UNIT-I.

Basics.

Scalar Quantity:- A scalar quantity can be described by its magnitude only.

Addition, substraction, division or multiplication can be done according to the ordinary rules of algebra.

Ex. Mass, volume, density etc.

Vector Quantity: If a physical quantity in addition to magnitude has a specified direction. This is known as Vector Quantity.
It should as well as obey the law of parallelogram of addition.

Ex. Displacement, velocity, acceleration, force etc.

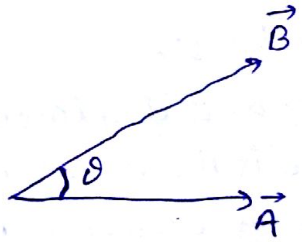
Components of a vector.

$$\vec{F} = F_x\hat{i} + F_y\hat{j} + F_z\hat{k}$$

$$F = \sqrt{F_x^2 + F_y^2 + F_z^2}$$

Product of vectors:-

$\vec{A}\cdot\vec{B} = AB\cos\theta$ scalar product.



as. Work $= \vec{F}\cdot\vec{d}$

$\hat{i}\cdot\hat{i} = \hat{j}\cdot\hat{j} = \hat{k}\cdot\hat{k} = 1$

$\hat{i}\cdot\hat{j} = \hat{j}\cdot\hat{k} = \hat{k}\cdot\hat{i} = 0$

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

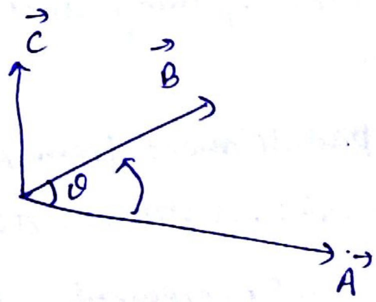
$$\vec{A}\cdot\vec{B} = \vec{B}\cdot\vec{A}$$

Cross Product:-

$\vec{C} = \vec{A}\times\vec{B} = AB\sin\theta\,\hat{n}$

$\vec{C}$ is normal to the plane AB.

→ right hand screw rule



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

$\hat{i}\times\hat{i} = \hat{j}\times\hat{j} = \hat{k}\times\hat{k} = 0$

$\hat{i}\times\hat{j} = -\hat{j}\times\hat{i} = \hat{k}$

$\hat{j}\times\hat{k} = -\hat{k}\times\hat{j} = \hat{i}$

$\hat{k}\times\hat{i} = -\hat{i}\times\hat{k} = \hat{j}$

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

$$\vec{A}\times\vec{B} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ a_1 & b_1 & c_1 \\ a_2 & b_2 & c_2 \end{vmatrix} \qquad \hat{n} = \frac{\vec{A}\times\vec{B}}{|\vec{A}\times\vec{B}|}$$

Average

Ques:-
① $\vec{A} = 2\hat{i}+\hat{j}-\hat{k}$ $\quad \vec{B} = \hat{i}-\hat{k}$ $\quad \vec{A}\cdot\vec{B} = ?$ $\quad \vec{A}\times\vec{B} = ?$ $\quad \theta = ?$ $\quad \hat{n}$

② $\vec{A} = 2\hat{i}+3\hat{j}+\hat{k}$ $\quad \vec{B} = \hat{i}-\hat{j}+\hat{k}$

NOTE.

$0^\circ \le \theta \le 90^\circ \quad \vec{a}\cdot\vec{b} = +ve$

$90^\circ \le \theta \le 180^\circ \quad \vec{a}\cdot\vec{b} = -ve$

$\theta = 90^\circ \quad \vec{a}\cdot\vec{b} = 0 \quad \cos 90^\circ = 0$

Mechanics:- Mechanics is the branch of physics which deals with the motion of particles or bodies in space and time.

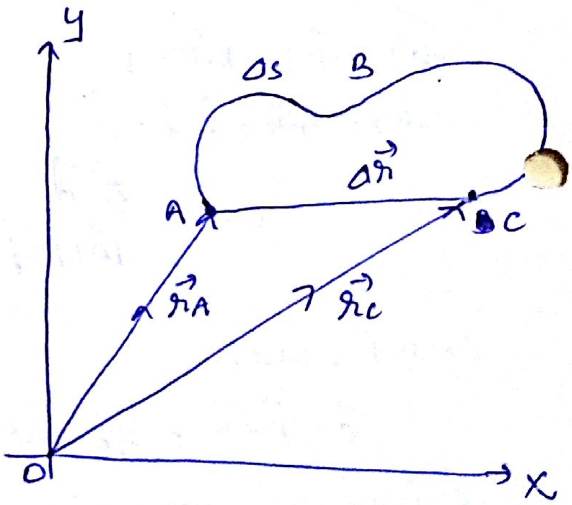
→ Kinematics is the branch of mechanics which deals with the motion regardless of the cause producing it. The study of cause of motion is called dynamics.

Basic Definitions:-

① **Distance and displacement:-**

Distance is the actual path length covered by a moving particle or body in a given time interval.

While displacement is the change in position vector joining initial to final position.



If a particle move from A → C through a path ABC, distance = Δs

$$\text{displacement} = \Delta\vec{r} = \vec{r}_C - \vec{r}_A$$

$$|\text{displacement}| \le \text{distance}$$

② Average speed and velocity:-

The average speed of a particle in a given time interval is defined as the ratio of distance travelled to the time taken while average velocity is defined as the ratio of displacement to time taken.

$$\text{average speed} = V_{av} = \frac{\Delta s}{\Delta t}$$

$$\text{average velocity} = \vec{V}_{av} = \frac{\Delta \vec{r}}{\Delta t}$$

③ Instantaneous speed and velocity:- at particular instant.

$$v = \lim_{\Delta t \to 0} \frac{\Delta s}{\Delta t} = \frac{ds}{dt}$$

$$\vec{v} = \lim_{\Delta t \to 0} \frac{\Delta \vec{r}}{\Delta t} = \frac{d\vec{r}}{dt}$$

④ Average and instantaneous acceleration-

Average accⁿ is defined as the ratio of change in velocity $\Delta\vec{v}$ to the time interval Δt.

