CHAPTER 04

DYNAMICS

↳ The branch of mechanics which deals with the study of the motion of the objects with talking into the account of the cause of the motion in the objects.

First law of Newton's:-

↳ It state that, "Every body continue in it's state of rest or of uniform motion in a straight line. Unless it is compelled (act) by some external force."

Force:-

↳ Force is an external agency which change or tends to change the state of rest or uniform motion of a body. It is denoted by F and given by;

$F = ma$

Where, m = mass and a = acceleration

And it is a vector quantity. It's unit is $kgms^{-1}$ (N).

☆ Effect of force:-

* It change the state of body.
* It change the speed of body.
* It change the direction of body.
* It change the shape of body.

☆ First law gives defination of force:-

↳ According to the first law, "Force is an external agent that change or tends to change the state of rest or uniform motion of a body which is defination of force.

★ First law is also gives or Called law of inertia:-
↳ The inability of a body to change the State of rest or of uniform motion by itself is Called inertia.
According to newton's first law of motion, A body is unable to change it's State of rest or of uniform motion without any external force.
So, first law and law of inertia are equivalent each other.

5Q> The dust fall down when Cloth are beaten with Stick?
→ Before the cloth is beaten both dust and cloth are in rest. After cloth is beaten cloth is in motion and dust want to be in rest. So dust fall down when cloth are beaten.

Second law of Newton's:-

↳ It state that, "The force acting on any body is directly proportional to it's rate of change of momentum".

i.e,
$$F \propto \frac{dp}{dt}$$

$$\text{or, } F = K\frac{dp}{dt}$$

Where, k is proportionality constant whose value is equal to 1.

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

Since, $P = mv$

$$\text{or, } F = \frac{d(mv)}{dt}$$

$$\text{or, } F = m\frac{d(v)}{dt}$$

Since, $a = \frac{dv}{dt}$

$$\therefore \boxed{F = ma}$$

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Since, $a = \frac{dv}{dt}$

$$\therefore \boxed{F = ma}$$

Third law of Newton's:-

↳ It states that, "Every action there will be equal and opposite reaction."

5Q) If action and reaction are equal and opposite then why can cancel each other?

→ For example the gun is fired where equal & opposite in bullet takes place action and to plung takes place reaction. here action and reaction are act in different two bodies. Hence, They Somotime Cancel each other.

5Q) When a ballon filled with air and its mouth downwards is released, it moves upwards, why?

→ According to Newton's third law, "every action there will be equal and opposite reaction". Here when a ballon filled with air and its mauth downwards released because when released air moves downward is action and after released it moves upward is reaction. So, when air filled ballon's mouth is released, it moves upwards.

momentum:-

↳ The momentum is defined as the total quantity of motion contain in a body and it is equal to the product of mass and velocity.

i.e, momentum = mass × velocity

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

It is a vector quantity and it's unit is $kgms^{-1}$.

V.Imp :-

Principle of Conservation of linear momentum:-

↳ It state that, "If no external force act on a system of interacting particle then total linear momentum of the system remains constant."

From newton's second law,

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

If $F=0$ then, $\frac{dP}{dt} = 0$

$$\Rightarrow P = \text{Constant}$$

★ proof:

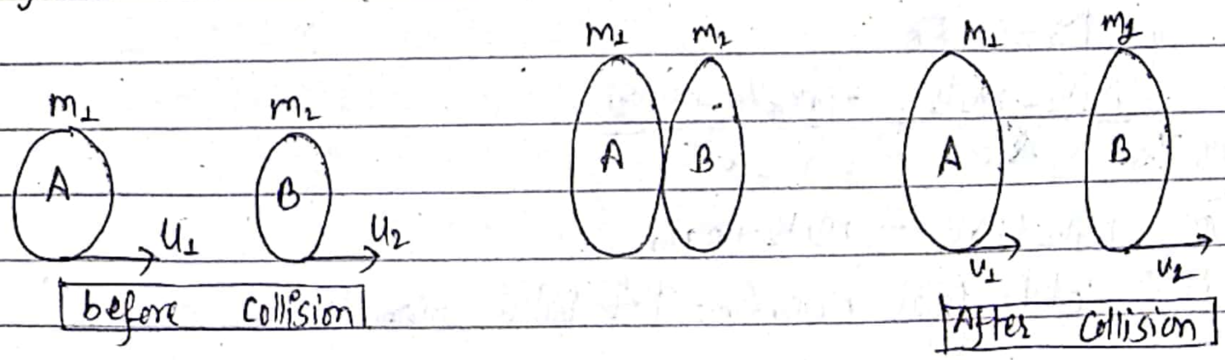


fig: Collision between two sphase.

