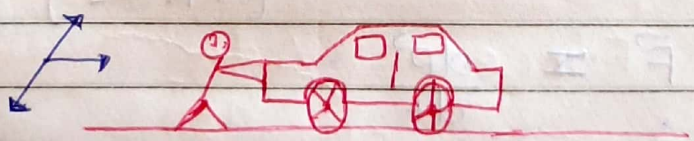
3. Newtons Law of motion

The great scientist newtons defined 3 law of motion to describe the motion of particle . These theee laws aee as Follow:

1. Laws of inertia: According to 1^{st} law of newton only external forces are responsible to change the state body. If A body at rest it remain rest if its in motion then continue to move untill an external force acting on it. These laws define inertia of the body which is the mass of the body.

★ These law define the requirement of force as well to change the state of the body.

The internal forces can not change the state of the body only external forces can change the state of body. as explained below:



① 1^{st} Law in mathematic Form

$$F_{ext.} = MA$$

If $F_{ext.} = 0$, $\vec{a} = 0$.

$\because \vec{a} = 0$

Rest ($V = 0$) | $V = k$ constant.

★ If $\vec{a} = 0$ then $\vec{F} = 0$.

★ If $V = const. \Rightarrow a = 0$ $\vec{F} = 0$.

② 2nd Laws of motion: According to these law of motion the rate of change of momen[tum] of a body or system is directly proportion[al] to external Force act on it.

$$\vec{F} \propto \frac{d\vec{p}}{dt} \quad \text{(Where } P = \text{momentum)}$$

$(\because k = 1)$

$$\vec{F} = \frac{d\vec{p}}{dt}$$

★ momentum : The product of mass & velocity of an object is called momentum it's represented by $\vec{p}$.

$m \bullet \longrightarrow \vec{v}$

$\vec{p} = m\vec{v}$ MLT^{-1} $kg\,m\,s^{-1}$

Application

$$\vec{F} = \frac{d\vec{p}}{dt}$$

$$\vec{F} = \frac{d(m.\vec{v})}{dt}$$

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

Case I : $\vec{F} = \frac{m d\vec{v}}{dt} + \frac{\vec{v} dm}{dt}$

If m = constant $\therefore \frac{dm}{dt} = 0$

$$\boxed{\vec{F} = \frac{m d\vec{v}}{dt}}$$

Case II : If $m \neq$ constant v = constant

$\therefore \frac{dv}{dt} = 0$

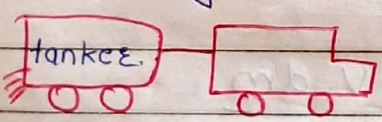
$$\boxed{\vec{F} = \frac{\vec{V} dm}{dt}}$$

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

$F_{ex} = ma$

500kg. 1000 N.

2kg/s



V.

$$a = \frac{F}{m} = \frac{1000}{500} = 2ms^{-1}$$

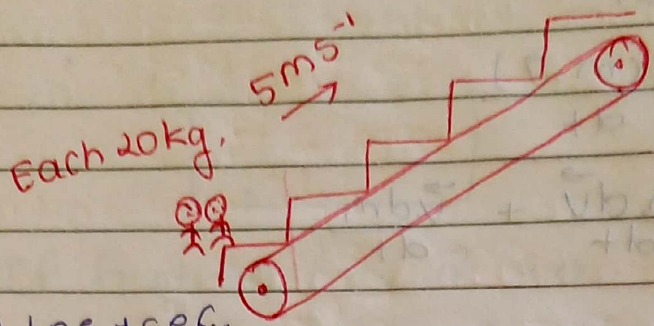
after 125sec.

$125 \times 2 = 250kg$

$$a = \frac{F}{(500-250)} = \frac{1000}{250} = 4ms^{-1}$$

Question.

①



after 1sec.

force = $\frac{V.dm}{dt}$

= 5 × 40

= 200 Newton.

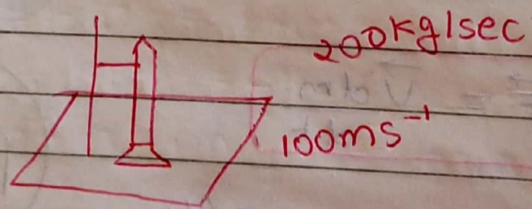
∴ force exerted by elivator will be 200 N

power = F.V.

