Inertia :- Tendency of body to remain at its own position.

→ Inertia depends upon mass.

→ Two bodies of equal mass, one is at rest and another is in motion then inertia is same for both.

- **Inertia of rest :-** rest मे रहन खोजने Tendency.

e.g.- book lying on the table remains there till eternity.

- Backward falling of passenger when bus suddenly starts.

→ (action हुनु अघ्दा अगाडि rest मा हुन पर्यो)

- **Inertia of motion :-** motion मै रहन खोज्ने Tendency.

e.g. → running of athletes before long jump, switch off the fan, Forward falling of passenger when bus is acting

→ action हुनु अघ्दा अगाडि motion मा हुन पर्यो।

- **Inertia of direction :-** same direction मै रहन खोज्ने Tendency.

Newtons Laws of Motion

① **1st law :-** Gives the concept of inertia.

→ unless it is compelled by ext. force. (state remains constant).

→ also gives the qualitative defination of Force.

e.g. → all eg of inertia.

② **2nd law :-** Force is directly proportional to rate of change of momentum.

$$F \propto \frac{dp}{dt}$$

$$F = \frac{dp}{dt}$$

$$F = \frac{d\,mv}{dt}$$

$$F = \frac{m\,dv}{dt} + \frac{v\,dm}{dt}$$

- If mass (m) is constant :- $\frac{dm}{dt} = 0$

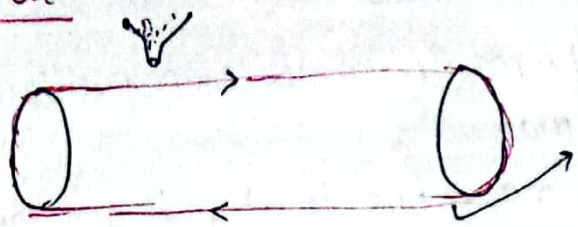
$$F = \frac{m\,dv}{dt} = ma$$

- If velocity is constant, $\frac{dv}{dt} = 0$

- $\boxed{F = \frac{v\,dm}{dt}}$ → Rocket propulsion

↓ Conveyers belt

- Conveyer's belt



10m/s sand is dropped at the rate of 0.5kg/s.

Q. Sand is dropped at the rate of 0.5 kg/s. What ext. Force is required to maintain the constant velocity of 10m/s?

$$F = v\frac{dm}{dt} = 10 \times 0.5$$
$$= 5N.$$

Q. The mass of rocket is 400 kg, it is set for vertical firing with speed 1000 m/s. What is the mass of fuel ejected per sec to supply the ~~1st~~ thrust needed to overcome the weight?

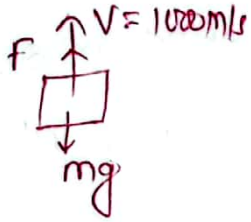
→

$$F = v\frac{dm}{dt}$$

$$mg = v\frac{dm}{dt}$$

$$400 \times 10 = 1000\frac{dm}{dt}$$

$$\therefore \boxed{\frac{dm}{dt} = 4\ kg/s}$$ Ans



→ Second law gives the measurement of force. (Quantitative defination).

→ Second law is most general law / real law.
  └ 1st & 3rd law is derived from 2nd law.

(3) 3rd law:- To every action, there is an opposite & equal rxn.

→ A pair of force ⇒ action & reaction.
  └ equal & opposite

but they donot cancel each other because they act on different body.

e.g. swimming on pool, walking on ground, firing of bullet, Flying of bird, rocket launching, boating, etc.

Q. A book lying on the table remains there till eternity is an e.g. of:-

(a) 1st law (b) 2nd law (c) 3rd law (d) Pascal's law

Q. A book lying on the table is an e.g. of:-

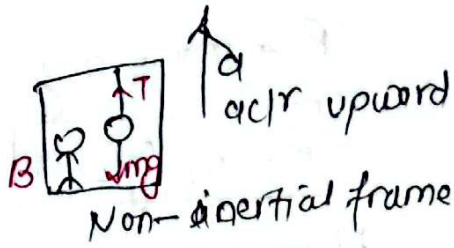
(a) 1st law (b) 2nd law (c) 3rd law (d) Pascal's law

└ force provided by book & table is equal & op.

Frame of reference

① Interial frame:- rest or constant velocity मा भएको frame.
acl^r → zero.

