar product:

a) $\vec{A}\cdot\vec{B} = \vec{B}\cdot\vec{A}$

b) $\vec{A}\cdot(\vec{B}+\vec{C}) = \vec{A}\cdot\vec{B} + \vec{A}\cdot\vec{C}$

c) $\vec{i}\cdot\vec{i} = \vec{j}\cdot\vec{j} = \vec{k}\cdot\vec{k} = 1$

d) $\vec{i}\cdot\vec{j} = \vec{j}\cdot\vec{k} = \vec{k}\cdot\vec{i} = 0.$

2. Cross product

If $\vec{A}$ & $\vec{B}$ are two vectors & θ is angle betn them,

$$\vec{A}\times\vec{B} = |\vec{A}|\cdot|\vec{B}|\sin\theta\,\hat{n}$$

- Properties of vector product.

a) $\vec{A}\times\vec{B} = -\vec{B}\times\vec{A}$

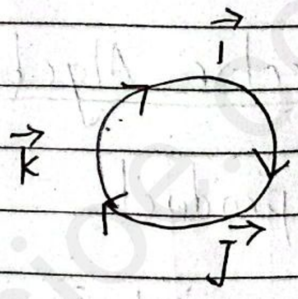
b) $\vec{A}\times(\vec{B}+\vec{C}) = \vec{A}\times\vec{B} + \vec{A}\times\vec{C}$

c) $\vec{i}\times\vec{i} = \vec{j}\times\vec{j} = \vec{k}\times\vec{k} = 0.$

d i) $\vec{i}\times\vec{j} = \vec{k}$

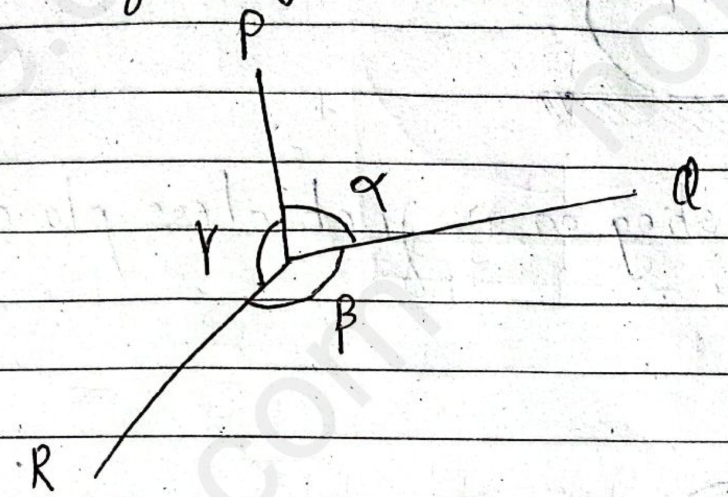
ii) $\vec{j}\times\vec{k} = \vec{i}$

iii) $\vec{k}\times\vec{i} = \vec{j}$



Lami's Theorem

"If a body is in equilibrium under the action of three forces, then each force is proportional to sine of angle betn two other forces."



Mathematically,

$$\boxed{\frac{P}{\sin\beta} = \frac{Q}{\sin\gamma} = \frac{R}{\sin\alpha}}$$

Basic Concept of Statics & Statics Equilibrium

Example:

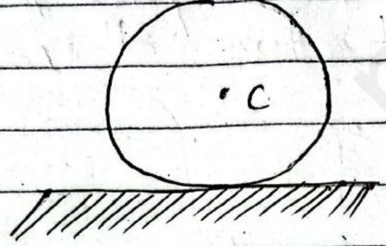
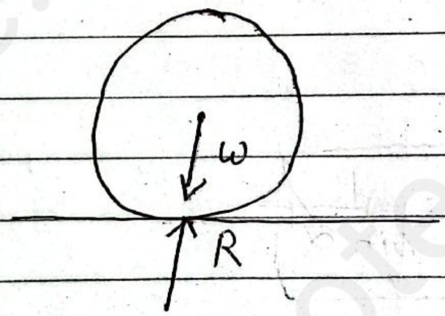
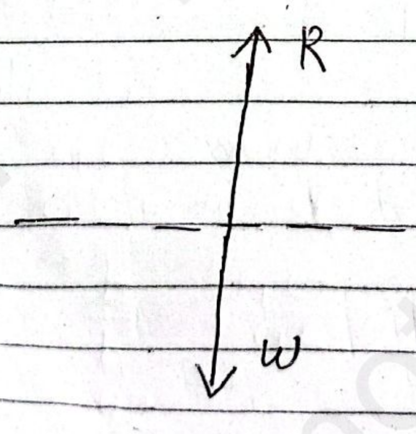