$$\vec{a}_{av} = \frac{\Delta \vec{v}}{\Delta t}$$

The instantaneous acceleration is defined at a particular instant -

$$\vec{a} = \lim_{\Delta t \to 0} \frac{\Delta \vec{v}}{\Delta t} = \frac{d\vec{v}}{dt}$$

One Dimensional Uniform Acceleration Motion-

① $v = u + at$

② $s = ut + \frac{1}{2}at^2$

③ $v^2 = u^2 + 2as$

④ $S_n = u + \frac{1}{2}a(2n-1)$

Motion under gravity:-

① Maximum height obtained by a particle thrown upward from ground-

$$h = \frac{u^2}{2g}$$

② $v = \sqrt{2gh}$

③ $t = \sqrt{\frac{2h}{g}}$ ④ $S_n = u + \frac{1}{2}g(2n-1)$

Newton's Laws of Motion:-

I^{st} Law:- Every body continues in its state of rest or in uniform motion in a straight line unless it is compelled to change that state by forces impressed upon it.

II^{nd} Law:- The change of motion is proportional to the magnitude of force impressed and is made in direction of the straight line in which that force is impressed. $\vec{F} = m\vec{a}$

III^{rd} Law:- To every action there is always an equal and opposite reaction.

Work:- A work is said to be done if the sole effect external to the system is such that it raises the weight.

$$W = \vec{F}\cdot\vec{s} = Fs\cos\theta$$

Spring $W = -kx$

Kinetic Energy:- KE is the capacity of a body to do work by virtue of its motion

$$KE = \frac{1}{2}mv^2$$

Potential Energy:- Energy possessed by a body or system by virtue of its position or configuration is known as the potential energy.

$$PE = mgh$$

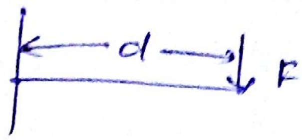
$$PE = \frac{1}{2}kx^2$$

Power:- Rate of work done by applying force is known as power,

$$P = \frac{dw}{dt}$$

$$P = \vec{F}\cdot\vec{v} = Fv\cos\theta$$

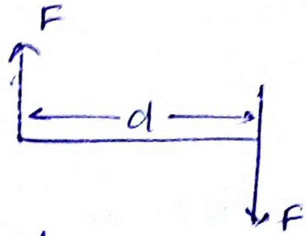
ment:- Moment is defined as the multiplication of force and perpendicular distance from the axis of rotation. (about point



$$\vec{M} = \vec{F} \times \vec{d}$$

Couple:- Two unlike non-collinear forces having same magnitude form a couple.

The distance b/w two forces is known as arm of couple.

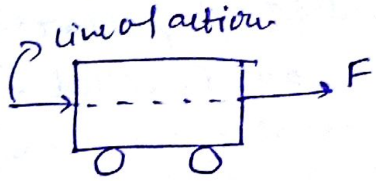


$$\vec{M} = \vec{F} \times \vec{d}$$

Principle of Transmissibility:-

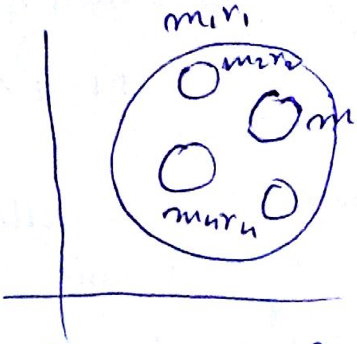
The principle of transmissibility states that.

If a force acts at a point in rigid body, it may be considered to act at any other point of the body on the line of action of force.



Centre of Mass:- centre of mass is ~~one~~ a point which behaves as though the entire mass of the system is concentrated there.

$$CG = \frac{m_1r_1 + m_2r_2 + m_3r_3 + m_4r_4}{m_1 + m_2 + m_3 + m_4}$$



Momentum:- The product of mass and velocity of a particle is defined as its linear momentum $\vec{P}$.

$$\vec{P} = m\vec{v}$$

$$KE = \frac{1}{2}mv^2 = \frac{P^2}{2m}$$

Force = rate of change of linear momentum

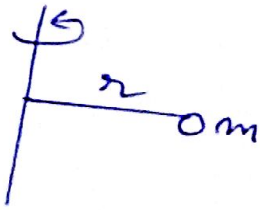
$$\vec{F} = \frac{d\vec{P}}{dt} = 0 \qquad \vec{P} = \text{constant}$$

Impulse:- The product of constant force $\vec{F}$ and the time t for which it acts is called the impulse $(\vec{J})$ of the force and this is equal to the change in linear momentum which it produces.

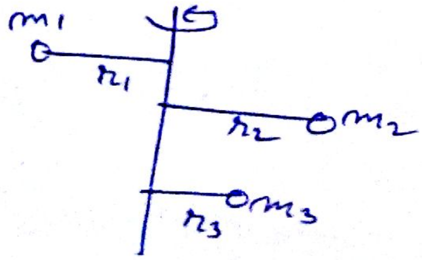
Impulse. $\vec{J} = \vec{F}t = \Delta\vec{P} = m(\vec{v_2} - \vec{v_1})$

Moment of Inertia:- Moment of inertia gives a measurement of the resistance of a body to a change in its rotational motion

$$I = mr^2$$



$$I = m_1r_1^2 + m_2r_2^2 + m_3r_3^2 \ldots$$



APPLIED MECHANICS

Unit - I

Mechanics:- Mechanics is a subject dealing with the science of forces.

— Mechanics is a branch of science which deals with the study of effects of forces on rigid bodies.

Mechanics

- Statics
- Dynamics
  - Kinematics
  - Kinetics.

— Statics deals with the study of forces on rigid ~~body~~ bodies at rest.

— Dynamics deals with the study of effects of forces on moving bodies.

— When we study the motion of bodies without any reference to the force then, it is called Kinematics.

— When motion of bodies is studied alongwith the forces and mass, it is termed as Kinetics.

Applied Mechanics:- It deals with the problems related to machine parts, mechanisms, structures and machine members.

Force:- Force is a phenomenon by virtue of which a body at rests starts moving or a body moving with uniform velocity tends to change its velocity.