= 200 × 5

= 1000 watts

②



Force = $\frac{V.dm}{dt}$

= 100 × 200

force = 20,000 N

∴ Force exerted by rocket is 20,000 Newton

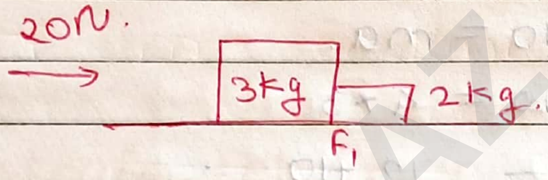
Application of 2^{nd} law.

(i) Accn. is same for all.

(ii) $a = \dfrac{F}{\Sigma m}$

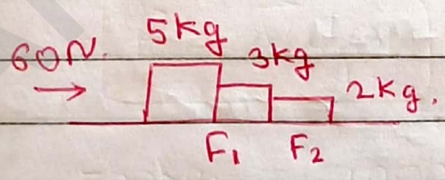
(iii) Any force = (mass (m) motion due to that force)

Question

1. 

$$a = \frac{20}{5} = 4 ms^{-1}$$

$$F_1 = 2 \times 4$$
$$F_1 = 8N.$$

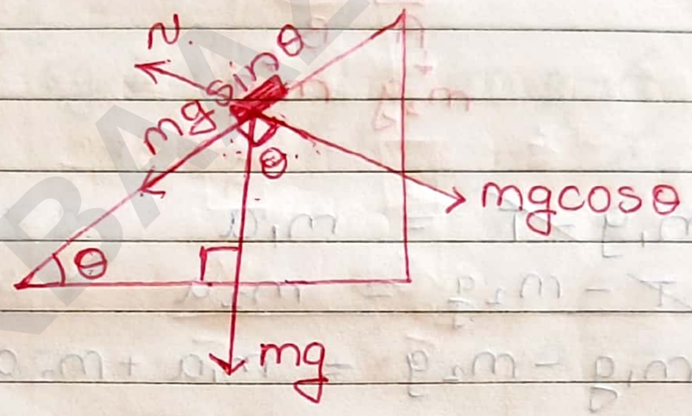
2. 

$$a = \frac{60}{10} = 6 ms^{-1}$$

$$F_1 = 5 \times 6 = 30N$$

$$F_2 = 2 \times 6 = 12N.$$

3. Inclined plane: If the motion of the plane on a body is inclined at angle of θ with horizontal then such plane is known as inclined plane.



4, Constrain relation: If two or more than two object are connected with each other by string or rod & movable pullies such system are known as constrain relation.

Mainly we discuss 7 type of constrain.

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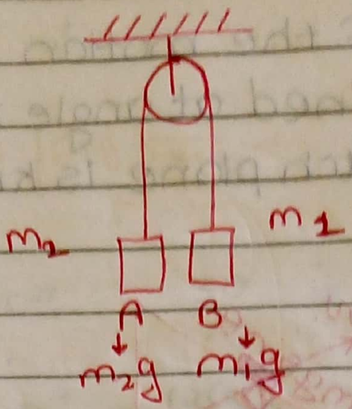


$$m_1 g - T = m_1 a$$
$$+ \quad T - m_2 g = m_2 a$$
$$m_1 g - m_2 g = m_1 a + m_2 a$$

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

MTR

$$\therefore acc^n = \frac{(m_1 - m_2) g}{m_1 + m_2}$$

$$m_1 g - T = m_1 a$$
$$- \quad -T \mp m_2 g = -m_2 a$$
$$-2T + m_1 g + m_2 g = m_1 a - m_2 a$$

$$-2T = \frac{(m_1 - m_2) a}{(m_1 + m_2) g}$$

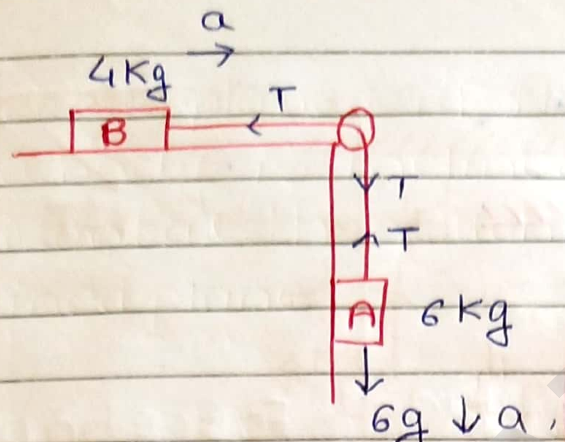
$$-2T =$$

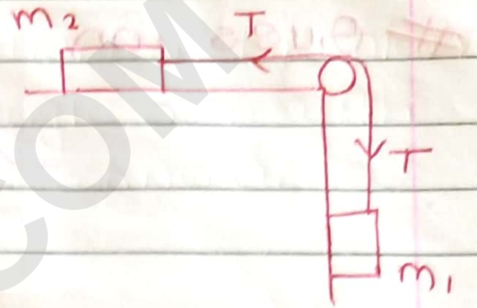
substitute these value of acc^n. in eq^n

