VISUAL PHYSICS

SHORT NOTES

CHAPTER

Newton's Laws Of Motion

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Newton's Law of Motion

Force → Force is the external form of push or pull which:
- → produce motion of body at rest.
- → stops a moving body
- → changes the direction
- → change in shape

Force

Contact forces
↓
These forces act between bodies in contact.

e.g. Tension, normal reaction.

Non-Contact forces
↓
Forces that act without any actual contact.

e.g. gravity, electrostats

Frame of reference

Inertial frame of reference
↓
frame of reference, without acceleration.

i.e. steady or moving with constant velocity.

→ Also known as unaccelerated frame

→ Ideally, no inertial frame exists.

*if acceleration is negligible.

Non-inertial frame of reference
↓
a fr an accelerating frame of reference.

i.e. having some acceleratio

for falling objects, Earth can be refer as 'inertial frame.'

→ Newton's law of motion can only be applicable in 'Inertial frame'.

Newton's first law of motion:

→ A body continues to be in its state of rest or uniform motion along a straight line unless it is acted upon by some external force to change the state.

Inertial of rest: It is the inability of a body to change by itself, its state of rest.

This means a body at rest remains at rest and cannot start moving by its own.

Inertia of motion: It is the inability of a body to change its state of uniform motion.

uniform motion ↙ constant velocity.

linear momentum: It is the quantity of motion in a body.

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

direction of $\vec{p}$ is same as $\vec{v}$

Newton's second law:

$$\vec{F}_{ext} \propto \frac{d\vec{p}}{dt}$$

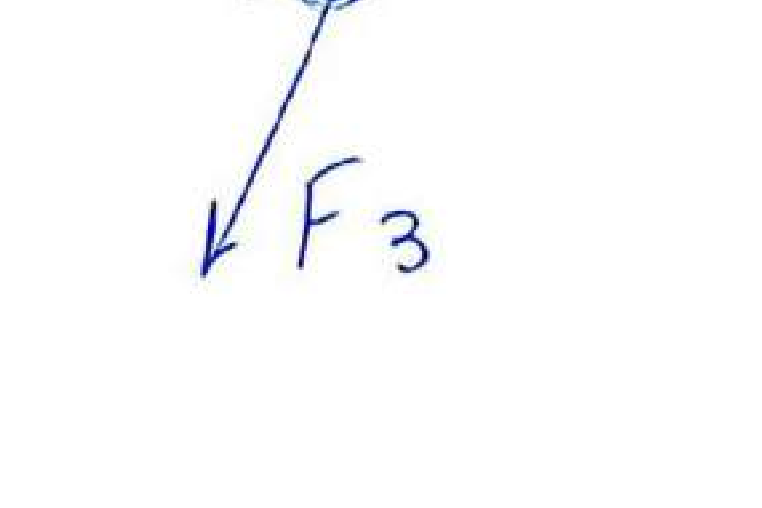
$$\Rightarrow \vec{F}_{ext} = \frac{d\vec{p}}{dt} = \frac{d}{dt}(m\vec{v})$$

$$= \frac{dm}{dt}\vec{v} + m\frac{d\vec{v}}{dt}$$

if m is constant $\frac{dm}{dt} = 0$

$$\Rightarrow \boxed{\vec{F}_{ext} = m\vec{a}}$$

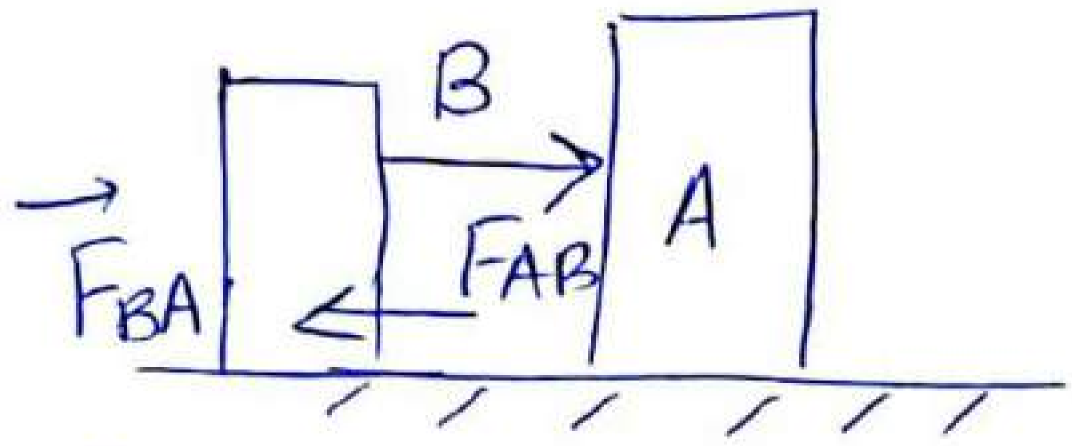
Net external force on a body.



So, $\boxed{\vec{F}_{ext} = \vec{F}_1 + \vec{F}_2 + \vec{F}_3}$

Newton's third law:

To every action, there is always opposed an equal reaction.