★ proof:

Let us consider two bodies A & B with masses m_1 & m_2 moving with initial velocities u_1 & u_2 ($u_1 > u_2$). Suppose the collides with each other for small time Δt, then after collision their velocities becomes v_1 & v_2 respectively;

Now,

Initial momentum of body A $= m_1 u_1$

Final momentum of body A $= m_1 v_1$

Initial momentum of body B $= m_2 u_2$

Final momentum of body B $= m_2 v_2$

Again,

change in momentum of body A $= m_1 v_1 - m_1 u_1$

change in momentum of body B $= m_2 v_2 - m_2 u_2$

Then;

According to newton's second law,

Force acting on body A

$$F_A = \frac{\text{change in momentum}}{\text{time taken}}$$

$$F_A = \frac{m_1 v_1 - m_1 u_1}{\Delta t}$$

Similarly

$$F_B = \frac{m_2 v_2 - m_2 u_2}{\Delta t}$$

Also, From third law of Newton's;

$$F_A = -F_B$$

or, $$\frac{m_1 v_1 - m_1 u_1}{\cancel{\Delta t}} = \frac{-(m_2 v_2 - m_2 u_2)}{\cancel{\Delta t}}$$

or, $m_1 v_1 + m_2 v_2 = m_1 u_1 + m_2 u_2$

i.e, total final momentum = Total initial momentum.

Which proves principle of conservation of linear momentum.

problem of mass and pulley:-

For body m_1:
$F = m_1g - T$

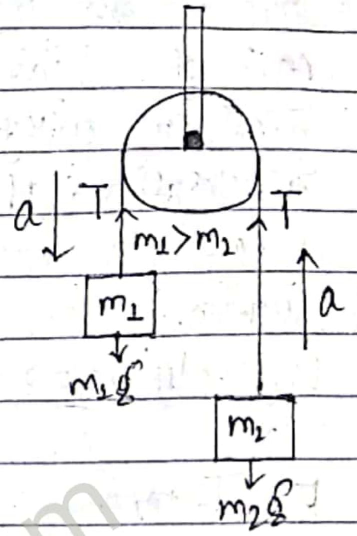
For body m_2:
$F = T - m_2g$

Since, $F = m_1a$

Since, $F = m_2a$

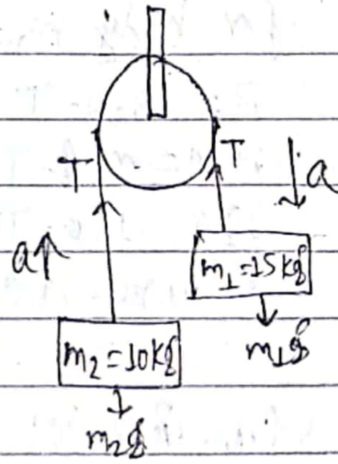
$\therefore \boxed{m_1a = m_1g - T}$

$\therefore \boxed{m_2a = T - m_2g}$



1.Q.[5A] In the Atwood's machine in the given figure, the system starts from rest. What is the acceleration of the given mass?

☆ Soln:



For body $m_1 = 15$ kg;
$F = m_1g - T$
or, $m_1a = m_1g - T$
or, $15a = 150 - T$
or, $T = 150 - 15a$ --- (i)

For body $m_2 = 10$ kg;
$F = T - m_2g$
or $m_2a = T - m_2g$
or $10a = T - 100$
or, $T = 10a + 100$ —— (ii)

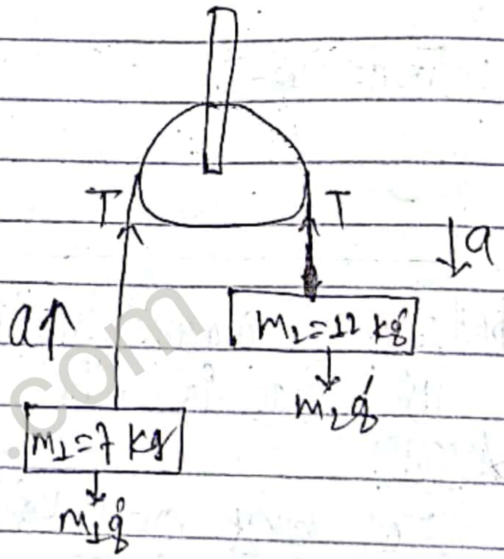
from eqn (i) & (ii), we get;
$150 - 15a = 10a + 100$
or, $50 = 25a \Rightarrow a = 2\ ms^{-2}$

Hence, acceleration is $2\ ms^{-2}$. #

LQ[50] Two masses 7 kg and 12 kg are connected at the two ends of light inextensible string the passes over a frictional pulley. Using free diagram method, find the acceleration of masses and the tension in the string when the masses are leased?