MTR

$$T = \frac{(2 m_1 m_2) g}{m_1 + m_2}$$

#





$$m_1 g - \cancel{T} = m_1 a$$
$$\cancel{T} = m_2 a$$
$$m_1 g = (m_1 + m_2) a$$

MTR

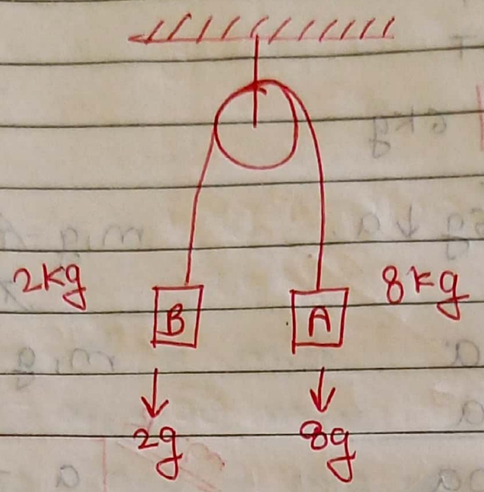
$$\boxed{a = \frac{m_1 g}{m_1 + m_2}}$$

$$6g - \cancel{T} = 6a$$
$$\cancel{T} = 4a$$
$$6g = 10a$$
$$6 \times 10 = 10a$$
$$a = \frac{6 \times 10}{10}$$
$$a = 6 ms^{-2}.$$

MTR

$$\boxed{\text{Tension} = \frac{m_1 m_2 g}{m_1 + m_2}}$$

Question



MTR

$$\text{accn} = \frac{F_{net}}{\text{mass.}}$$

Ans:

$F_{net} = 8g - 2g = 6g = 6 \times 10$

$= 60$ Newton

mass $= 8kg + 2kg = 10kg.$

$\therefore \text{accn.} = \frac{60}{10}$

accn. $= 6 m/s^2.$

Force on puli = 2 × tension

MTR

$F_{puli} = 2 \times T$

$= 2 \times 32$

$\therefore F_{puli} =$ ~~280~~ 64N

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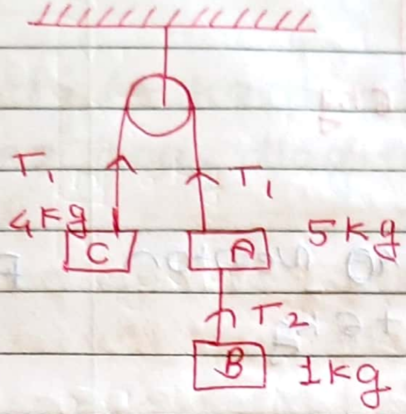

Ans: $accn. = \frac{F_{net}}{mass}$

$= \frac{6g - 4g}{4+1+5}$

$= \frac{2 \times 10}{10}$

$\therefore accn = 2 ms^{-2}$

$T_1 - 4g = 4 \times 2$

$T_1 = 4 \times 2 + 4 \times 10$

$T_1 = 8 + 40$

$\therefore T_1 = 48 Newton.$

Force on puli $= 2 \times T_1$

$= 2 \times 48$

$= 96N.$

$1g - T_2 = 1 \times 2$

$T_2 = 10 - 2$

$T_2 = 8N$

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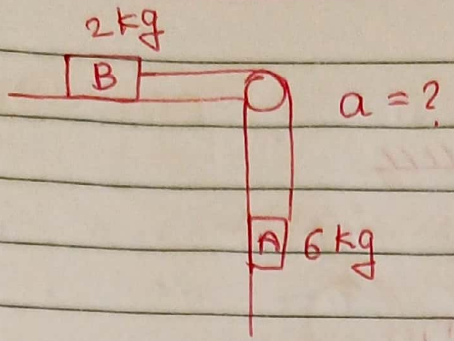
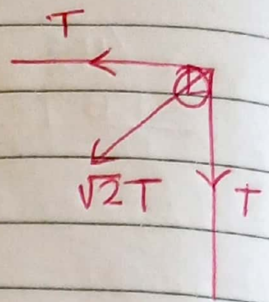




accn. = $\frac{6 \times 10 \text{ Newton}}{2+6 \text{ kg}}$

= $\frac{60}{8}$

= $7.5 \, ms^{-2}$

Tension = $m \times a$

= 2×7.5

= 15N.