$\vec{F}_{AB} \rightarrow$ Force on A due to B

$\vec{F}_{BA} \rightarrow$ Force on B due to A

$$\Rightarrow \boxed{\vec{F}_{AB} = -\vec{F}_{BA}}$$

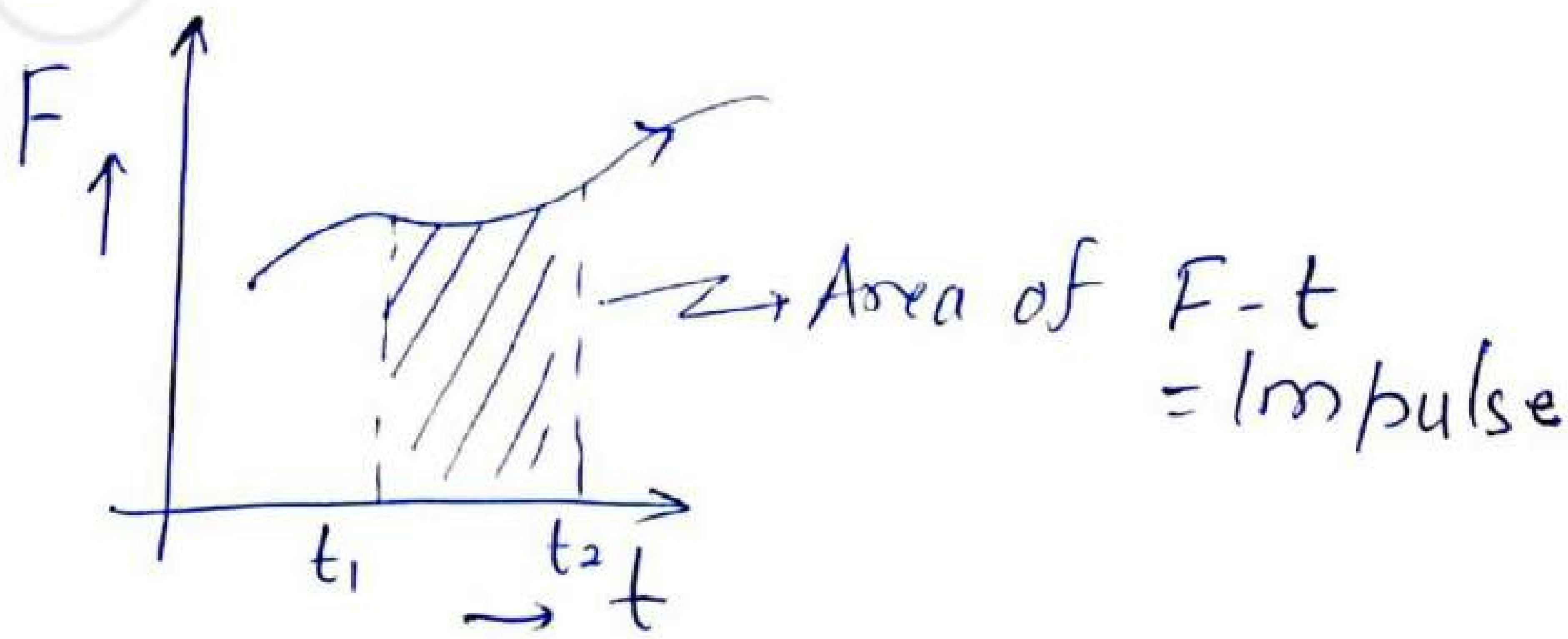
IMPULSE:-

$$\boxed{J = \int_{t_1}^{t_2} \vec{F}_{ext}\, dt = \vec{\Delta P}}$$

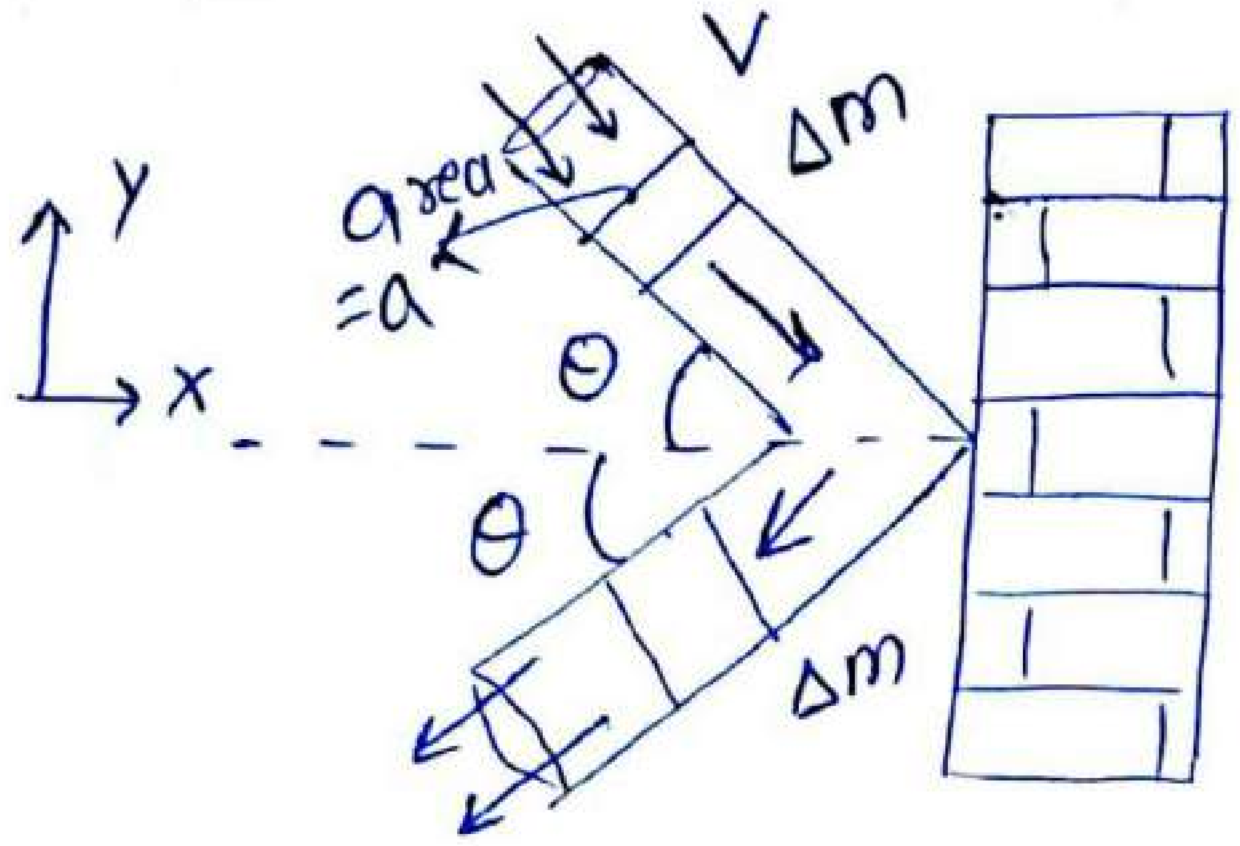
J → Impulse

$$\boxed{\vec{F}_{ext} = \Sigma F}$$

$$\vec{\Delta p} = \vec{p}_f - \vec{p}_i$$



Impulse of force Exerted by liquid Jet on wall



$(\Delta P_x)_{wall} = 2\Delta m v \cos\theta$

and $(\Delta P_y)_{wall} = mv\sin\theta - mv\sin\theta = 0$

$$F = \frac{[\Delta P_x]_{wall}}{\Delta t}$$

$$F = \frac{2\Delta m v\cos\theta}{\Delta t}$$

$$= 2v\cos\theta\left(\frac{\Delta m}{\Delta t}\right)$$

now $\Delta m = \rho \Delta V$ → Volume of water striking for Δt time.