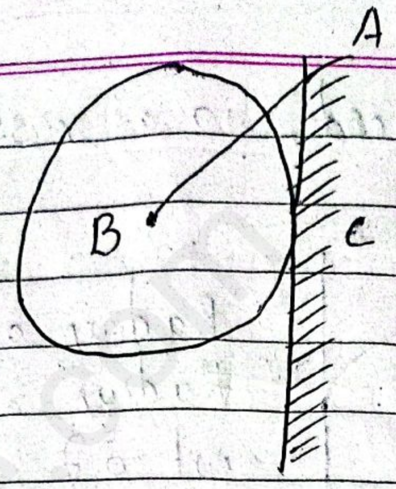
fig: sphere resting on a frictionless plane surface

Its F.B.D,

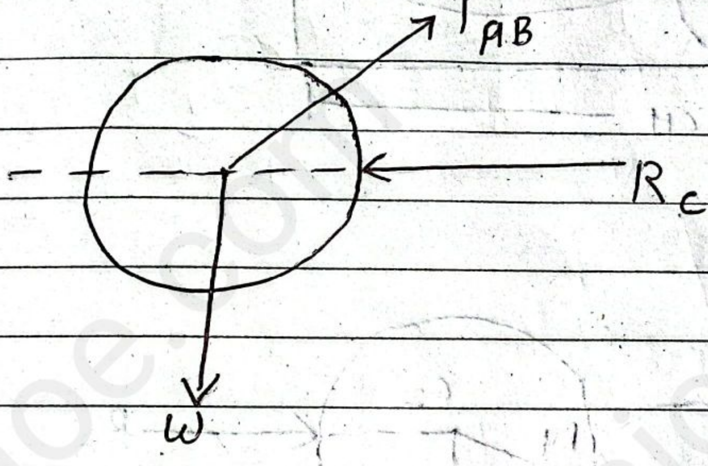


Force Diagram,

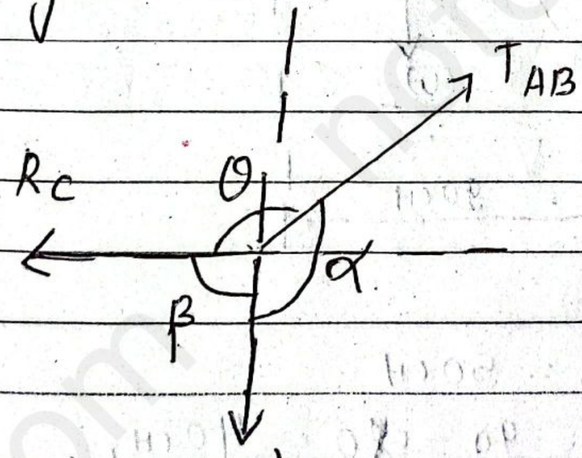




F.B.D,



Force diagram,



Using lami's theorem,

$$\frac{T_{AB}}{\sin\beta} = \frac{W}{\sin\theta} = \frac{R_C}{\sin\alpha}.$$

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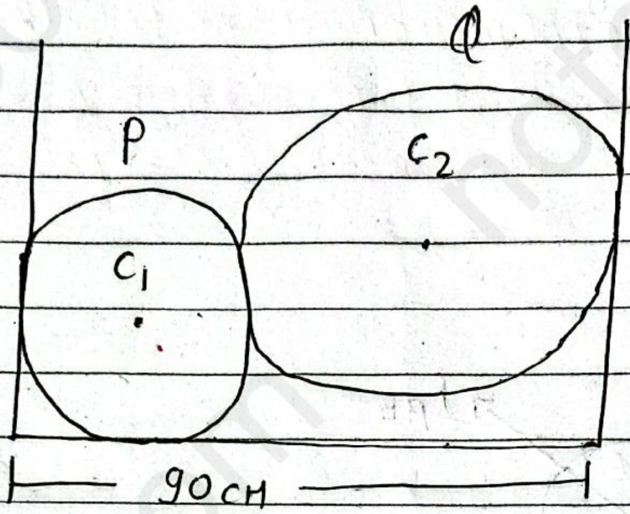
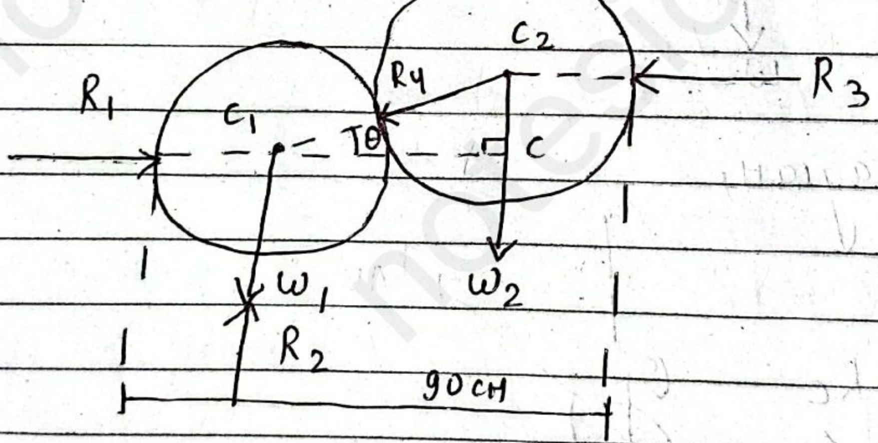
Q>

a> Two ~~she~~ spheres P, Q placed in a vessel.