② Non-inertial frame:- acl^r $(a \neq 0)$. acl^red. motion.



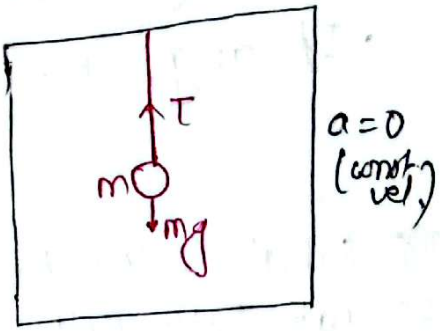
· Non-inertial frame
↓
pseudoforce
└ balances the equation.
└ act opposite to the direction of acl^r.



$T_A = mg + ma$

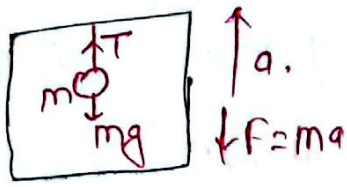
$T_B = mg$

① Lift is at rest or in uniform motion (moving with constant force)



$\boxed{T = mg}$ no acl^r → no pseudoforce. $(ma = 0)$

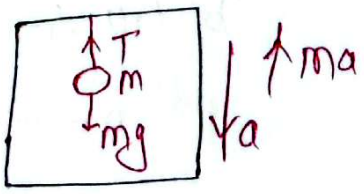
② Lift is acl^ring upward



$\boxed{T = mg + ma}$

$= m(g+a)$

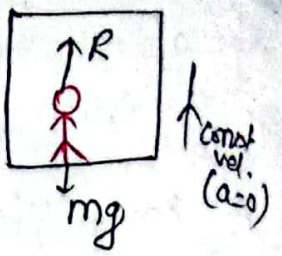
③ Lift is acl^ring downward



$T = mg - ma$ $(T + ma = mg)$

$\boxed{T = m(g-a)}$

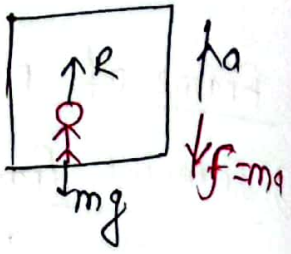
Man in a Lift



① Lift is at rest or moving constant velocity

$R = mg$ [no pseudoforce $(ma = 0)$]

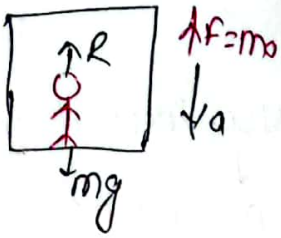
↳ normal rxn.



② Lift is accelerating upward

$R = mg + ma$

$\boxed{R = m(g+a)}$



③ Lift is accelerating downward

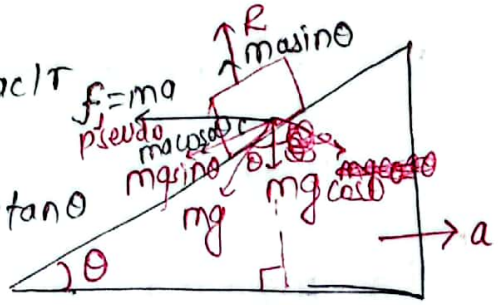
$R + ma = mg$

$\boxed{R = m(g-a)}$

- If $a < g$, R = +ve
- If $a = g$, $R = 0$ (weightlessness)
- If $a > g$, R = −ve (goes upward)
  (दाइको ceiling मा धोकिन्छ)

Q What is the minimum horizontal acl^n so that body falls freely?

(a) $g\sin\theta$ (b) $g\cos\theta$ (c) $g\cot\theta$ (d) $g\tan\theta$



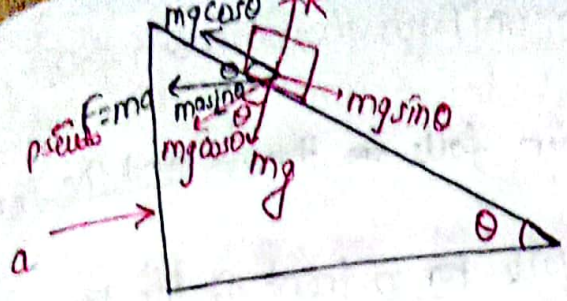
at eqm,

$R + ma\sin\theta = mg\cos\theta$

To fall freely, $R = 0$ (Body ले contact छोड्नु पर्यो)