Force on puli = $\sqrt{2}T$

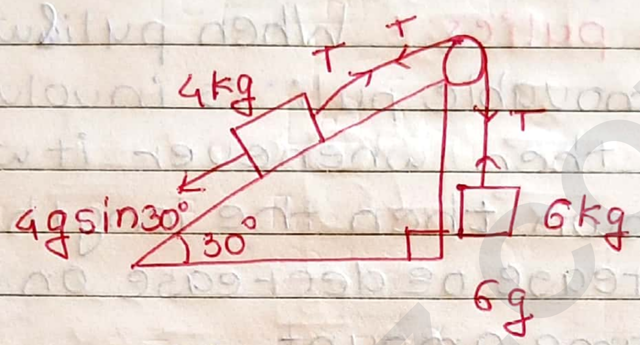
∴ $15 \times \sqrt{2}$

= 15×1.41

F_{puli} = 21.15 newton

3. Inclined Plane

It a body is kept on inclined plane. then its free body diagram will be as under given below.



A] $T - 4g \times \frac{1}{2} = 4a$ — (1)

B] $6g - T = 6 \times a$ — (2)

$6g - 2g = 10a$

$4g = 10a$

$4 \times 10 = 10 \times a$

$a = \frac{4 \times 10}{10}$

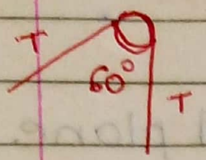
$a = 4\,ms^{-1}$

$6g - T = 6 \times a$

$6g - T = 6 \times 4$

$60 - 24 = T$

$T = 36$



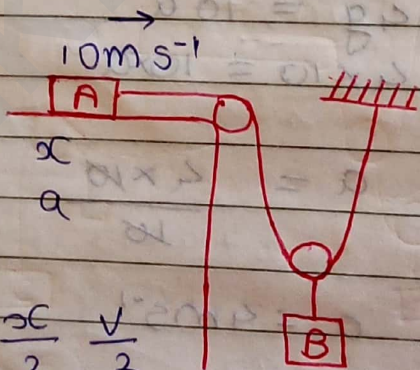
Force on puli $= T\sqrt{3}$

$= 36\sqrt{3}$

4. Movable pulies : When puli & wedge constrain
It any movable puli is involved in a system then whenever it will move up or down then the length of string will increase or decrease on both side by the same amount.

1] slacking method we can find the releation between diffenent bodies as explained below.

(1)



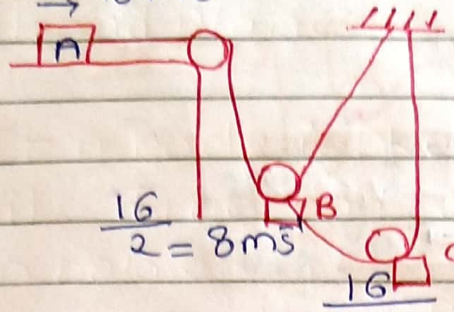
$\frac{a}{2}$ $\frac{x}{2}$ $\frac{v}{2}$