Radius of P = 25cm
Radius of Q = 25cm
wt. of P = 500N
wt. of Q = 500N.

F·B·D,



For angle θ,

$$C_1C_2 = 50\,cm$$

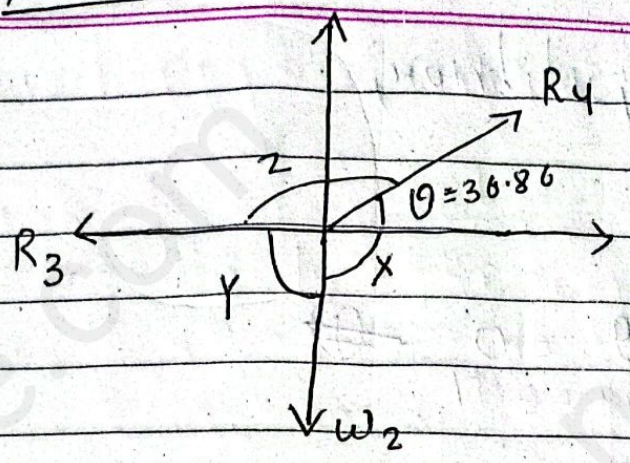
$$C_1C = 90 - 50 = 40\,cm,$$

$$\cos\theta = \frac{b}{h} = \frac{C_1C_2}{C_1C}$$

$$\cos\theta = \frac{40}{50}$$

$$\therefore \theta = 36.86^\circ$$

For C_2



$$\frac{R_3}{\sin(90+36.86)} = \frac{R_4}{\sin 90} = \frac{w_2}{\sin(90+53.14)}$$

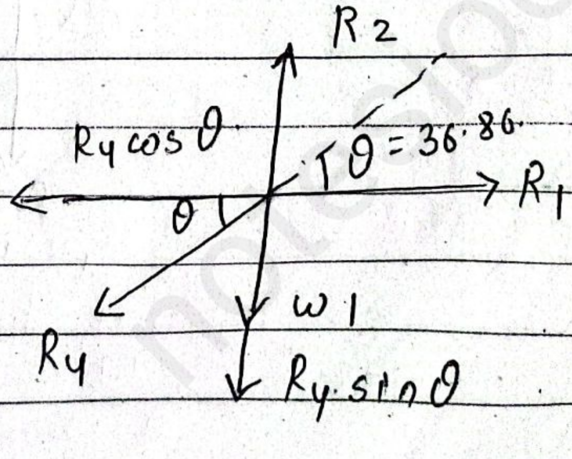
or, $$\frac{R_3}{\sin(90+36.86)} = R_4 = \frac{500}{\sin(90+53.14)}$$