$0 + ma\sin\theta = mg\cos\theta$

$\therefore \boxed{a = g\cot\theta}$



Q Body remains at rest with respect to the wedge, what should be the minimum horizontal acc^{n}

(a) $g\sin\theta$ (b) $g\cos\theta$ (c) $g\tan\theta$ (d) $g\cot\theta$

- To remain at rest;

$$ma\cos\theta = mg\sin\theta$$

$$a = g\frac{\sin\theta}{\cos\theta} = g\tan\theta$$

Conclusion

→ तल फुर्त रखने (contact cut हुने)

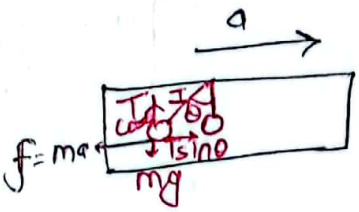
$$\boxed{a = g\cot\theta}$$

→ टासिराख्नलाई

$$\boxed{a = g\tan\theta}$$

± Accelerating Train

- Train is accelerating forward horizontally.



at eqm:

- Tsinθ balances ma ...(i)
- Tcosθ balances mg ...(ii)

$$\therefore T\tan\theta = \frac{a}{g}$$

$$\boxed{a = gT\tan\theta}$$

squaring & adding (i) & (ii)

$$T^2 = m^2(a^2+g^2)$$

$$\boxed{T = m\sqrt{a^2+g^2}}$$

$$\therefore T = mg_{eff}$$

$$\therefore \boxed{g_{eff} = \sqrt{a^2+g^2}}$$

$$\boxed{T = 2\pi\sqrt{\frac{l}{g_{eff}}}} = 2\pi\sqrt{\frac{l}{\sqrt{a^2+g^2}}}$$

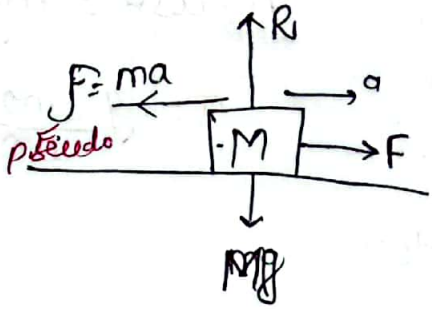
→ A bus or train is at rest or in uniform motion, coin falls on the thrower hand.

→ A train is accelerating forward, coin falls ~~on the~~ behind the thrower hand.

→ A train is deaccelerating, coin falls ~~for~~ in front of the throwers hand.

Pulling and Pushing force

① If pulling is horizontal

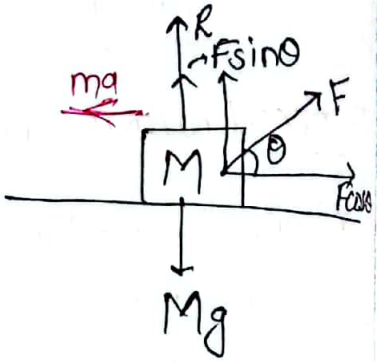


$$R = Mg$$

$$F = Ma$$

$$\therefore \boxed{a = \frac{F}{M}}$$

② If the pulling is acting at an angle θ with horizontal



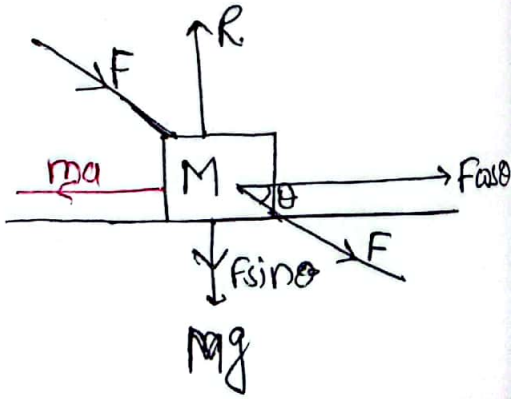
$$R + F\sin\theta = Mg$$

$$\boxed{R = Mg - F\sin\theta} < Mg$$

$$F\cos\theta = Ma$$

$$\boxed{a = \frac{F\cos\theta}{M}}$$

③ Pushing force is acting at an angle θ with the horizontal



$$\boxed{R = Mg + F\sin\theta} > Mg$$

$$F\cos\theta = Ma$$

$$\boxed{a = \frac{F\cos\theta}{M}}$$

* Pulling is easier than pushing.