$\frac{\Delta V}{\Delta t} = Q = a v$ → v: velocity, a: Area

$\Rightarrow F = 2v\cos\theta\left(\rho\frac{\Delta V}{\Delta t}\right)$

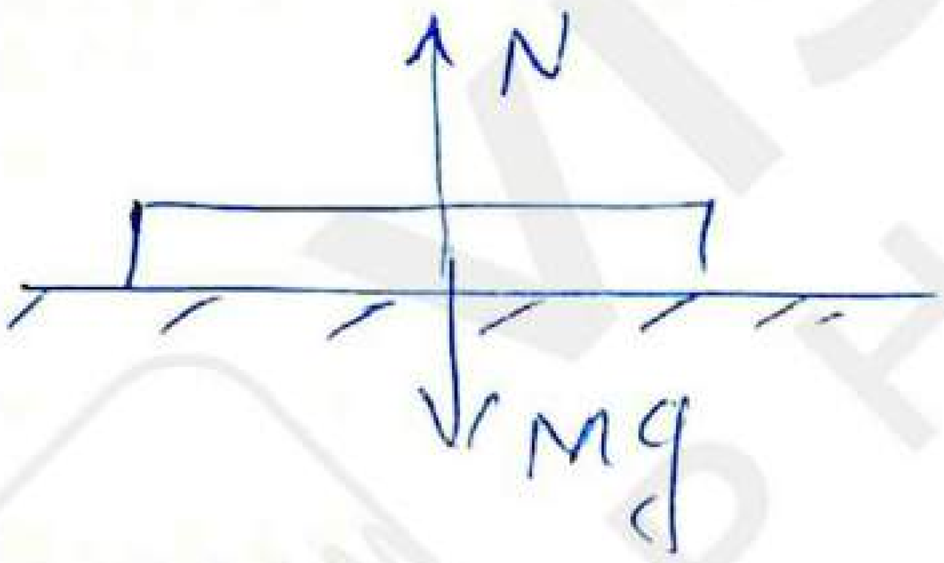
$$\boxed{F = 2\rho a v^2\cos\theta}$$

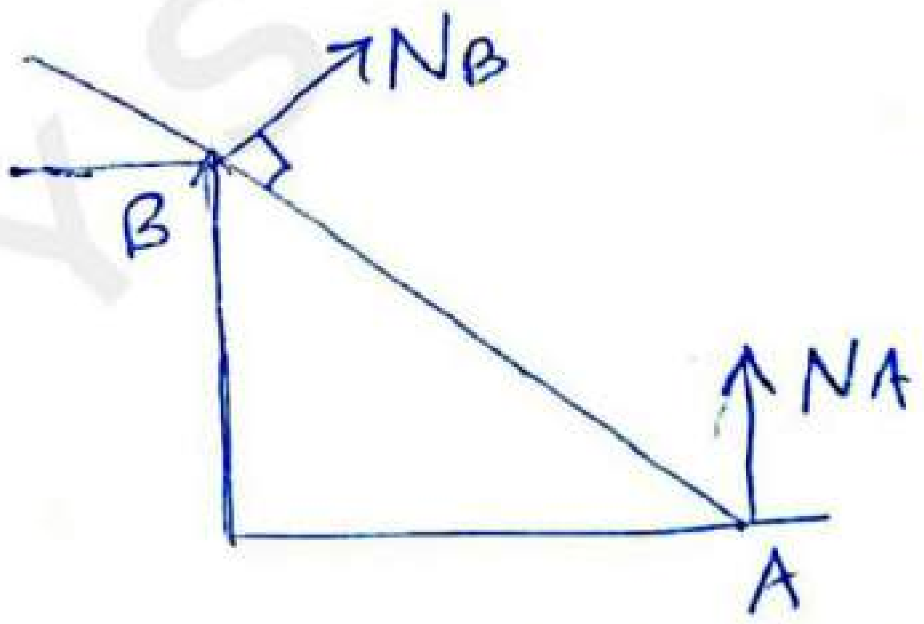
Free-Body Diagram:

The object of interest is isolated from its surroundings, and the interactions between the object and the surrounding in terms of forces.

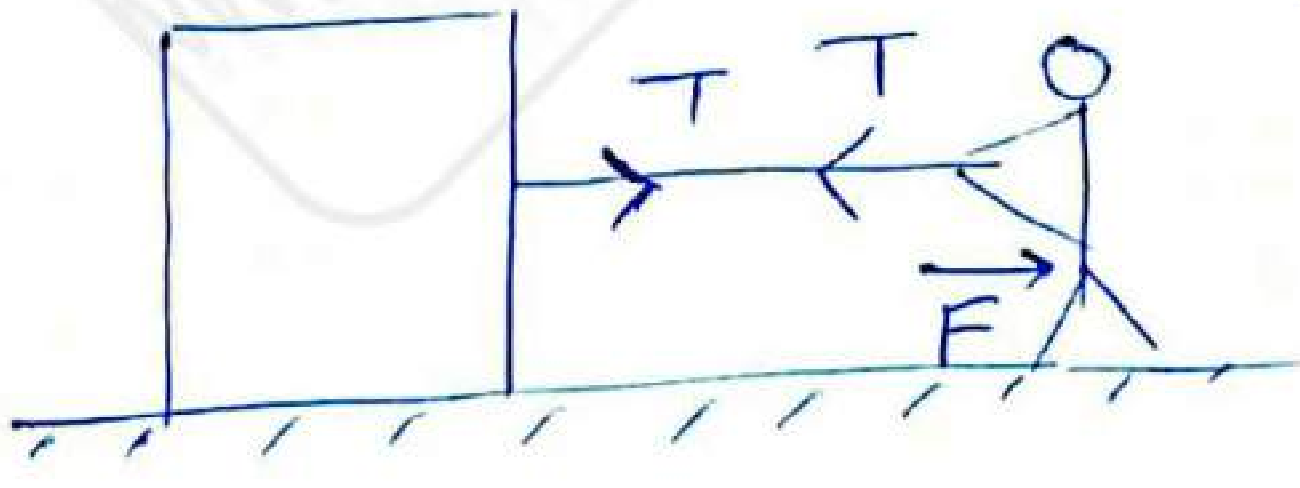
Weight: mg (Reaction of ground)
↳ mass x acceleration due to gravity.

Normal force: Whenever two surfaces are in contact, they press (or push) each other by a force called contact force.

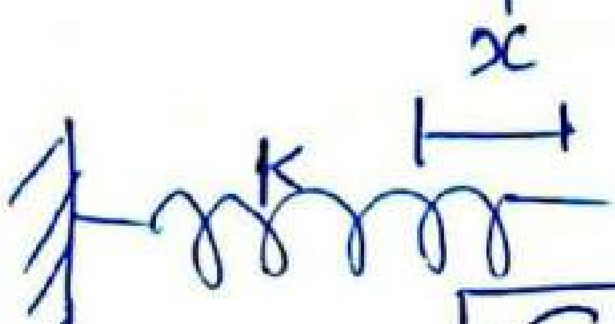




Tension: It is an inter-molecular force between the atoms of a string.