Then, $R_4 = 833.5253N$

Now,

$R_3 = \sin(90+36.86) \times 833.5253$
$= 666.90N$

For C_1,



By using statics equilibrium,

$(\xrightarrow{+}) \sum F_x = 0$

or, $R_1 - R_y \cos\theta = 0$ — (i)

$(\uparrow^{+}) \sum F_y = 0$

or, $R_2 - R_y \sin\theta - \omega_1 = 0$ — (ii)

~~Dividing~~ eqn

or, $R_1 = R_y \cos\theta$

$= 833.53 \times \cos(36.86)$

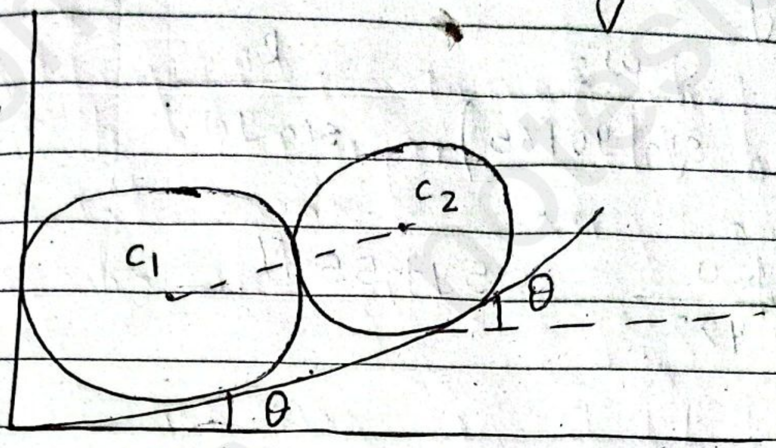
$= 666.91 \ N$

or, $R_2 = 500 + 833.53 \times \sin(36.86)$

$= 1000 \ N$

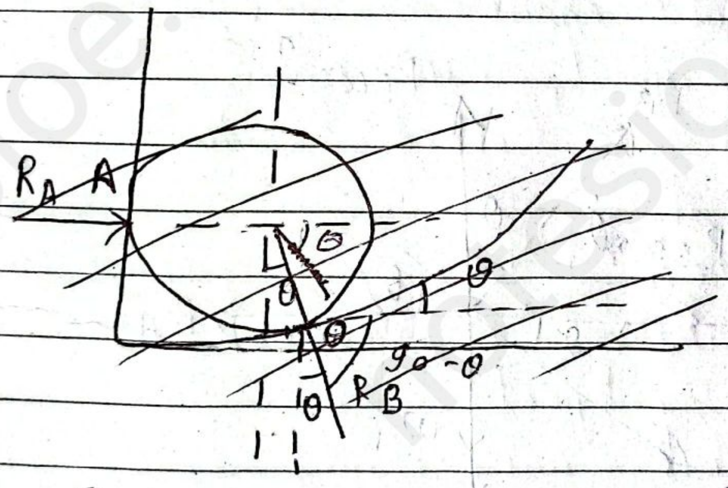
(11) Roller with same diameter resting on inclined plane.