Q. A body of mass 10kg is applied pulling force of 50N at an angle 30° with the horizontal. Find the normal rxn and acceleration produced?

$F = 50N$, $\theta = 30°$, $M = 10kg$

$\therefore R = Mg - F\sin\theta$ (in pulling)

$= 10\times10 - 50\times\frac{1}{2}$

$= 75N$.

$\therefore a = \frac{F\cos\theta}{M} = \frac{50\times\sqrt{3}}{2\times10}$

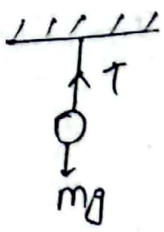
$= 2.5\sqrt{3}\ m/s^2$

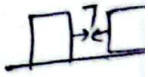
Contact Force ← Normal rxn, Tension

• **Normal rxn** :- Tries to compress the body.
→ act perpendicular to the surface of body in contact.
→ It may or may not balances the weight.



• **Tension** :- Tries to contract the string.
→ Tension act opposite to the system.
→ may or may not balances the weight.





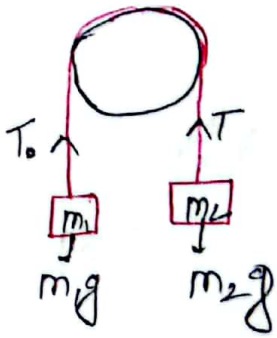
① If $m_1 = m_2$,

String same → Tension same.

$T = m_1g$, $T = m_2g$

$\boxed{T = m_1g = m_2g}$ — system is in equilibrium.

$(a = 0)$



• **Thrust** on pulley = $2T = 2m_1g$ or $2m_2g$

② If $m_2 > m_1$

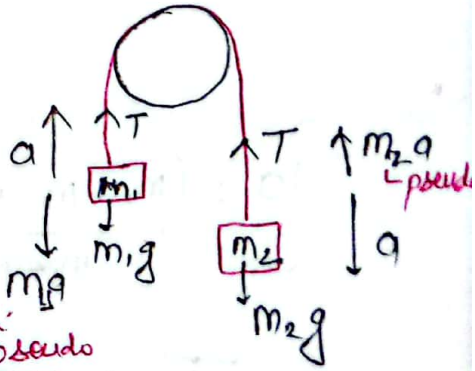
$T = m_1g + m_1a$

$T + m_2a = m_2g$

$T = m_2g - m_2a$

$\therefore m_1g + m_1a = m_2g - m_2a$

$\therefore \boxed{a = \frac{m_2g - m_1g}{m_1 + m_2}}$



$$T = m_1 g + m_1 a$$

$$= m_1 g + m_1 \left(\frac{m_2 g - m_1 g}{m_1 + m_2} \right)$$

$$= \cancel{m_1 g + m_1 m_2}$$

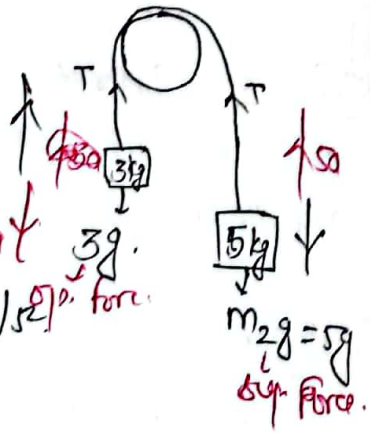
$$= \frac{m_1 g (M_1 + M_2) + m_1 m_2 g - m_1^2 g}{M_1 + M_2}$$

$$= \frac{\cancel{m_1^2 g} + m_1 m_2 g + m_1 m_2 g - \cancel{m_1^2 g}}{m_1 + m_2}$$

$$\boxed{T = \frac{2 M_1 M_2 g}{M_1 + M_2}} = (H.M)$$

Trick

$$\boxed{a = \frac{\text{supporting force} - \text{opposing force}}{\text{Total mass}}}$$