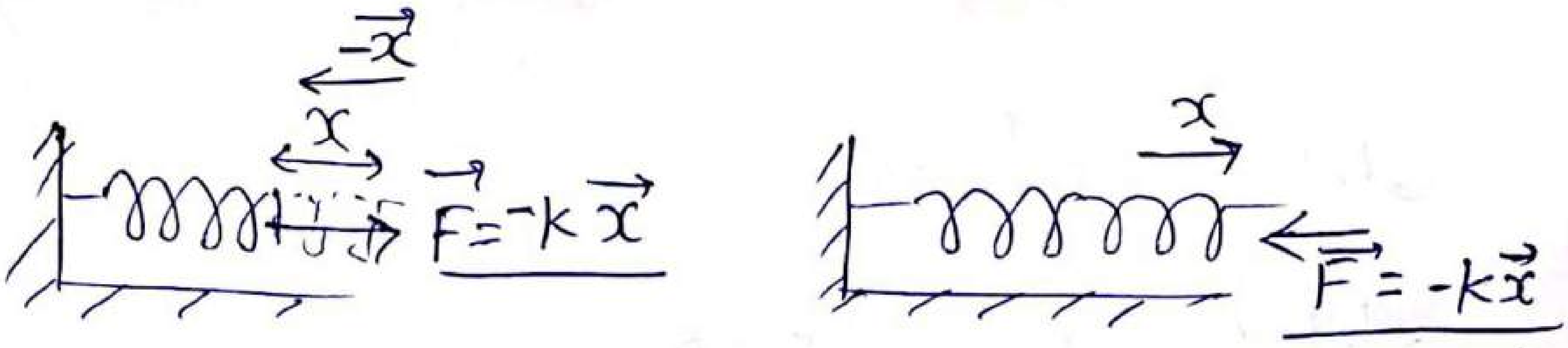


Spring force:



x → change in length of spring (elongation or compress)

$$F = kx$$

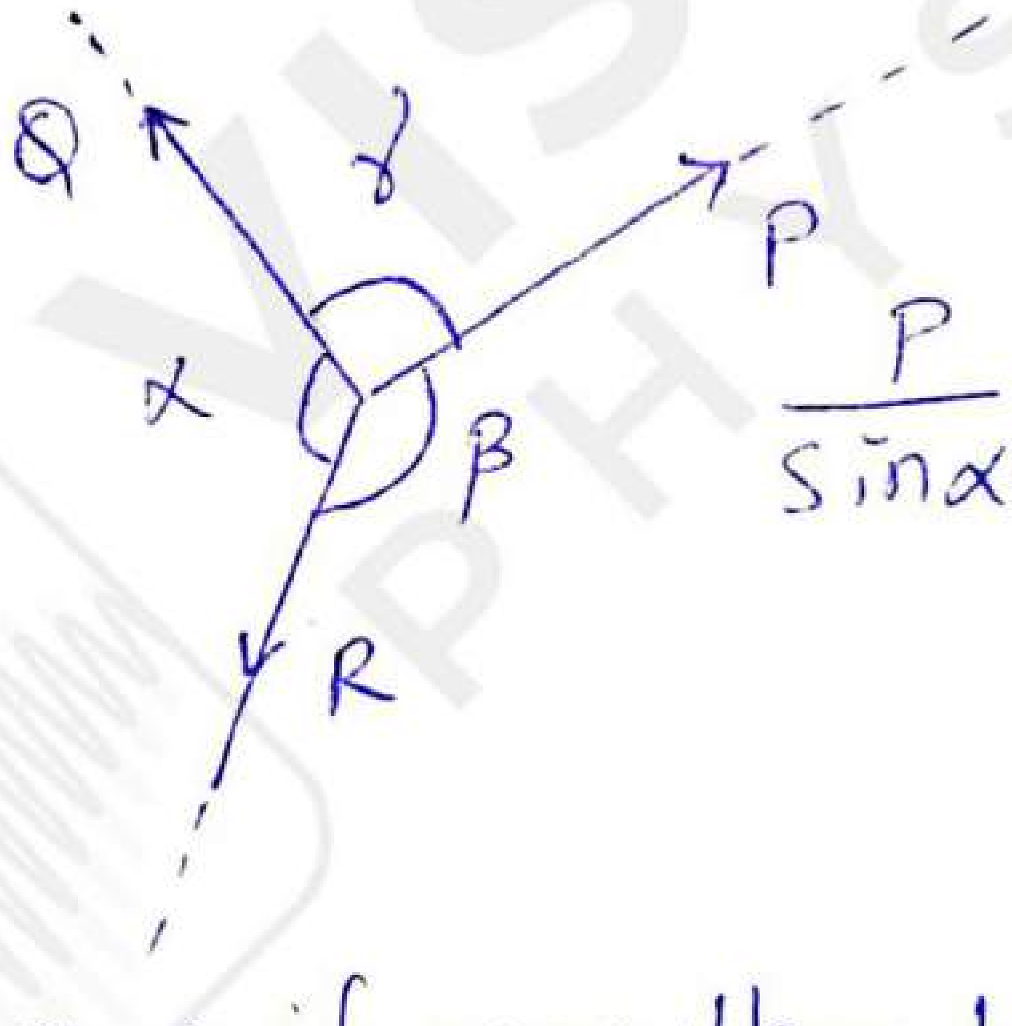


$\vec{F}$ & $\vec{x}$ are opposite

Equilibrium of a particle: No net external Force on an object.

$$\Rightarrow \boxed{\sum \vec{F}_{ext} = 0}$$

Lami's Theorem:



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

Concurrent forces → if more than two forces act on same particle.

Steps of solving:

Step 1: Draw FBD

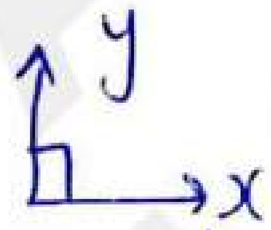
Step 2: apply Newton's second law

$$\Sigma \vec{F} = m a$$

now apply that.

Resolve the Forces acting on the objects and apply $\vec{F} = m\vec{a}$.