i.e. $\frac{10}{2}$

$B = 5\ m s^{-1}$

②

$\rightarrow 16\,ms^{-1}$



$\frac{16}{2} = 8\,ms^{-1}$

$\frac{16}{2\times 2} = 4\,ms^{-1}$

$\therefore C = 4\,ms^{-1}$

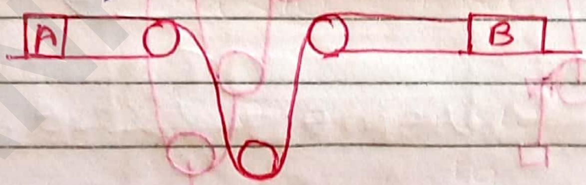
③

$6\,ms^{-1} \rightarrow$ $\leftarrow 4\,ms^{-1}$

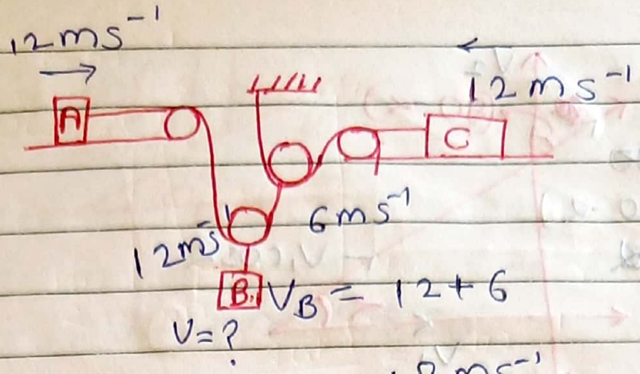
$\frac{6+4}{2} = 5\,ms^{-1}$

④

$6\,ms^{-1} \rightarrow$ $4\,ms^{-1} \rightarrow$



$\frac{6-4}{2} = 1\,ms^{-1}$

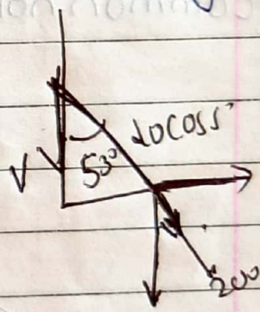
3. 

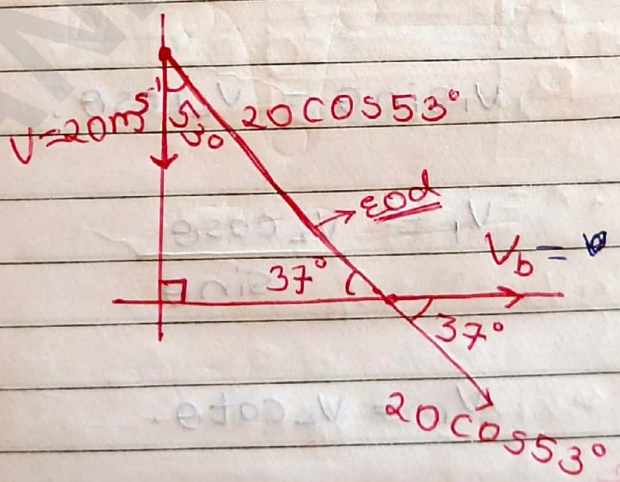
$V_B = 12 + 6$

$= 18\,ms^{-1}$

5. Rond constrain

For any rod placed beside wall suddenly start sleeping down hense to calculate the velocity of 2nd and we will be the concept that " The distance between any two point of the rod will remain constant". means the velocity of end points along the rod will be same.



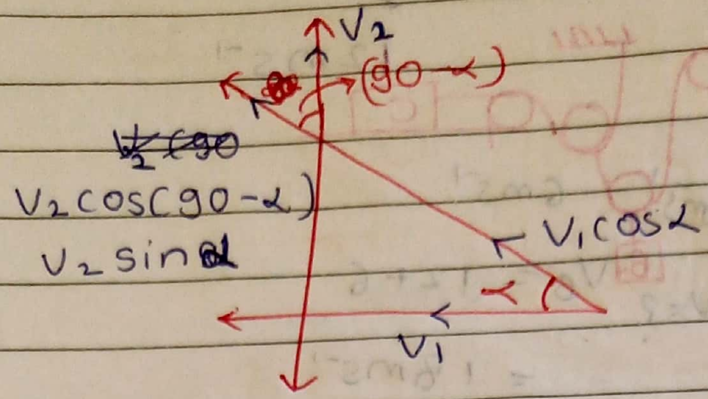


$V_b = 15\,ms^{-1}$

$$20 \times \frac{3}{5} = V_b \times \frac{4}{5}$$

$$V_b = \frac{4 \times 3 \times 5}{4}$$

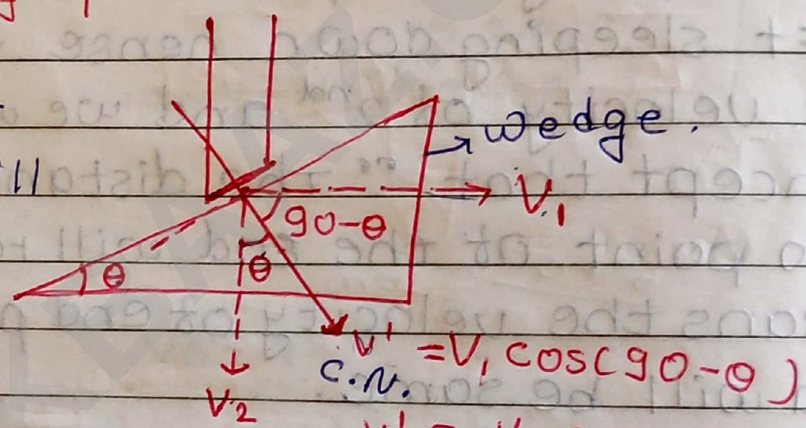
$$\therefore V_b = 15\,ms^{-1}$$



$\therefore V_1\cos\alpha = V_2\sin\alpha.$

Rod & wedge problem:

Velocity of rod & wedge will be same along the common normal



$V_1\sin\theta = V_2\cos\theta.$

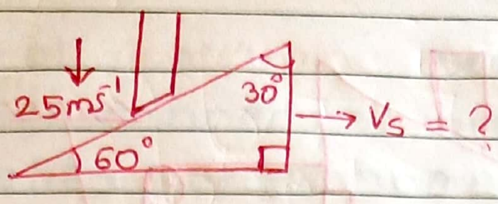
$V_1 = \frac{V_2\cos\theta}{\sin\theta}$

$V_1 = V_2\cot\theta.$

MTR

$\therefore V_w = V_2\cot\theta.$

①

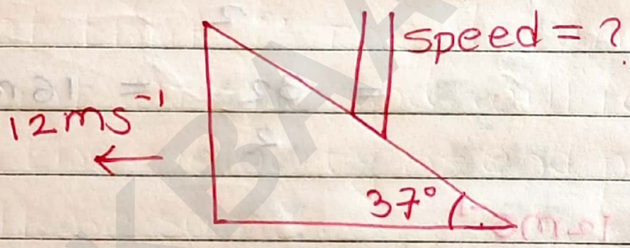


$V_s = 25 \cot 60°$

$= 25 \times \frac{1}{\sqrt{3}}$

$V_w = \frac{25}{\sqrt{3}}$

②



$V_w = V_2 \cot\theta$

$V_w = V_E \cot 37°$

$12 = V_E \cot 37°$

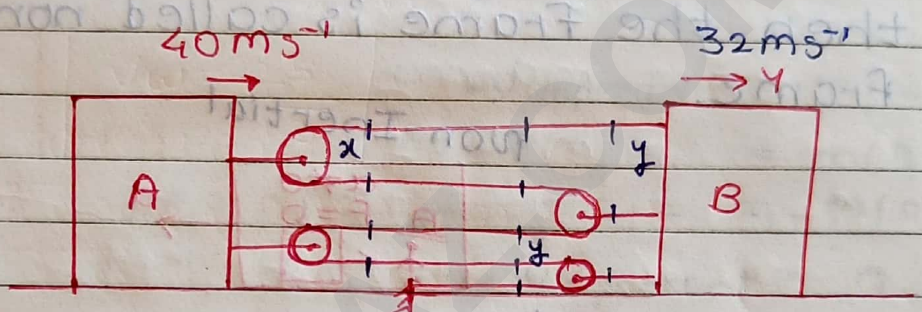
$V_E = \frac{12 \times 3}{4}$

$V_E = 9 m/s$

∴ Velocity of rod is 9m/s.

Horizontal Constrain:

some times the blocks are connected with each other by many pulies hense one of them is moving with certain velocity then calculate the velocity of other bodies we will use the concept that "Total length of the string will be constant" as explain below:



$$4x = 5y$$

$$4\frac{dx}{dt} = 5\frac{dy}{dt}$$

$$4V_A = 5V_B$$

$$\frac{4V_A}{5} = V_B$$

$$V_B = \frac{4}{5} \times 40 \; 8$$

$$\boxed{\therefore V_B = 32ms^{-1}}$$

$4x = 5y$

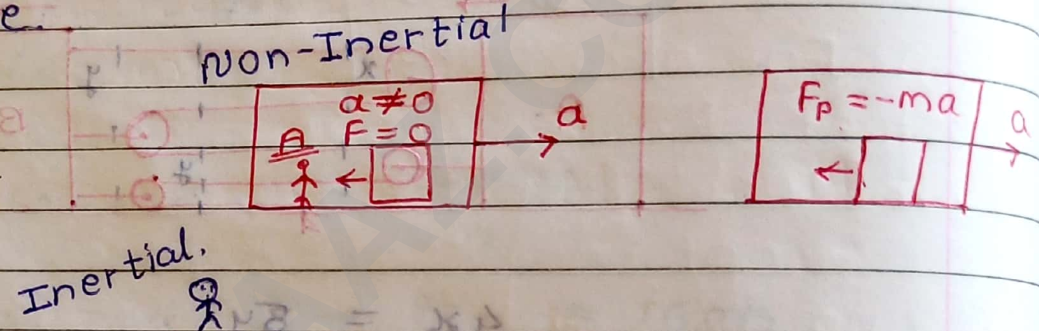
$V_A - V_B = ?$

$40 - 32 = 8ms^{-1}$

Inertial and non-Inertial Frame

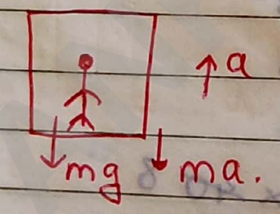
If any even can be explained on the bases of law of inertia and that frame is called inertial frame or

In a frame the value of force is zero on a body but accn. is non-zero then the frame is called non-enertial frame.