$$\therefore a = \frac{5g - 3g}{5 + 3} = \frac{2g}{8} = 5/2 = 2.5 m/s^2$$

$$T - 3a = 3g + 3g$$

$$= 3 \times 2.5 + 3 \times 10$$

$$= 37.5 N.$$

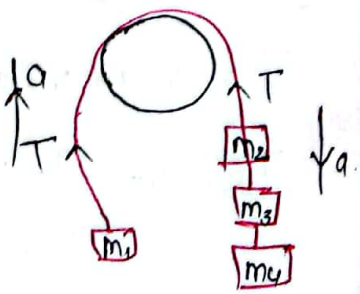
or, $T + 5g - 5a = 5g$

$$T = 5 \times 10 - 5 \times 2.5$$

$$= 37.5.$$

$\therefore$ ~~Tension~~

$$\boxed{a = \frac{(m_2 + m_3 + m_4) g - m_1 g}{m_1 + m_2 + m_3 + m_4}}$$

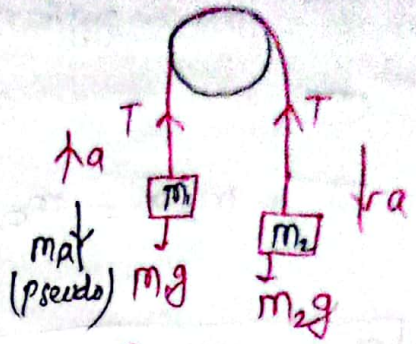


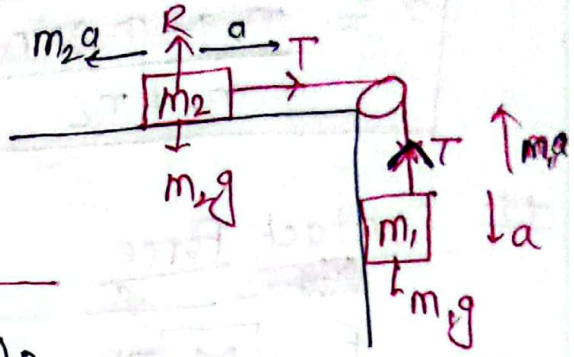
$$T = m_1 g + m_1 a.$$

or, $T + m_2 a + m_3 a + m_4 a = m_2 g + m_3 g + m_4 g$

$$a = \frac{m_2 g - m_1 g}{m_1 + m_2}$$

$$T = m_1 g + m_1 a$$





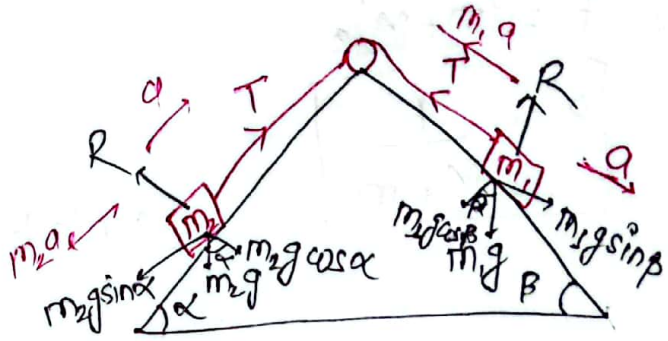
→ $T + m_1 a = m_1 g$

$T = m_2 a$

$\therefore m_2 a + m_1 a = m_1 g$

$$a = \frac{m_1 g}{m_1 + m_2}$$

$$a = \frac{m_1 g - (\text{no op.}) 0}{m_1 + m_2}.$$



→ If $m_1 = m_2$,

$\beta > \alpha$

$T = m_2 g \sin\alpha + m_2 a$ — (1)

$T + m_1 a = m_1 g \sin\beta$ — (ii)

$\therefore m_2 g \sin\alpha + m_2 a + m_1 a = m_1 g \sin\beta$

$a(m_1 + m_2) = m_1 g \sin\beta - m_2 g \sin\alpha$

$$\therefore a = \frac{m_1 g \sin\beta - m_2 g \sin\alpha}{m_1 + m_2}$$

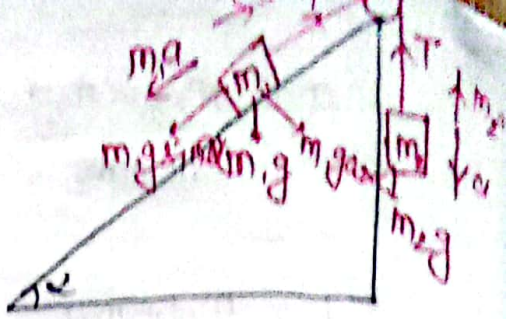
$\because a = \frac{\text{S.F} - \text{O.F}}{\text{tot mass}}$