$\vec{a_x}$ and $\vec{a_y}$



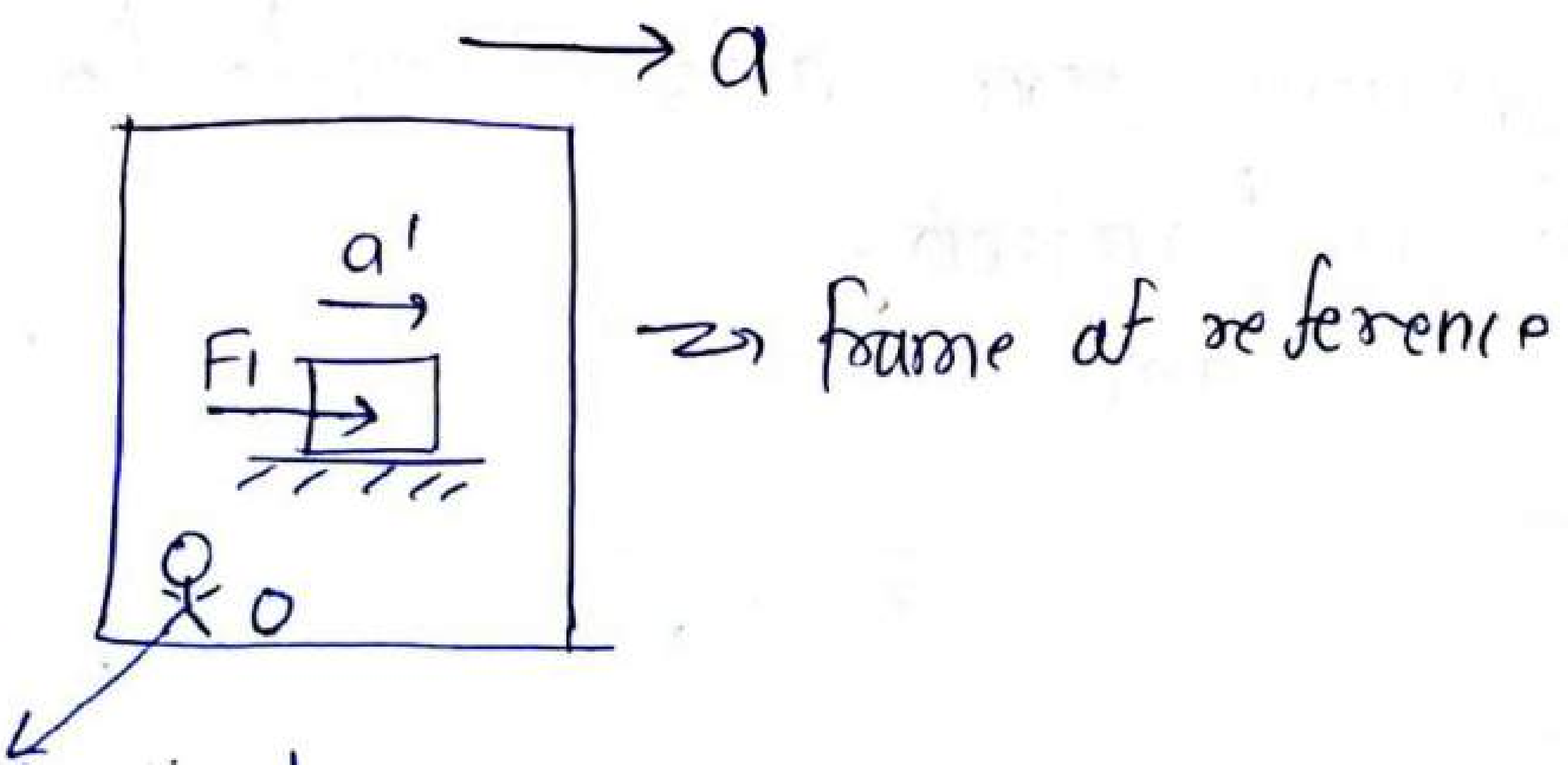
two perpendicular direction and resolve it in these two directions individualy.

Step 3: Solve the component equations for the unknowns. In each direction.

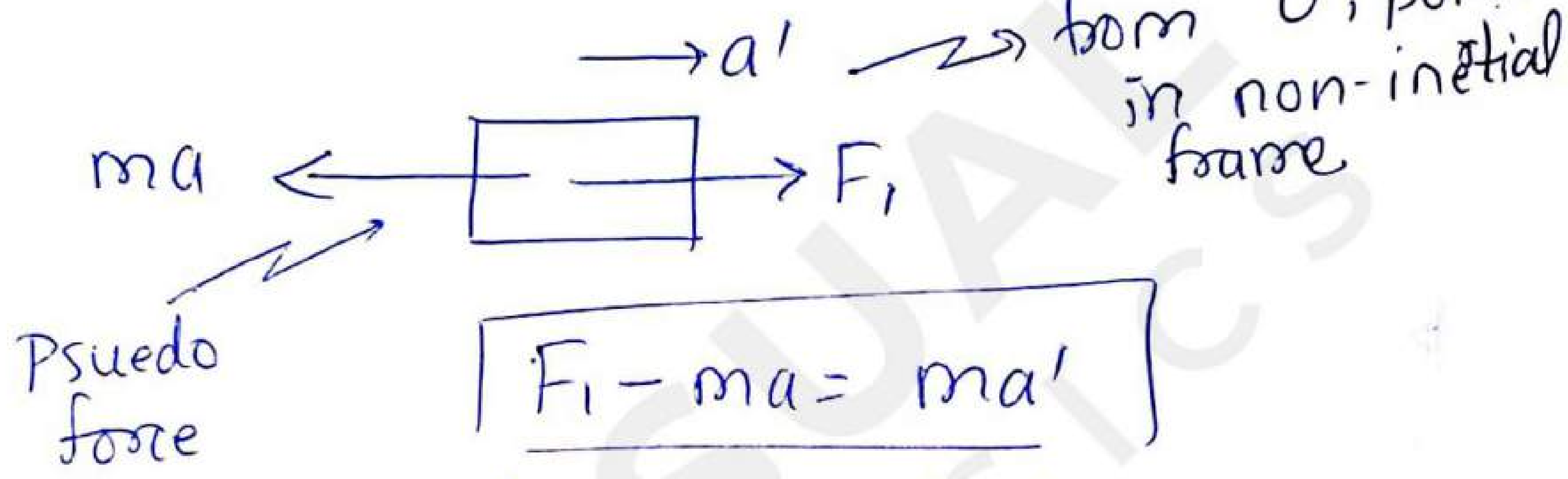
Non-inertial frame of reference and pseudo force:

If frame of reference is non-inertial..

To make the condition so that Newton's law can be applied we need to apply psuedo force.