F = rate of change of linear momentum

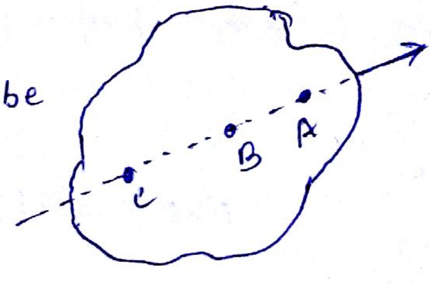
$$F = \frac{\Delta P}{\Delta t}$$

$$F = \frac{mv - mu}{\Delta t} = \frac{m(v-u)}{\Delta t} = ma$$

$$\boxed{F = ma}$$

Principle of Transmissibility of force:-

When a force acts on a body, this force may be assumed to be acting on all particles of the body which lie on the line of action of the force.



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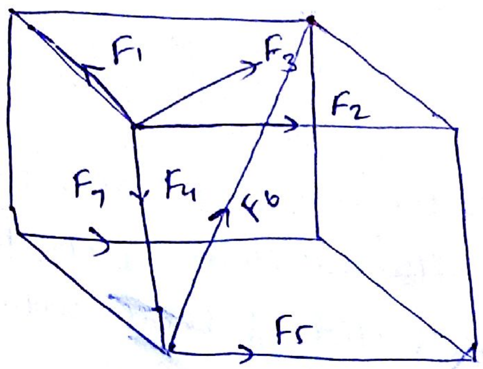
System of Force:- Forces are grouped according to their direction, point of action and plane of action.

→ All forces acting in a certain direction make a system of parallel forces.

→ All forces acting at a point make a system of concurrent forces-

① Coplanar Forces:- All those forces which are acting on the same plane of a body are called co-planar forces. Therefore line of action of coplannar force lies on same plane.

Ex. F_1, F_3, F_2

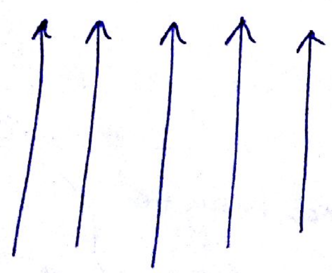


② Non-coplanar Forces:- Those forces which do not lie on the same plane of the body, are called non-coplanar forces. Therefore their line of action do not lie on the same plane.

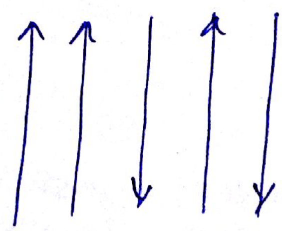
③ Parallel Forces:- Forces which have parallel lines of action are called parallel forces. There are two types of parallel forces-

— Like Parallel Forces:- Line of action of these forces ~~lies~~ acts in the same dirn.

— Unlike Parallel Forces:- Line of action of these forces act in the opposite direction



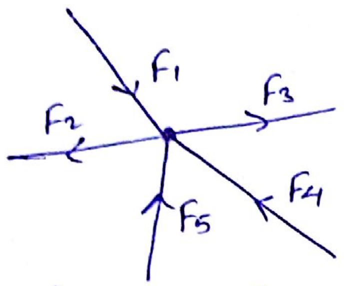
Like Parallel Forces



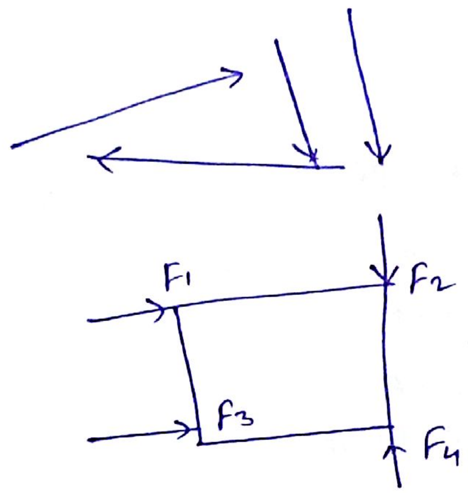
Unlike Parallel Forces.

(4) Concurrent Forces:- Those forces whose line of action meet at a single point are called concurrent forces.

(5) Non Concurrent Forces:- Those forces whose line of action do not meet at a single point are called non-concurrent forces.



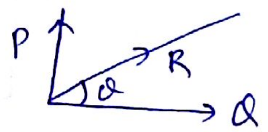
Concurrent forces



Non-concurrent forces.

Resultant force:- Suppose a body is acted upon by a number of forces. If we replace these forces with a single force, which produces same effects as that of all forces produce together, than that single force is known as resultant force.

Therefore vector addition of all forces is called resultant force.



Equilibrium of forces:-

Suppose a body is being acted upon by a number of forces. If all forces neutralize each other, then vector sum of forces will be zero. Body is said to be in the state of equilibrium under these conditions.

→ Under the state of equilibrium, a body at rest will remain at rest and it will not move, this is called state of static equilibrium.

→ If a body is moving with uniform velocity, it will keep moving with same velocity in equilibrium. This is called the state of dynamic equilibrium.

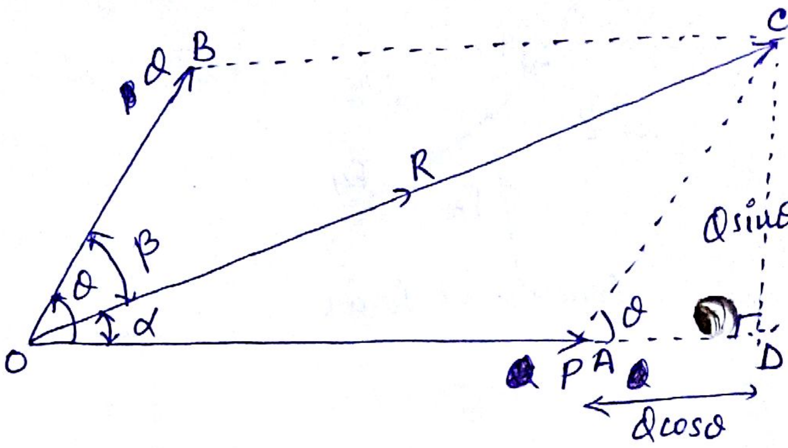
Vector Quantities:-

Scalar Quantities:-

ase III:

Law of Parallelogram of forces:-

If two concurrent forces, acting at a point are represented in magni[tude] and direction by the two adjacent sides of a parallelogram drawn from the point, then their resultant is represented in magnitude and direction by the diagonal of the parallelogram drawn from the same point.