$$= \frac{m_1 g \sin\beta - m_2 g \sin\alpha}{m_1 + m_2}.$$

$T = m_1 a + m_1 g \sin\alpha$ — (1)

or

$T + m_2 a = m_2 g$ — (11)



$$a = \frac{m_2 g - m_1 g \sin\alpha}{m_1 + m_2}$$

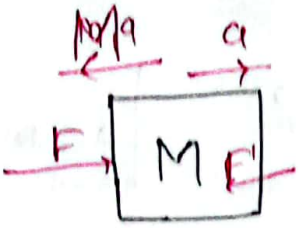
Contact Force



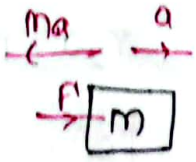
$F = ma + Ma$

$f = (m+M)a$

$$a = \frac{F}{M+m}$$



$F = F' + Ma$



$F' = ma$

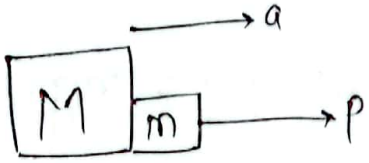
contact Force

$F' = ma$

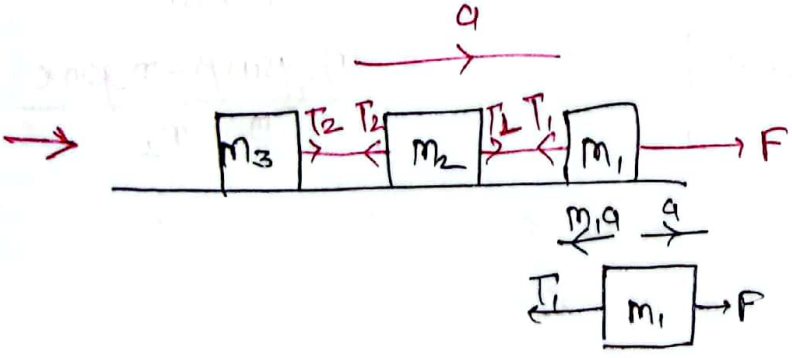
$$F' = m \cdot \frac{F}{m+M}$$

Trick

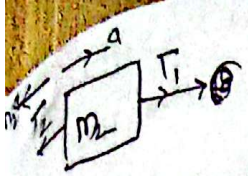
$$a = \frac{\text{applied force}}{\text{total mass}}$$

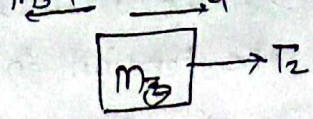


$$a = \frac{P}{M+m}$$



$F = T_1 + m_1 a$.





$T_1 = T_2 + m_2 a$ $\qquad$ $T_2 = m_3 a.$

$\because T_1 = m_3 a + m_2 a$

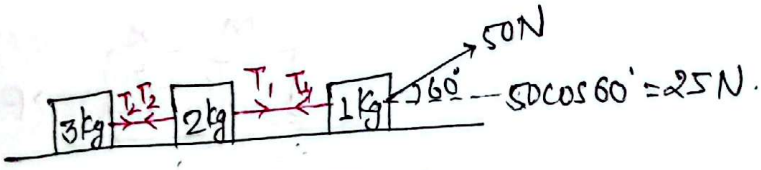
$\because F = m_3 a + m_2 a + m_1 a$

$$\therefore \boxed{a = \frac{F}{m_1 + m_2 + m_3}}$$

$$\because \boxed{T_2 = \frac{m_3 F}{m_1 + m_2 + m_3}} \qquad \boxed{T_1 = \frac{(m_2 + m_3) F}{m_1 + m_2 + m_3}}$$

Trick $\because$ $\boxed{T = \frac{\text{पछाडिका mass हरुको sum}}{\text{total mass}} \times \text{Applied force}}$

Q.