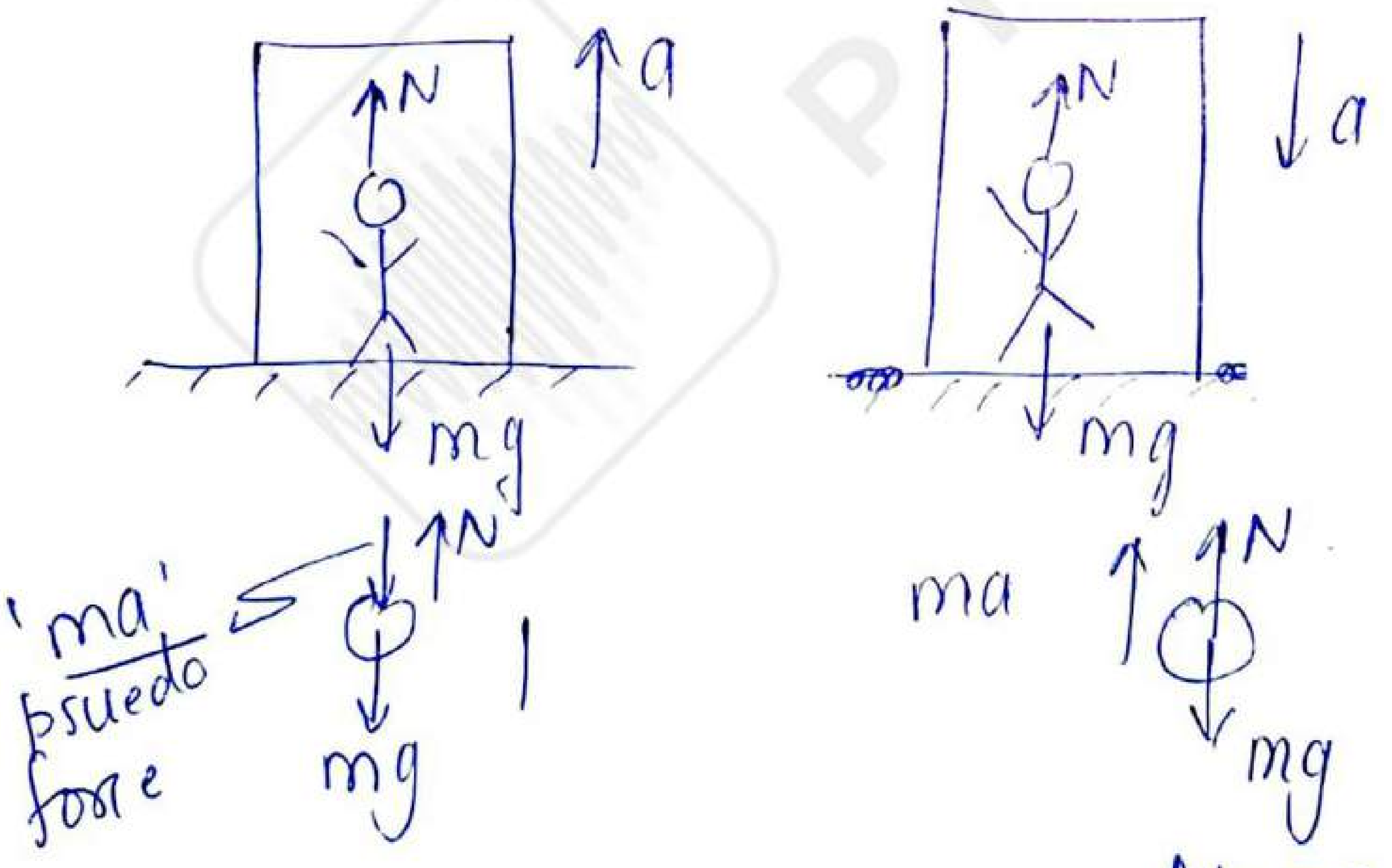


so from here.



$$F_1 - ma = ma'$$

After applying psuedo force we can apply Newton's law.



$N = mg + ma$
(going up weight increase)

$N = mg - ma$
going down decrease force.

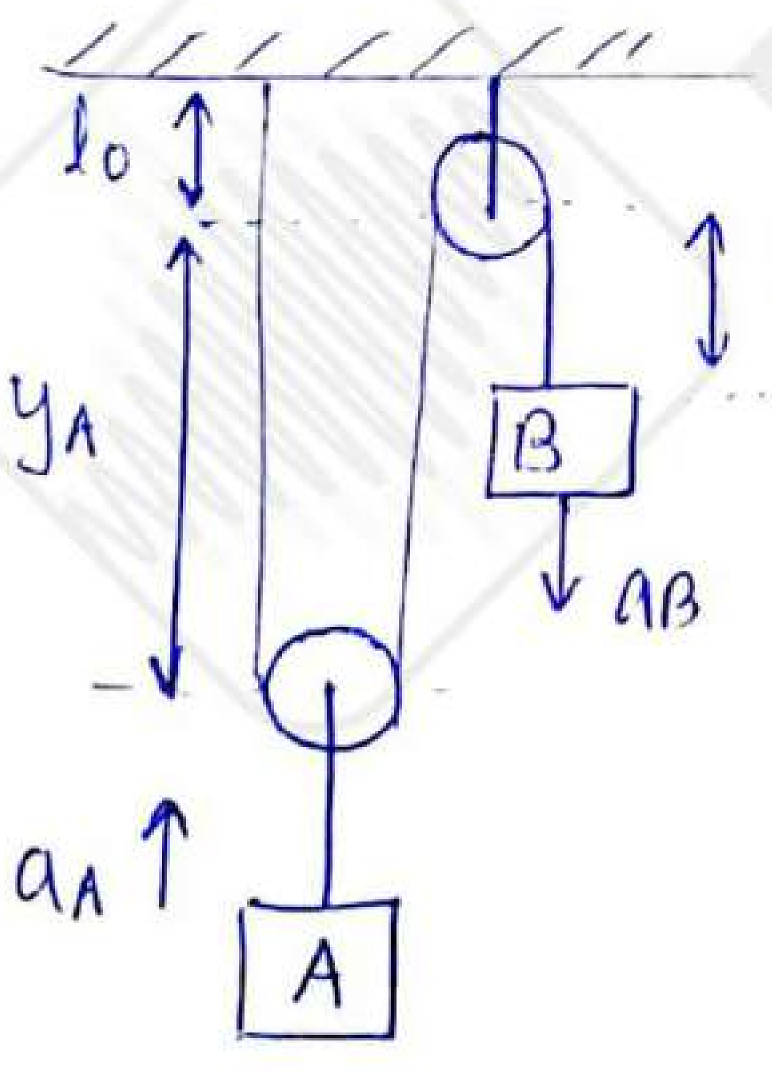
psuedo force acts opposite to direction of acceleration.
and magnitude is mass x acceleration of frame of reference

Constraint relations

↳ Constraints mean that two bodies are not free to move the way they want.

pulley Constraint:

pulley Constraints are applicable when the bodies concerned are connected through pulleys and the rope connecting them is inextensible.