In force Triangle

$AD = Q.\cos\theta$

$CD = Q\sin\theta$

$OD = OA + AD$

$= P + Q\cos\theta$

Pithagorous Theorem-

$OC^2 = OD^2 + CD^2$

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

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

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

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

$\tan\alpha = \frac{CD}{OD}$

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

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

Case I. If two forces are parallel. $\theta = 0°$. $\cos 0° = 1$

$R = P + Q$

Case II:- If forces are anti parallel $\theta = 180°$, $\cos 180° = -1$

$R = P - Q$

Case III :- If two forces are perpendicular. $\theta = 90^\circ$ $\cos 90^\circ = 0$

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

Case IV :- If magnitude of two forces are same. $P = Q$

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

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

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

$$\tan\alpha = \frac{\sin\theta}{1+\cos\theta} = \frac{2\sin\theta/2 \cdot \cos\theta/2}{\cancel{1}+2\cos^2\frac{\theta}{2}-\cancel{1}}$$

$$\tan\alpha = \frac{\cancel{2}\sin\theta/2 \cdot \cancel{\cos\theta/2}}{\cancel{2}\cos^{\cancel{2}}\theta/2}$$

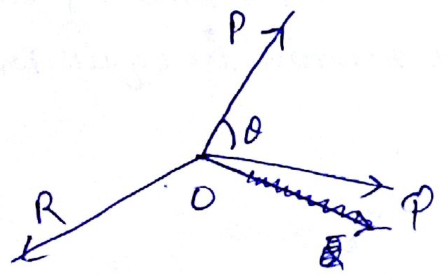
$$\tan\alpha = \tan\theta/2$$

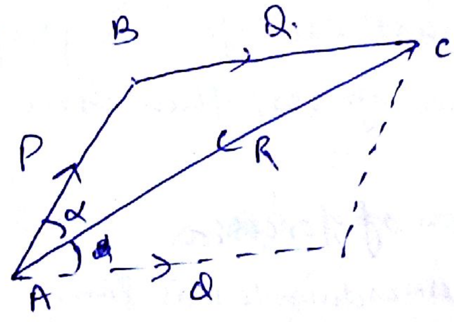
$$\boxed{\alpha = \theta/2}$$

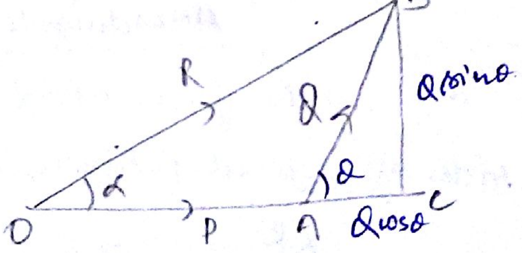
Numericals :- from book.

Law of Triangle of forces :-

According to this law, "If three forces acting at a point can be represented by the three sides of a triangle, then three forces will be in equilibrium."







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

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

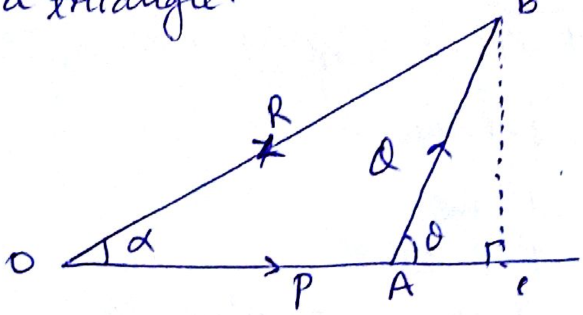
Pithogorous Theorem.

$$OB^2 = OC^2 + BC^2$$

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

Converse of Law of Triangle:-

If three forces acting at a point are in equilibrium, then their ~~resultant~~ magnitude and directions can be represented by successive sides of a triangle.

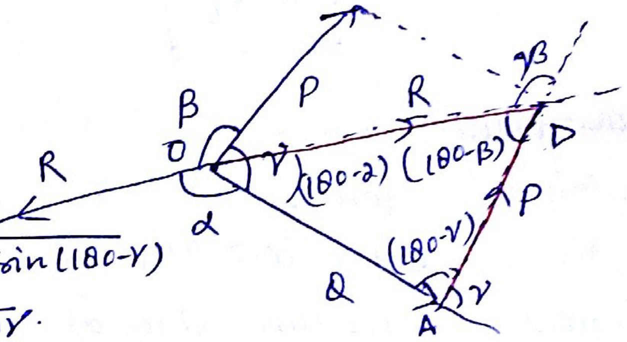


Lami's Theorem:-

According to Lami's theorem-

If three forces acting at a particle are in equilibrium then each force is proportional to the sine of angle between rest two forces.

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



Sine Rule = $\frac{AD}{\sin(180-\alpha)} = \frac{OA}{\sin(180-\beta)} = \frac{OD}{\sin(180-\gamma)}$

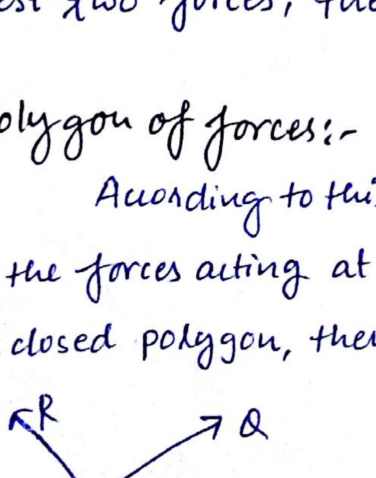
$$\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma}.$$

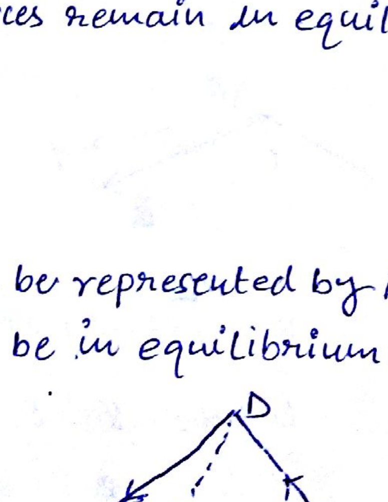
Converse of Lami's theorem:- If three forces are acting at a particle such that each force is proportional to the sine of angle b/w the rest two forces, then three forces remain in equillibrium.