$w_1 = 200N$
$w_2 = 250N$
$\theta = 25^\circ$

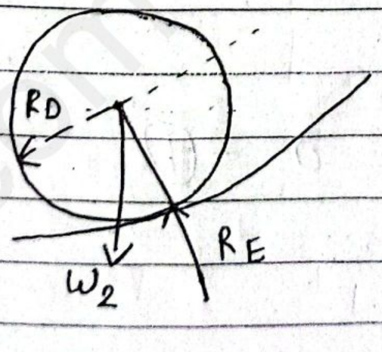


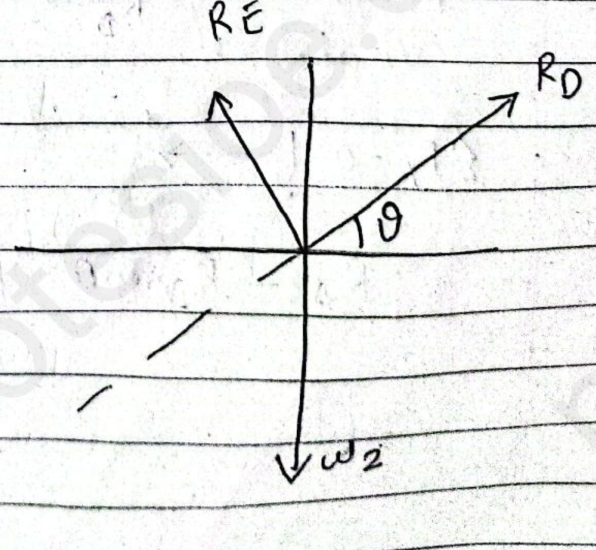
F.B.D,

~~At C1~~,



At C2,





Using lami's theorem,

$$\frac{R_E}{\sin(90+25)} = \frac{w_2}{\sin(90+65)} = \frac{R_D}{\sin 90}$$

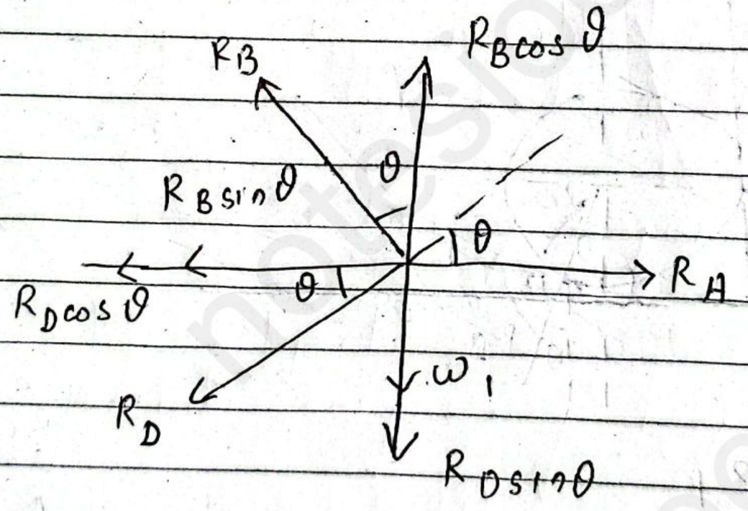
or, $R_D = \dfrac{250}{0.422} = 591.55\ N$

Again,

$R_E = 591.55 \times \sin(90+25)$

$= 536.126\ N$

For C_1



$\Sigma F_x = 0\ (\xrightarrow{+})$

$R_A - R_B\sin\theta - R_D\cos\theta = 0$ — (1)

$\Sigma F_y = 0 \ (\uparrow^+)$

$R_B \cos\theta - w_1 - R_D \sin\theta = 0$

or, $R_B \times \cos 25 = 200 + 591.55 \times \sin 25.$

$\therefore R_B = 496.51 N$

Again,

eq^n (1),

$R_A = 496.51 \times \sin 25 - 591.55 \times \cos\theta = 326.29 N.$

What is free body diagram? Why is it necessary?

A free body diagram is a graphical demonstration used to represent all the reaction force when the body is isolated from its surroundings.

F.B.D is necessary because:

It is an essential tool used when force on an object needs to be determined by using equilibrium equations.
They help us focus attention on the object of interest in order to determine forces acting on it.
It is used in every major engineering calculations later on civil as well as other field subjects.
It is general enegineering language for calculation.