net length of string

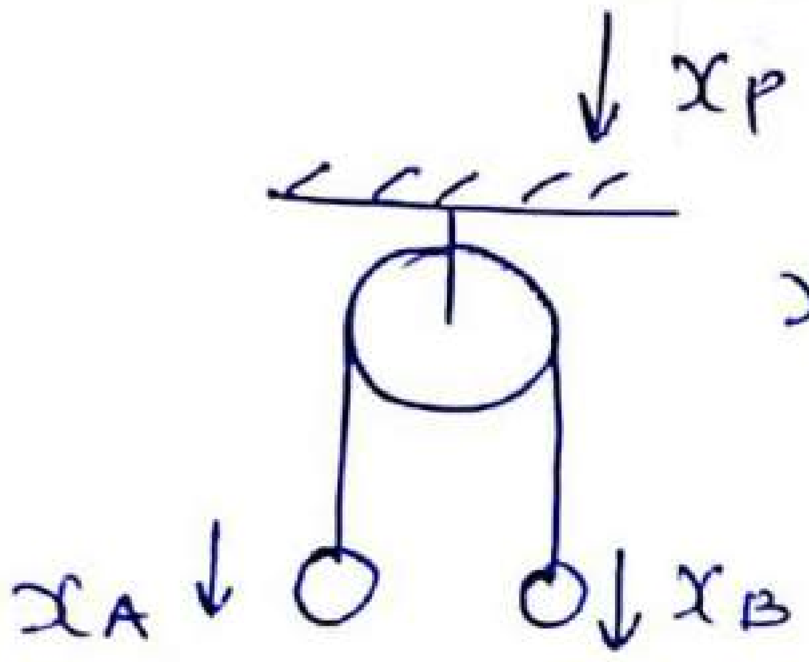
$$y_B + 2y_A + l_0 = 0$$

$$\frac{d}{dt}(y_B + 2y_A + l_0) = 0$$

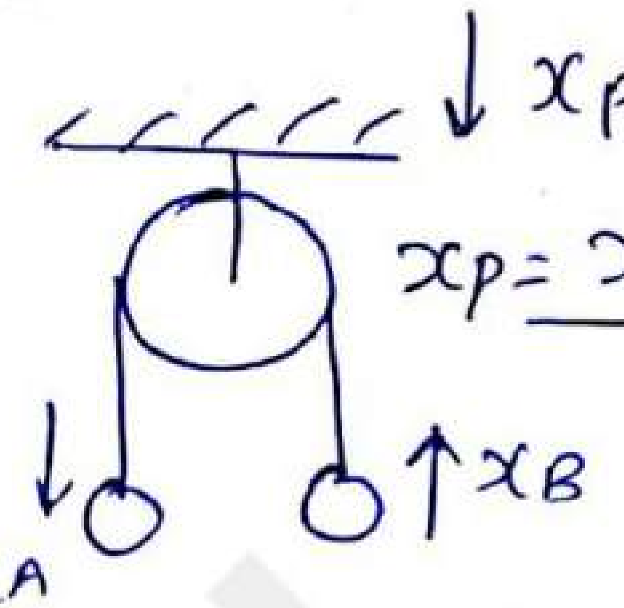
$$\Rightarrow \boxed{V_B = -2V_A}$$

$$\Rightarrow \boxed{a_B = -2a_A}$$

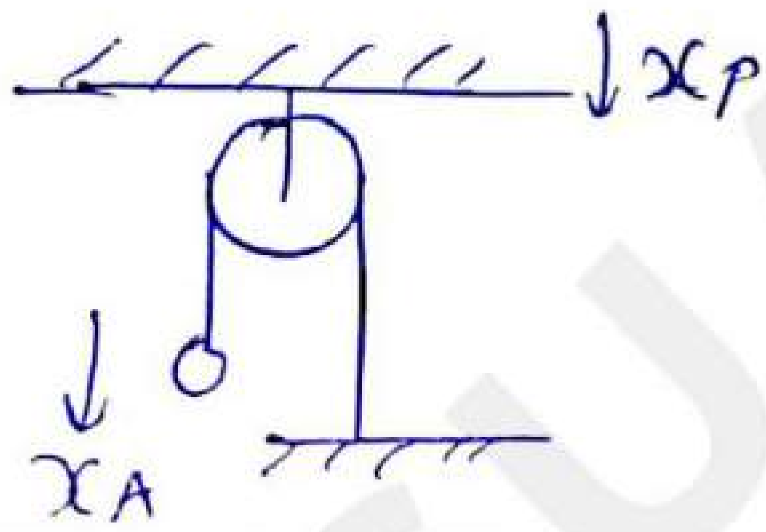
Shortcut methods:



$$x_P = \frac{x_A + x_B}{2}$$

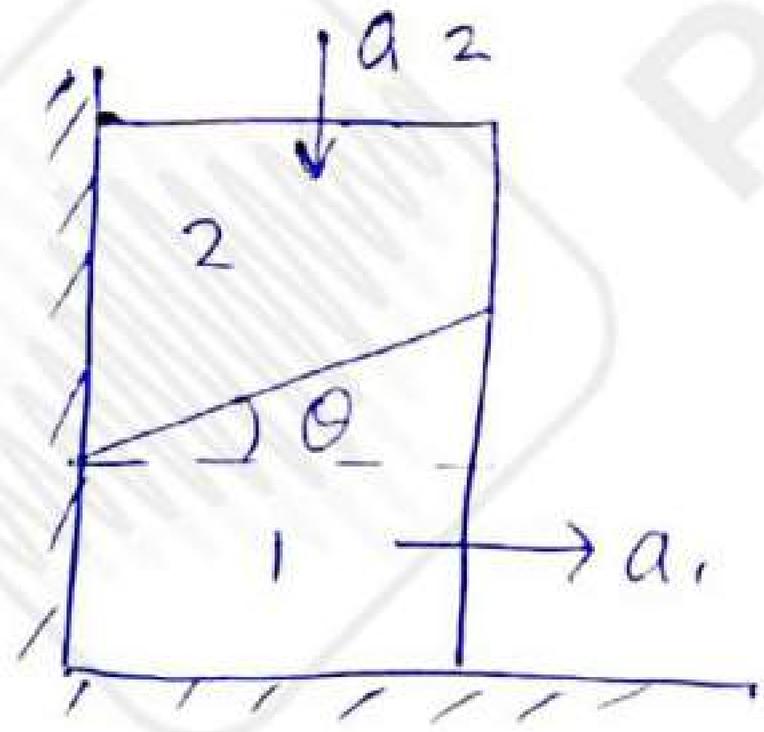


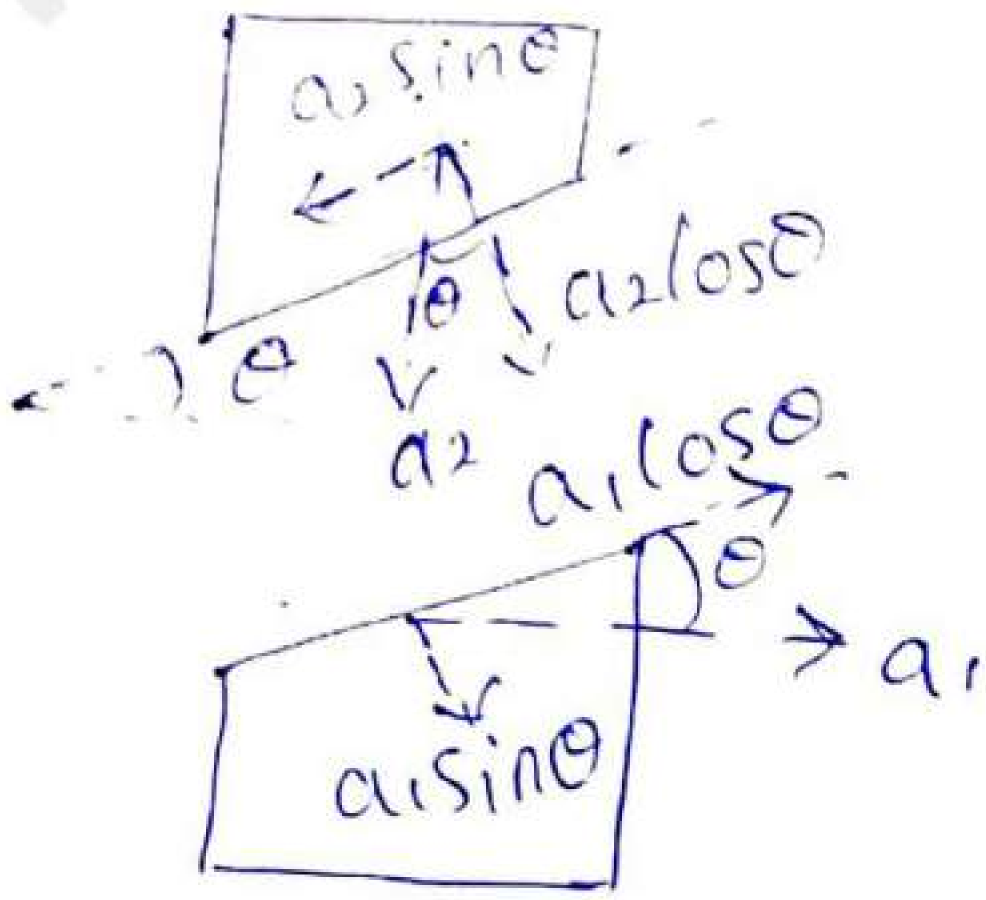
$$x_P = \frac{x_A - x_B}{2}$$



$$x_P = \frac{x_A + 0}{2} = \frac{x_A}{2}$$

Wedge Constraint.





The two objects always remain in contact.

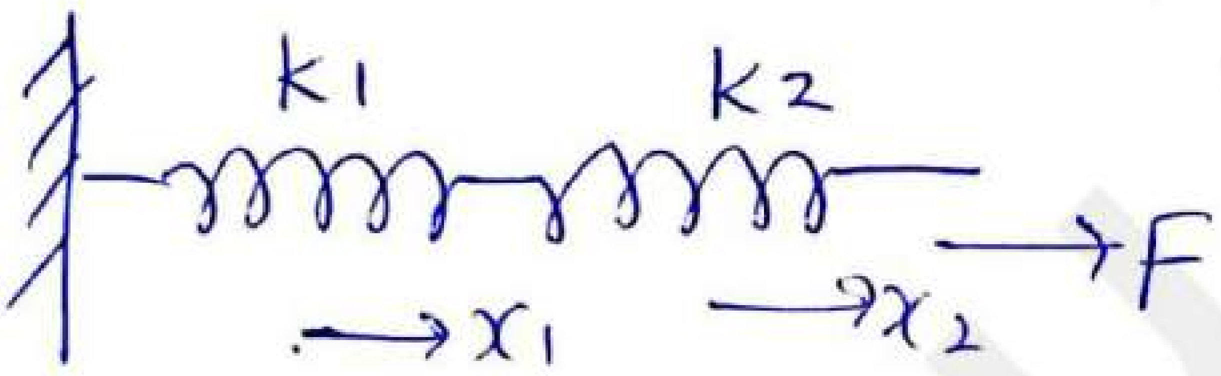
⇒ In order to main the component of velocity the ~~br~~ vector perpendicular to contact surface will be same.

i.e. component of acceleration as well

$$\Rightarrow \boxed{a_1 \sin\theta = a_2 \cos\theta}$$

combination of springs

series:

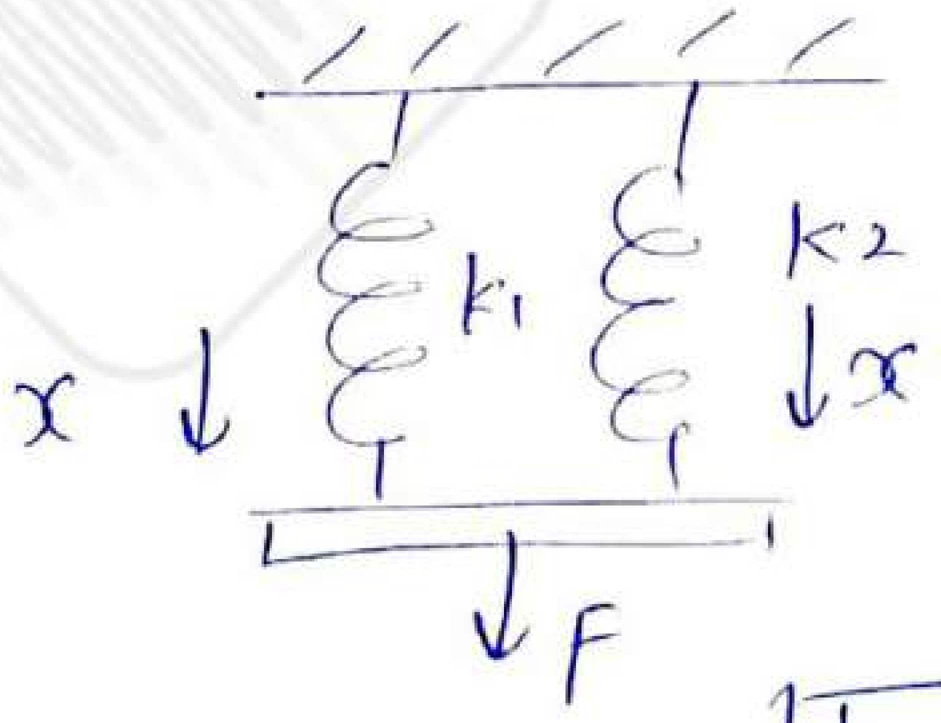


$$\boxed{F = k_1 x_1 = k_2 x_2}$$

$$\boxed{K_{net} = \frac{k_1 k_2}{k_1 + k_2}}$$

x = net displacement $= x_1 + x_2$

parallel:



$$\boxed{F = (k_1 + k_2)\, x}$$

$$\boxed{k_{net} = k_1 + k_2}$$