Law of Polygon of forces:-

According to this law,-

" If all the forces acting at a point can be represented by successive sides of a closed polygon, then forces will be in equilibrium."





Other form of Law of Polygon of forces:-

If a number of forces acting at a particle can be represented by sides of an open polygon, then their resultant is represented by closing side taken in opposite order.

→ Converse of law of polygon of forces is not true

Ques:- Two forces of magnitude 20 N and 10 N are acting at a point. The angle of inclination b/w two forces is 60°. Determine the resultant force when both forces are in tension

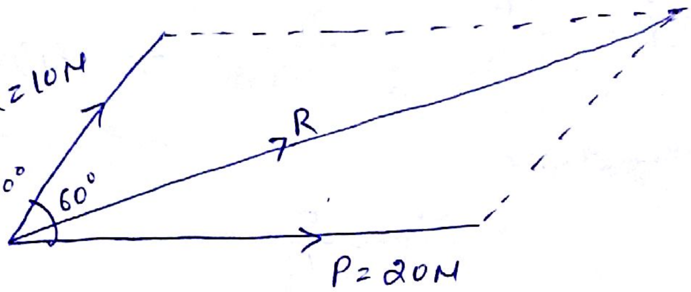
$R = \sqrt{P^2+Q^2+2PQ\cos\theta}$

$R = \sqrt{400+100+2\times 20\times 10\cos 60^\circ}$

$R = \sqrt{500+400\times\frac{1}{2}}$

$R = \sqrt{500+200}$

$R = \sqrt{700} = 26.45$ N Ans



$\tan\alpha = \dfrac{Q\sin 60^\circ}{P+Q\cos 60^\circ} = 0.346$

$\alpha = 19.10$ Ans

ii) If 10 N force is in compression whereas 20 N force is in tension

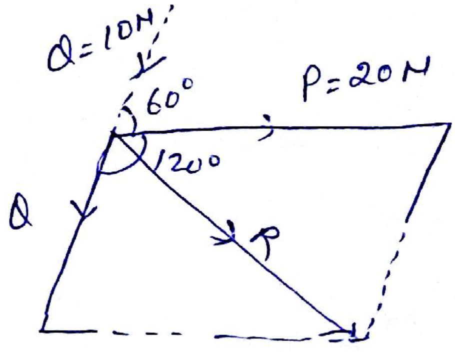
$R = \sqrt{P^2+Q^2+2PQ\cos 120^\circ}$

$R = \sqrt{400+100+2\times 20\times \cancel{Q}^{10}\times\left(-\frac{1}{2}\right)}$

$R = \sqrt{500-200}$

$R = \sqrt{300}$

$R = 17.3$ N. Ans



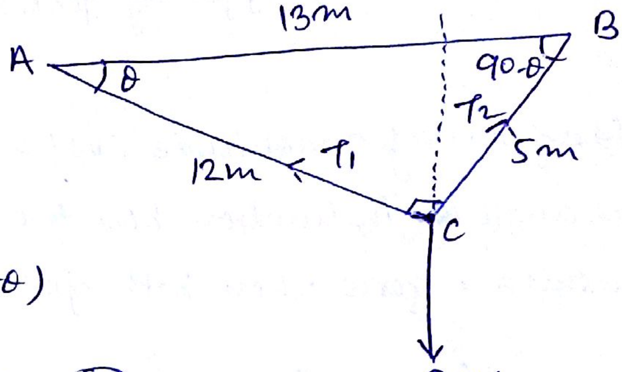
$\tan\alpha = \dfrac{Q\sin 120^\circ}{P+Q\cos 120^\circ}$

$\tan\alpha = \dfrac{10\sin 120^\circ}{20+10\cos 120^\circ} = 0.577$

$\alpha = 30^\circ$ Ans

Ques:- A body of 90 N is suspended by two light strings, Ends of both strings are fixed on horizontal line at two points 13 m apart. Lengths of the string supporting body are 5m and 12m. Determine tension in the strings.

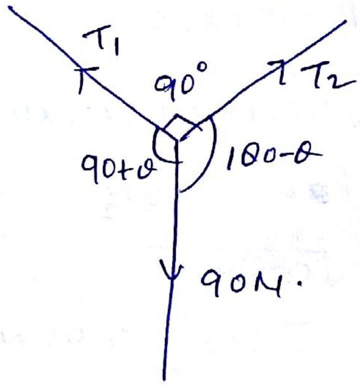
Solⁿ:-



Applying Lami's theorem -

$$\frac{90}{\sin 90^\circ} = \frac{T_2}{\sin(90+\theta)} = \frac{T_1}{\sin(180^\circ-\theta)}$$

$$\frac{90}{1} = \frac{T_2}{\cos\theta} = \frac{T_1}{\sin\theta} \quad \text{——— (1)}$$



from △ABC -

$$\sin\theta = \frac{5}{13}$$

$$\cos\theta = \frac{12}{13}$$

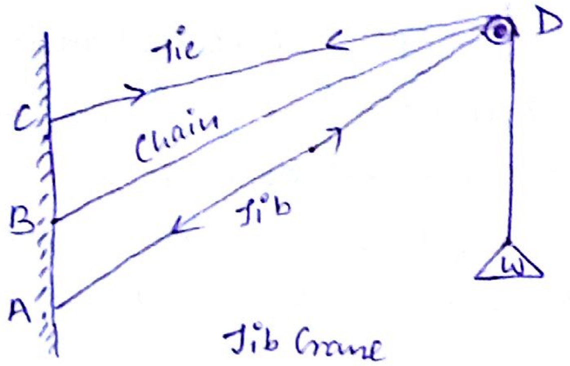
$$T_2 = 90\cos\theta = 90 \times \frac{12}{13} = 83.07\text{ N}.$$

$$T_1 = 90\sin\theta = 90 \times \frac{5}{13} = 34.61\text{ N}$$

Ans

Jib Crane:-

Jib crane is an instrument used to raise heavy loads. A load W can be lifted by using chain and pulley.