★ Solution:

For body $m_1 = 7\ kg$;



$F = T - m_1 g$

or, $m_1 a = T - m_1 g$

or, $7a = T - 70$

or, $T = 7a + 70$ ——(i)

For body $m_2 = 12\ kg$;

$F = m_2 g - T$

or, $m_2 a = m_2 g - T$

or, $12a = 120 - T$

or, $T = 120 - 12a$ ——(ii)

From (i) & (ii);

$7a + 70 = 120 - 12a$

or, $19a = 50$

$\Rightarrow a = 2.63\ ms^{-2}$

Again, From eqn (i),

$T = 7(2.63) + 70$

$\therefore T = 88.42\ N$

Hence, acceleration is $2\ ms^{-2}$ and tension in string is 88.42 N. #

LQ. [5C] A ball A of mass 0.1 kg moving with a velocity of $6\,ms^{-1}$ collides directly with a ball B of mass 0.2 kg at rest. Calculate their common velocity if both balls move off together. If A had rebounded with a velocity of $2\,ms^{-1}$ in the opposite direction after collision, what would be the new velocity of B?

SOLUTION:-

Let, Mass of ball A $(m_a) = 0.1$ kg

Initial velocity of ball A $(u_a) = 6\,ms^{-1}$

Mass of ball B $(m_b) = 0.2$ kg

Initial velocity of ball B $(u_b) = 0$

(I) Their common velocity $(v) = ?$

(II) after rebounded new velocity of B $(v'_b) = ?$

Now;

(I) Their common velocity $(v) = ?$

We have, $m_a u_a + m_b u_b = (m_a + m_b) v$

or, $[0.1 \times 6] + [0.2 \times 0] = (0.1 + 0.2) v$

or, $0.6 = 0.3 v$

$\therefore \boxed{v = 2\,ms^{-1}}$

Thus, their common velocity if both balls move off together is $2\,ms^{-1}$. #

(II) $v_a = -2\,ms^{-1}$, $v'_b = ?$

We have, $m_a u_a + m_b u_b = m_a v_a + m_b v_b$

or, $[0.1 \times 6] + [0.2 \times 0] = [0.1 \times -2] + [0.2 \times v'_b]$

or, $0.6 + 0.2 = 0.2\, v'_b$

$\therefore \boxed{v'_b = 4\,ms^{-1}}$

Hence, If A had rebounded new velocity of B would be $4\,ms^{-1}$. #

Apparent weight :-

↳ The reaction of machine on a person is called apparent weight.

Case I: When lift is moving upwards:

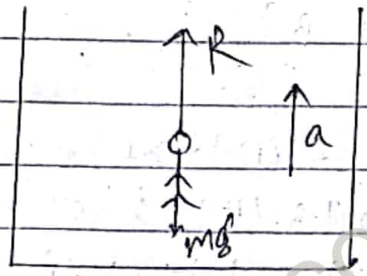
In this case,

$F = R - mg$

Since, $F = ma$

$ma = R - mg$

$\therefore \boxed{R = mg + ma}$



Hence, apparent weight increase when lift moves upward.

Case II: When lift is moving downward:

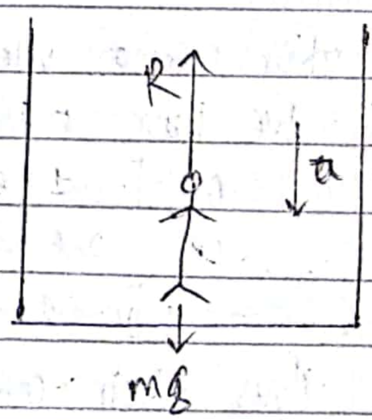
In this case,

$F = mg - R$

Since, $F = ma$

$ma = mg - R$

$\therefore \boxed{R = mg - ma}$

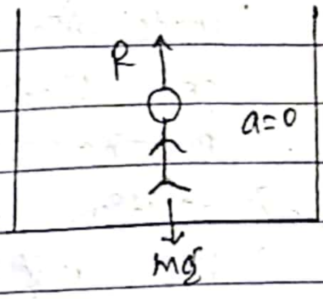


Hence,

Apparent weight decrease when lift moves downward.