Weight in a lift.

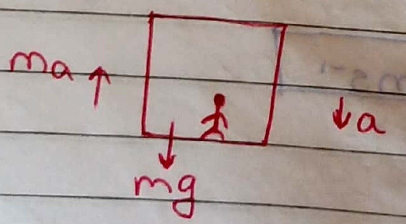
1\.



$W = mg + ma$

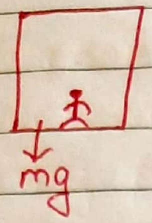
$\therefore W = m(g+a)$

2\.



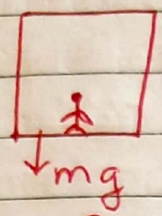
$W = mg - ma$

$W = m(g-a)$

3. 

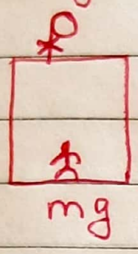
↑ V = const
∴ $a = 0$

$W = mg$

4. 

↓ V = const.
∴ $a = 0$

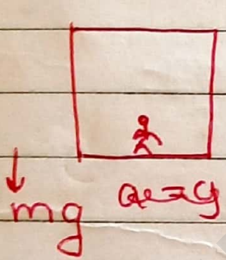
$W = mg$

5. 

↓ mg

$W_{apperant} = mg - mg$
$= m(g-g)$
$= m(0) = 0.$

∴ $W_{apperant} = 0$

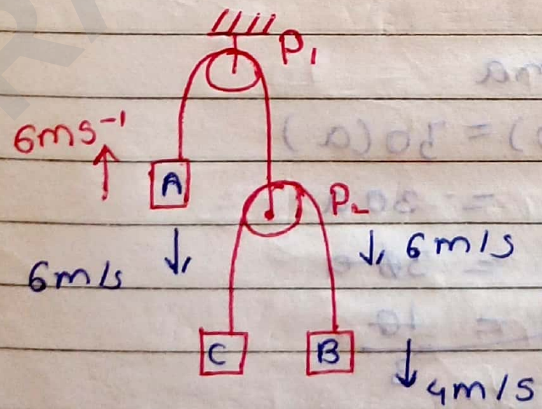
6. 

$a > g$

↑ ma

In these case the man will be strike the uppeside of lift.

Multiple pulies



$V_1 + 6$

$2 + 6 = 8$

$V_1 = 6 - 4$
$= 2 m/s$

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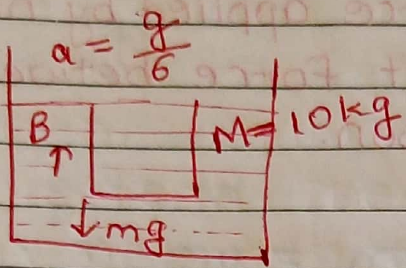
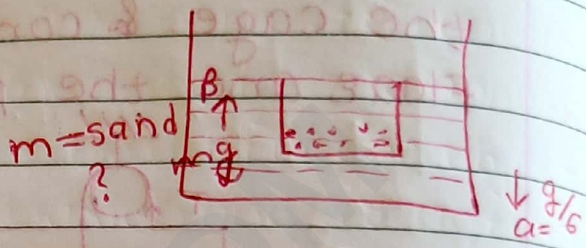
Addition and Substraction of the weight





$$B - Mg = M\frac{g}{6}$$

$$(M+m)g - B = (M+m)\frac{g}{6}$$

$$-Mg + Mg + mg = \frac{Mg}{6} + \frac{Mg}{6} + \frac{mg}{6}$$

$$mg = \frac{Mg}{3} + \frac{mg}{6}$$

$$mg - \frac{mg}{6} = \frac{mg}{3}$$

$$\frac{5mg}{6_2} = \frac{mg}{3}$$

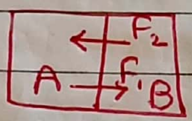
$$\frac{5}{2}m = 10$$

$$m = \frac{10 \times 2}{5}$$

$$m = 4$$

3^{rd} daw of motion (Law of action reaction)

According to this law every ~~law~~ reaction has equal and opposite reaction & they are equal in magnitude and opposite in directenn. They act on different object then we cannot say which one is action & which one is reaction.