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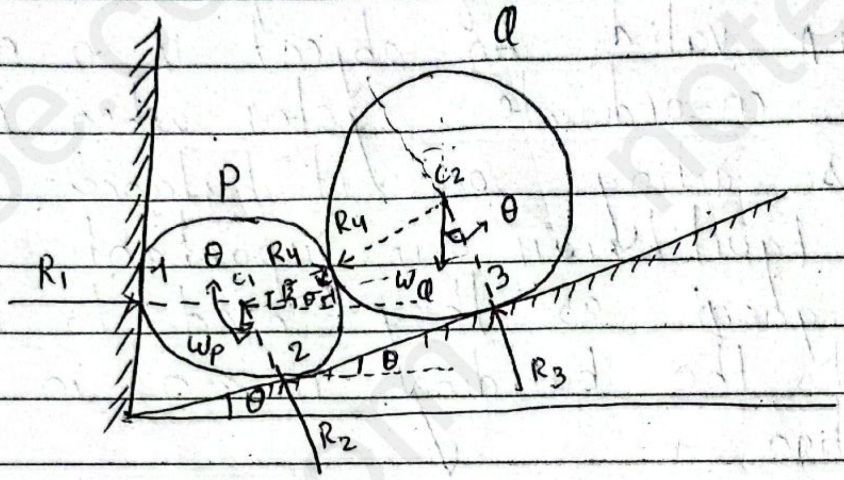
what is equilibrium condition & its importance?

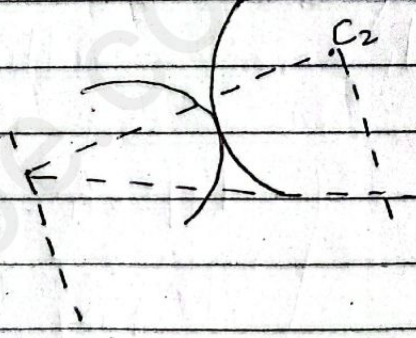
The equilibrium condition of an object exists when Newton's law is valid. An object is in equilibrium in a reference co-ordinate system when all external forces acting on it balance.

Equilibrium is important for engineers & designers as they need to make sure that the building remain in a static position.

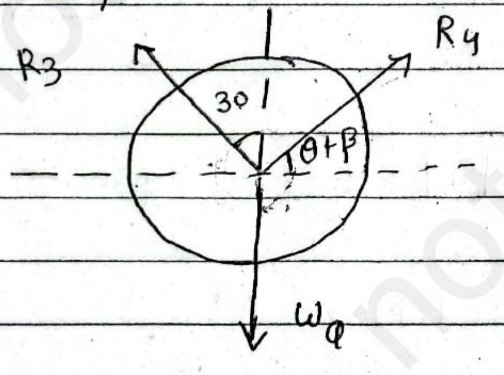
- Sphere with diff diameter resting on inclined plane.



$W_P = 200\,N$
$W_Q = 300\,N$
$r_p = 60\,mm$
$r_q = 90\,mm$
$\theta = 30^\circ$



For sphere Q_1

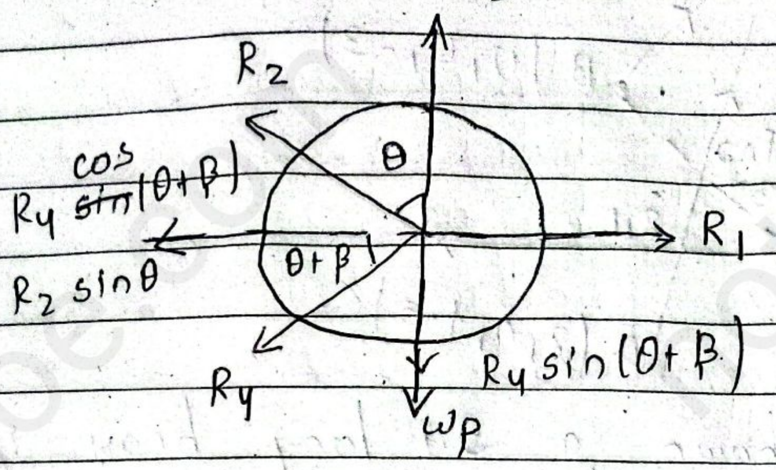


$$\frac{R_3}{\sin(90+41.53)} = \frac{W_Q}{\sin(30+48.47)} = \frac{R_4}{\sin(90+60)}$$