Jib Crane

Member CD → Tie

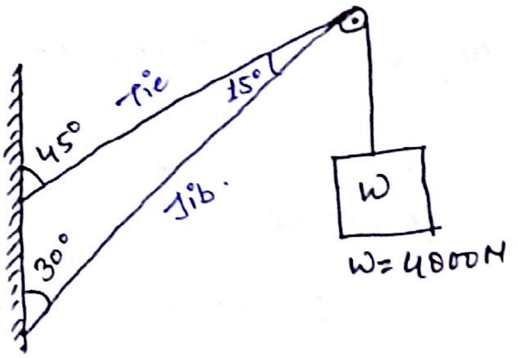
" AD → Jib

AC → Vertical Post

→ Tie member is a tensile member and jib is compressive member.

The forces in Tie and Jib members can be calculated by applying Lami's theorem at the point D.

Ques:- Find the forces in the Jib and tie when a load of 4800 N is hung from the crane as shown in figure.



W = 4800N

From Lami's Theorem -

$$\frac{F_T}{\sin 150^\circ} = \frac{F_J}{\sin 45^\circ} = \frac{4800}{\sin 165^\circ}$$

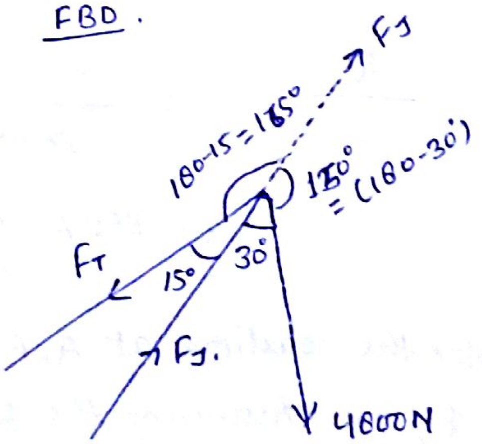
$$\frac{F_T}{\sin 150^\circ} = \frac{4800}{\sin 165^\circ}$$

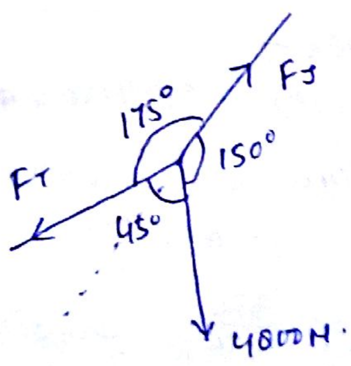
$$F_T = 9272.88 \text{ N}.$$

$$\frac{F_J}{\sin 45^\circ} = \frac{4800}{\sin 165^\circ}$$

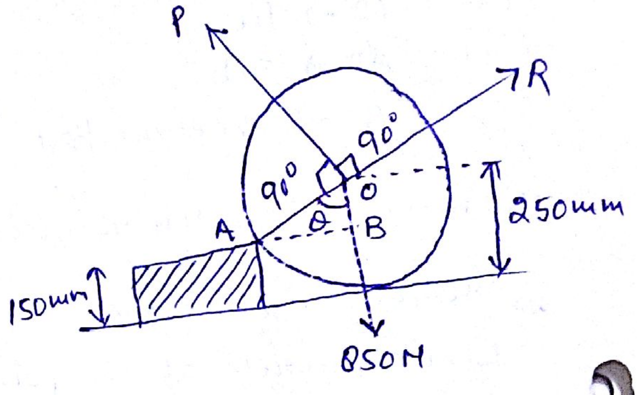
$$F_J = 13113.84 \text{ N}. \quad \text{Ans}$$

FBD.





Ques:- A uniform wheel 500mm in diameter rests against a rigid rectangular block 150mm thick. Find the least pull through the centre of the wheel to just turn it over the ~~smooth~~ corner of the block. All surfaces are smooth. Find also the reaction of the block. The wheel weights 850N.



Soln:- If pull is to be minimum it must be applied normal to OA.

In ΔOAB −

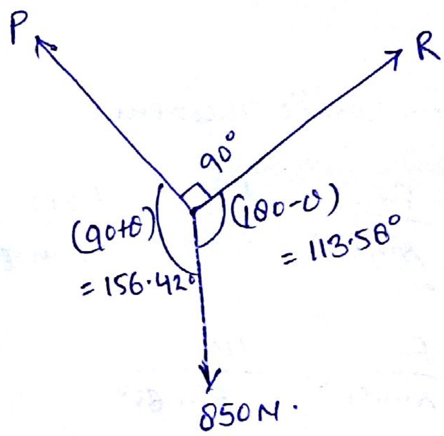
$OA = R = 250mm$

$OB = R - 150 = 100mm$

$\cos\theta = \frac{OB}{OA} = \frac{100}{250} = \frac{2}{5}$

$\theta = 66.42°$

Free Body Diagram.