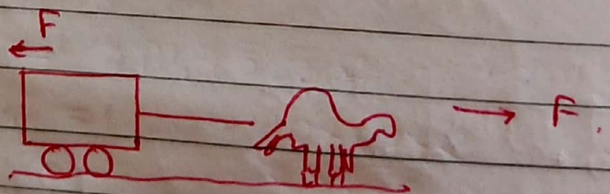
$$\vec{F_1} = -\vec{F_1}$$

$$\therefore F_1 + F_1 = 0$$

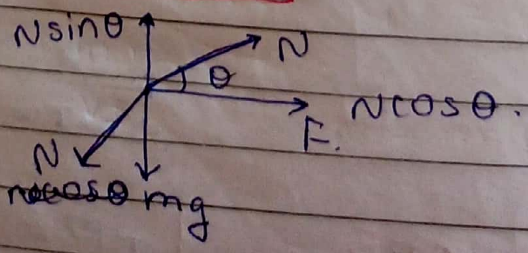
$$\therefore |F_1| = |F_2|$$

∴ Which is action / reaction can't be determine.

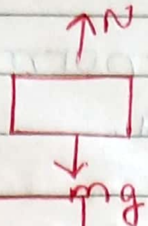
∴ They will act on diff. bodies.



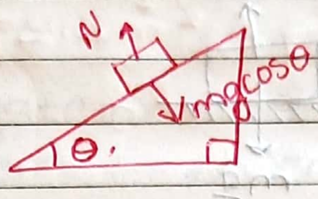
$F = m_c \times a$,



$$a = \frac{N\cos\theta}{m_H + m_c} \quad — (1)$$



$$\boxed{N = mg}$$



$$\boxed{N = mg\cos\theta}$$

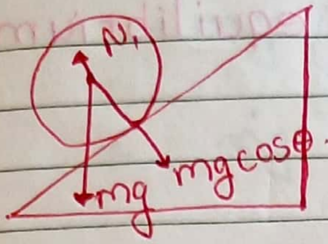
Normal reaction

1. When two surfaces are in contact. and they will apply they force on each other so as system the net force will be zero.

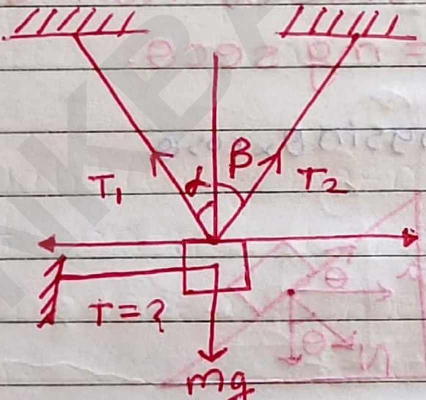
2. qualitively normal represent the degree of contact between the two surfaces more is the normal means bodies are well in touch.

3. If the normal between the bodies decreases it means the degree of contact is reduce.

4. If a contact between two bodies becomes zero it means normal become. zero. ∴ they will be not in contact

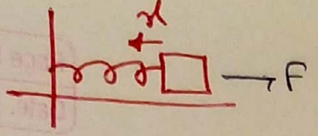


IF any system the body is in equilibrium or the system is in equilibrium then the net force on it will be zero. means forces along the x-direction will be balanced & also y-direction. As explained below:



$$T + T_1 \sin\alpha = T_2 \sin\beta$$

$$T_1 \cos\alpha + T_2 \cos\beta = mg$$



$F \propto -x$

$F = -kx$

$|k| = \frac{F}{x}$

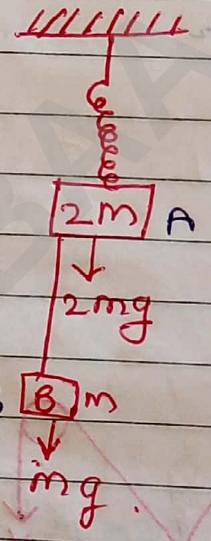
$k = F$ if $x = 1$ meter

if $k = 100\,N/m$

Spring system

To solve such system following steps are used

1] Write the equilbruim condition
2] Aftering cutting spring / string Write the net Force on it
3] Just after the cutting tension become zero so we can calculate the net force on it as explain below.



$kx_0 = 2mg + T$

$= 2mg + mg$

$\therefore kx_0 = 3mg$

$T = mg$

$a_A = \frac{3mg - 2mg}{2m}$

$= \frac{mg}{2m}$

$a_A = \frac{g}{2}$