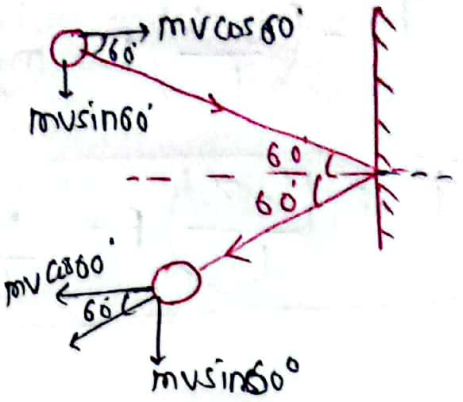
$a = ?$ $\quad T_1 = ?$ $\quad T_2 = ?$

- $a = \frac{F\cos\theta}{m_1 + m_2 + m_3} = \frac{50 \times \frac{1}{2}}{3+2+1} = 4.16\ m/s^2.$

- $T_1 = \frac{2+3}{3+2+1} \times 25 = \frac{5}{6} \times 25 = 20.5N.$

- $T_2 = \frac{3}{6} \times 25 = 12.5N.$

Q. A rigid ball of mass (m) strikes the rigid wall at 60° & gets reflected without the loss of speed. The value of impuse imparted by ~~Ball~~ the wall on the ball?



impulse = change in momentum

$= mv\cos 60° - (-mv\cos 60°)$

$= 2mv\cos 60°$

$= mv.$

Conservation of momentum

If $F_{ext} = 0$, then initial momentum = final momentum.

$$F = \frac{dp}{dt} = 0, \text{ so, } p \text{ is constant.}$$



before col. after col.

$p_{initial} = p_{final}$

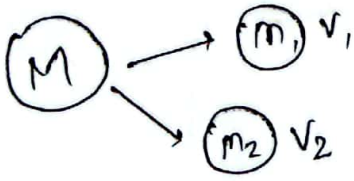
$$\boxed{m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2.}$$

$$m_1\frac{du_1}{dt} + m_2\frac{du_2}{dt} = m_2\frac{dv_1}{dt} + m_2\frac{dv_2}{dt}$$

$$f_1 + f_2 = f_1' + f_2'$$

→ also obey the newton's 3rd law.

- Stationary mass explode



→ init(0).

$0 = m_1v_1 + m_2v_2.$

$$\boxed{m_1v_1 = -m_2v_2}$$

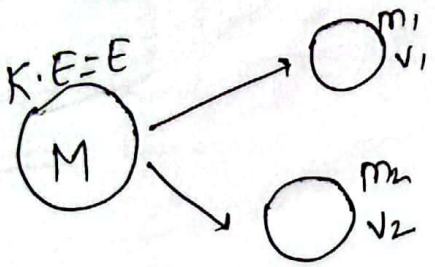
direction opposite

$\therefore V \propto \frac{1}{m}$

- **Recoiling of gun**

$0 = m_b v_b + m_g v_g$

$$v_g = \frac{-m_b v_b}{m_g}$$



$$KE_1 = \frac{m_2}{m_1+m_2} \times E$$

$$K.E_2 = \frac{m_1}{m_1+m_2} \times E$$

Q. $\rightarrow {}_{92}U^{235} \xrightarrow{5\,meV} {}_{2}\alpha^{4He} + {}_{90}X^{231}$

$$K.E_\alpha = \frac{m_\alpha}{m_\alpha + m_\alpha} \times E = \frac{231}{235} \times 5\,MeV.$$

Q. An explosion breaks rock into three parts in a horizontal plane. Two of them move perpendicular to each other. 1st part of mass 1 kg moves with velocity 12 m/s & 2nd part of mass 2 kg moves with velocity 8 m/s. If 3rd part flies off with velocity 4 m/s. Find the mass of 3rd?

(a) 2 kg (b) 3 kg (c) 4 kg ~~(d)~~ (d) 5 kg.



$0 = P_1 + P_2 + P_3$

$0 = m_1 v_1 \hat{j} + m_2 v_2 \hat{i} + P_3$

$0 = 1 \times 12\hat{j} + 2 \times 8\hat{i} + P_3$

$P_3 = \sqrt{12^2 + 16^2}$

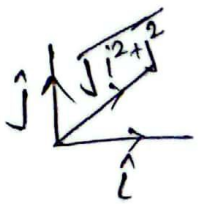
$P_3 = 20$

$m_3 v_3 = 20$

$\therefore m_3 = \frac{20}{4} = 5$ kg.

$P_3 = 16\hat{i} + 12\hat{j}$

$= \sqrt{16^2 + 12^2}$



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