Applying Lami's Theorem −

$$\frac{P}{\sin 113.58°} = \frac{850}{\sin 90°}$$

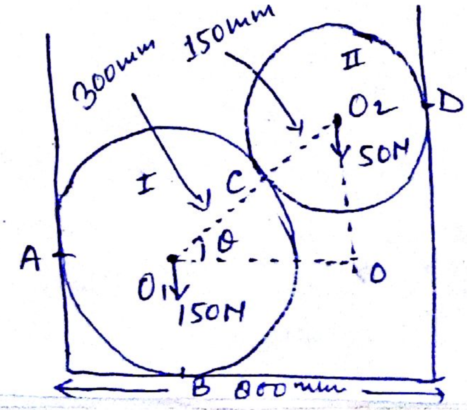
$P = 850 \times \sin 113.58°$

$P = 779.02\ N$. Ans

$$\frac{R}{\sin 156.42°} = \frac{850}{\sin 90°}$$

$R = 850 \sin 156.42° = 340\ N$. Ans

Ques:- Solve the reactions at A, B, C and D on the two cylinders shown in the figure. Assuming the surfaces to be smooth.



in $\Delta O_1 O O_2$ −

$O_1O_2 = 300 + 150 = 450mm$

$O_1O = 800 - 300 - 150$

$= 800 - 450 = 350mm$

$\cos\theta = \frac{350}{450}$ $\theta = 38.94°$

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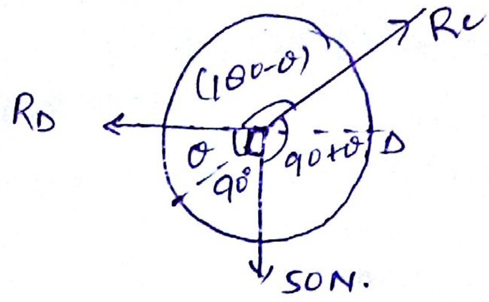
• FBD of cylinder II.

$\theta = 38.94°$

Applying Lami's theorem.



$$\frac{R_D}{\sin(90+\theta)} = \frac{W}{\sin(180-\theta)} = \frac{R_c}{\sin 90°}$$

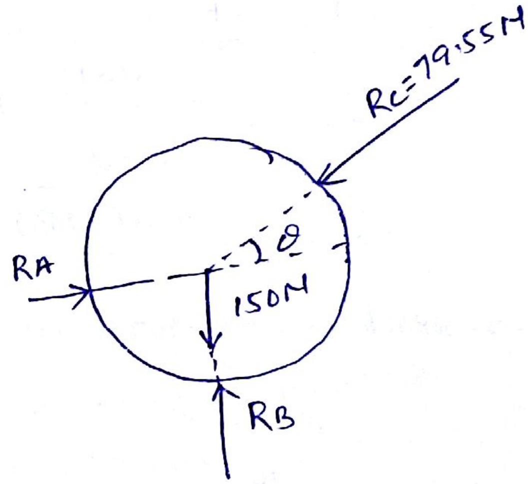
$$\frac{R_D}{\sin 128.94°} = \frac{W}{\sin 141.06} = \frac{R_c}{1}$$

$$R_c = \frac{W}{\sin 141.06} = 79.55\,N. \text{ Ans}$$

$$R_D = \frac{50 \times \sin 128.94°}{\sin 141.06°} = 61.87\,N \text{ Ans}$$

FBD for cylinder I:-

$\theta = 38.94°$



Resolving the components in horizontal and vertical direction.

$R_c \cos 38.94° = R_A$

$79.55 \cos 38.94° = R_A$

$R_A = 61.87\,N$ Ans

79.55

Rc ~~sin 79.55~~

$79.55 \sin 38.94 + 150 = R_B$

$R_B = 200\,N$ Ans

M.

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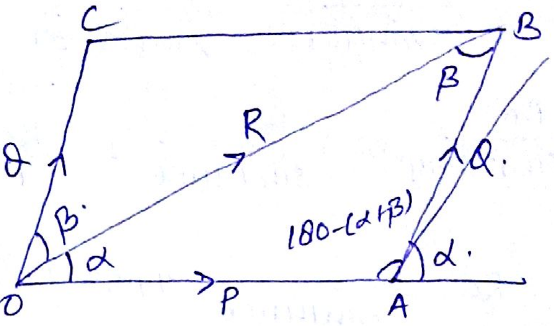
→ Resolution of forces:-

If magnitude and directions of forces are known then there will be only one resultant of definite magnitude and direction.

In ΔOAB.

Law of triangle.



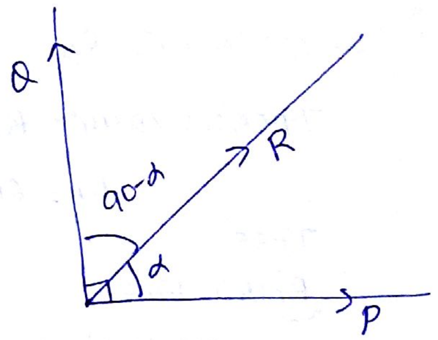
$$\frac{OA}{\sin\beta} = \frac{AB}{\sin\alpha} = \frac{OB}{\sin[180-(\alpha+\beta)]}$$

$$\frac{P}{\sin\beta} = \frac{Q}{\sin\alpha} = \frac{R}{\sin(\alpha+\beta)}$$

$$\boxed{P = \frac{R\sin\beta}{\sin(\alpha+\beta)}} \quad \text{——} (1)$$

$$\boxed{Q = \frac{R\sin\alpha}{\sin(\alpha+\beta)}} \quad \text{——} (2)$$

→ Resolution of force in two perpendicular directions:-



$\alpha+\beta = 90°$

$\beta = 90-\alpha$

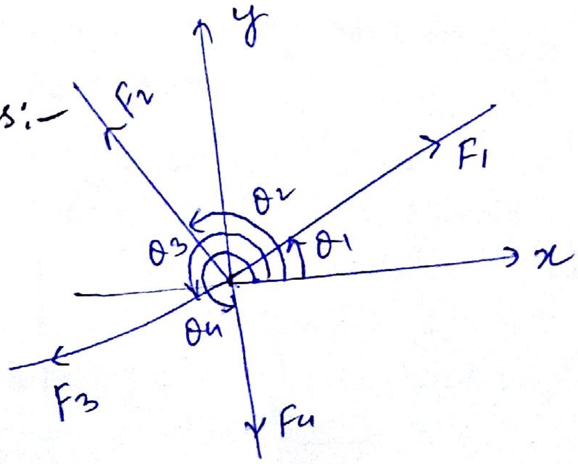
from eq^n (1) and (2) -

$$P = \frac{R\sin(90-\alpha)}{\sin 90°}$$

$$\boxed{P = R\cos\alpha}$$

$$\boxed{Q = R\sin\alpha}$$

→ Resolution of concurrent Coplanar Forces:-



Resolution of forces along x-dir^n.