$\therefore R_3 = 229.20\,N$
$\therefore R_4 = 153.08\,N$

$$\beta = \sin^{-1}\left(\frac{r_q - r_p}{r_q + r_p}\right)$$
$$= \sin^{-1}\left(\frac{90-60}{90+60}\right)$$
$$= 11.53^\circ$$

For sphere, P_1



By using static equilibrium,

$\sum F_x = 0 \; (\xrightarrow{+})$

or, $R_1 - R_4 \overset{\cos}{\cancel{\sin}}(\theta+\beta) - R_2 \sin\theta = 0$

or, $R_1 - 153.08 \times \overset{\cos}{\cancel{\sin}}\, 41.53 - R_2 \sin 30 = 0$

$\therefore R_1 - \frac{1}{2} R_2 = \cancel{101.49} \;\; (1) \;\; 114.597 \; - (1)$

$\sum F_y = 0 \; (\uparrow^{+})$

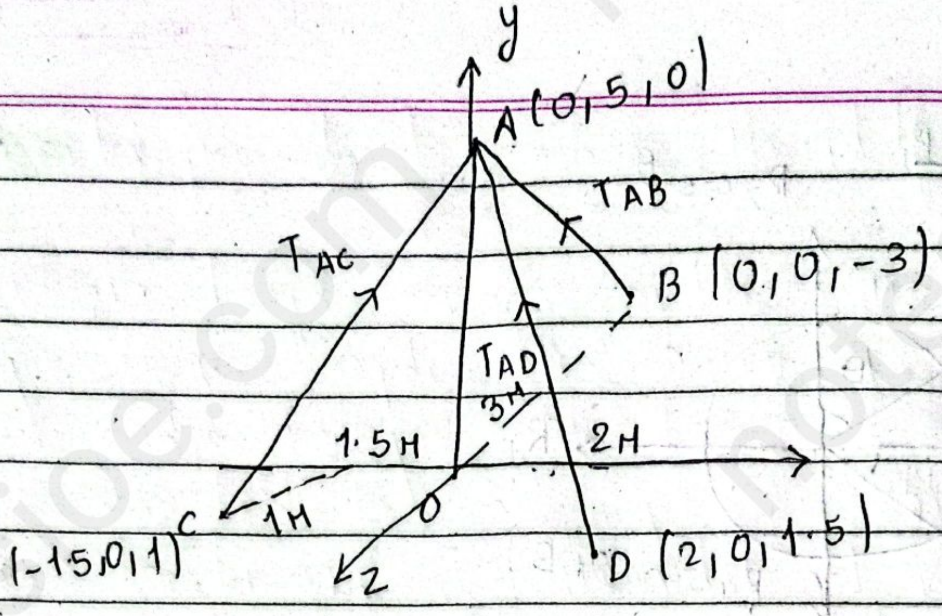
or, $R_2 \cos\theta - \omega_p - R_4 \sin(\theta+\beta) = 0$

or, $R_2 \cdot \frac{\sqrt{3}}{2} - 200 - 153.04 \times \sin 41.53 = 0$

$\therefore R_2 = 348.10\,N \; (\uparrow^{+})$

Now,

$R_1 = 114.597 + \frac{1}{2} \times 348.10 = 288.64\,N \; (\uparrow^{+})$



In a system shown a 5M long beam is held in vertical position AO by 3 wires AB, AD & AC. If a T eqv. to 600N is induced in AD & resultant force at A is to be vertical. Calculate the tension in wire AB & AC.

$$\left(\vec{F} = \hat{n} \times |F| = \frac{\vec{AB}}{|AB|} \times |F| \right)$$

$$\vec{T}_{AB} = \cancel{T}_{AB}\ \hat{n}_{AB} \times |F|$$

$$= \frac{\vec{AB}}{|\vec{AB}|} \times |F|$$

As,

$$\vec{AB} = 0\vec{i} - 5\vec{j} - 3\vec{k}$$

$$|\vec{AB}| = \sqrt{0^2 + 25 + 9}$$

$$= \sqrt{34} = 5.83$$