$$\Sigma F_x = F_1\cos\theta_1 + F_2\cos\theta_2 + F_3\cos\theta_3 + F_4\cos\theta_4 \;\ldots$$

$$\Sigma F_y = F_1\sin\theta_1 + F_2\sin\theta_2 + F_3\sin\theta_3 + F_4\sin\theta_4 \;\ldots$$

∴ Resultant Force, $R = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}$

direction of resultant:-

If resultant is inclined at θ angle with x-axis-

$$\tan\theta = \frac{\Sigma F_y}{\Sigma F_x}$$

Condn of equillibrium. $R = 0$, $\Sigma F_x = 0$, $\Sigma F_y = 0$

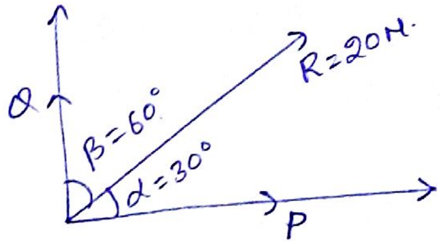
Ques:- Find the components of a 20 N force in a direction 30° and 60°.

Given:-

$\alpha = 30°$

$\beta = 60°$

$R = 20\,N.$



$$P = \frac{R\sin\beta}{\sin(\alpha+\beta)}$$

$$P = \frac{20\sin 60°}{\sin 90°} = 20 \times \frac{\sqrt{3}}{2} = 10\sqrt{3}\ N \text{ Ans;}$$

$$Q = \frac{R\sin\alpha}{\sin(\alpha+\beta)}$$

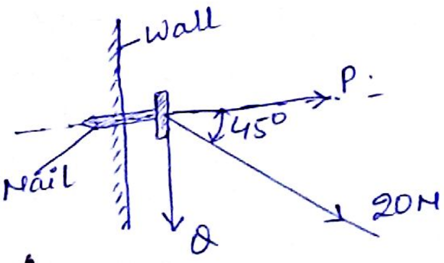
$$Q = \frac{R\sin 30°}{\sin 90°} = 20 \times \frac{1}{2} = 10\ N \text{ Ans;}$$

Ques:- A iron nail is fixed on a wall. Nail is being ~~fixed~~ pulled by a 20N force in a direction 45° with the axis of nail. What would be the magnitude of force which can remove the nail along its axis.

Soln:-

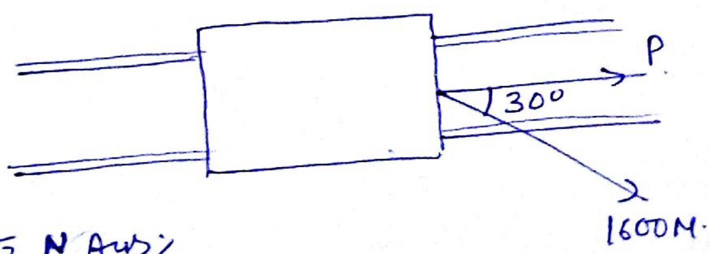
$P = 20\cos 45°$

$= 20 \times \frac{1}{\sqrt{2}} = 10\sqrt{2} = 14.14\ N$ Ans;



Ques:- A railway wagon is resting on rails. A horizontal force of magnitude 1600N is being applied on wagon in a direction 30° from rails. Calculate the useful force required to pull the wagon.

Soln:- Component of force along the dirn of rail.



$P = 1600\cos 30° = 1600 \times \frac{\sqrt{3}}{2} = 800\sqrt{3}\ N$ Ans;

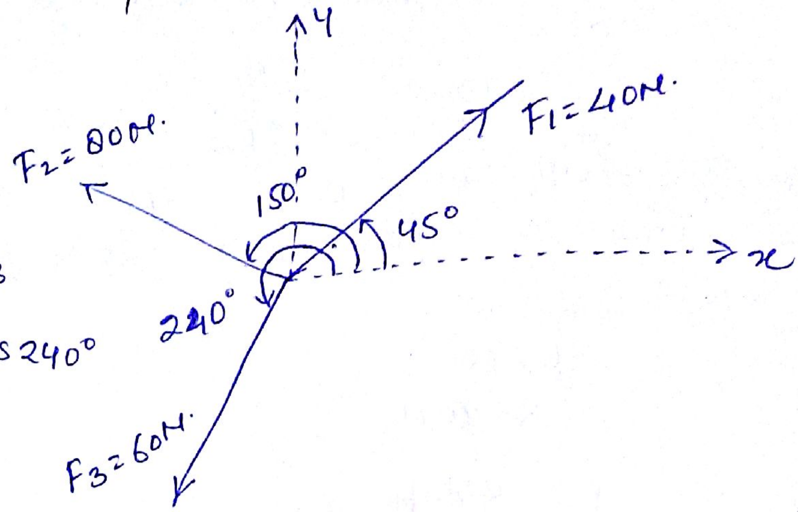
Ques:- Find the resultant of a given concurrent three force system. and the direction of resultant from x-axis.

Soln:-

$\theta_1 = 45°$ $\quad F_1 = 40N.$

$\theta_2 = 150°$ $\quad F_2 = 80N.$

$\theta_3 = 240°$ $\quad F_3 = 60N.$



$$\Sigma F_x = F_1\cos\theta_1 + F_2\cos\theta_2 + F_3\cos\theta_3$$

$$= 40\cos 45° + 80\cos 150° + 60\cos 240°$$

$$= -70.99\ N.$$

$$\Sigma F_y = F_1\sin\theta_1 + F_2\sin\theta_2 + F_3\sin\theta_3$$

$$= 40\sin 45° + 80\sin 150° + 60\sin 240°$$

$$= 16.32\ N.$$

Resultant Force, $R = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}$

$$R = \sqrt{(-70.99)^2 + (16.32)^2}$$

$$R = 72.84\ N.$$

direction of resultant force -

$$\tan\alpha = \frac{\Sigma F_y}{\Sigma F_x}$$

$$\tan\alpha = \frac{16.32}{-70.99}$$

$$\tan\alpha = -0.2298$$

$$\alpha = 180° - 12.94$$

$$\alpha = 167.06°\ \text{Ans}$$

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