Case III: When lift is at rest or moving with constant velocity:-

In this case,
When lift is at rest acceleration due to gravity is 0 i.e, $a = 0$
and $\boxed{R = mg}$



Hence, Apparent weight is equal to actual weight when lift is at rest or moving with constant velocity.

LQ-[53] A lift moves (1) up and (2) down with an acceleration of $2 ms^{-2}$. In each case, Calculate the reaction of the floor on a man of mass 50 kg standing in the lift

☆ Solution:-

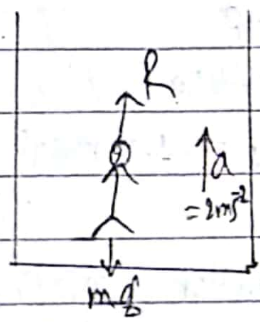


fig: moving upward

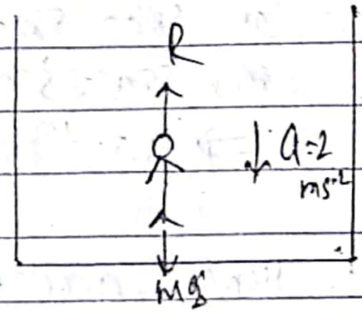


fig: moving downward.

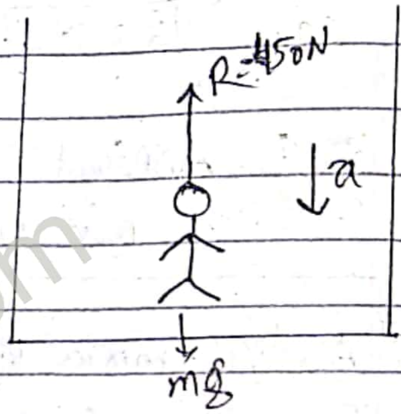
(1) When lift moves upward;
$a = 2\ ms^{-2}$, $m = 50$ kg,
We have,
$$F = R - mg$$
or, $ma = R - mg$
or, $50(2) = R - 50(10)$
or, $500 + 100 = R$
$\Rightarrow \boxed{R = 600\ N}$

(2) When lift moves downward;
$$F = mg - R$$
or, $ma = mg - R$
or, $100 = 500 - R$
$\Rightarrow \boxed{R = 400\ N}$

Hence, when lift move upward reaction on a man is 600 N. and when lift moves downward reaction on a man with 400 N.
#.

LQ[SE] A 550 N physics student stands on a bathroom scale in an elevator. As the elevator starts moving the scale reads 450 N. Draw free body diagram of the problem and find the magnitude and direction of the acceleration of the elevator.

★ Solution:-



Here weight of the physics student;

$mg = 550\ N$

or, $m \times 10 = 550\ N$

$\Rightarrow m = 55\ kg$

Now, and $R = 450\ N$

In this case, "a" moves downwards,

$F = mg - R$

or, $ma = mg - R$

or, $55a = 550 - R$

or, $55a = 550 - 450$

$\Rightarrow a = 100/55 = 1.8\ ms^{-2}$

Hence, acceleration moving downwards with $1.8\ ms^{-2}$ #

Moment of Force (Torque):-

↳ The product of force and moment arm(r) is called torque. And it measure the turning effect of force.

(Tau)

$$\boxed{\tau = Fr}$$

It's unit is Nm.

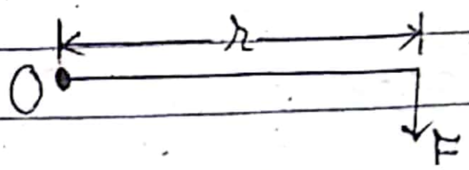


fig: torque

Clock wise and anticlock wise moment:-

↳ The moment of force which rotates the body in clockwise direction is called clockwise [direction in] moment. And

↳ The moment of force which rotates the body in anticlock wise direction is called anticlock wise moment.

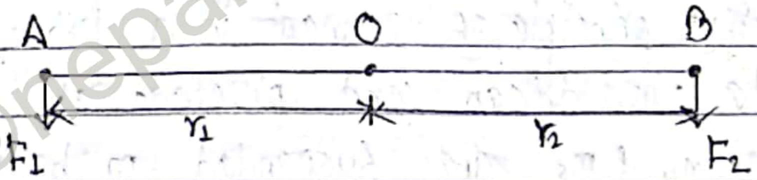


fig: Clockwise and anticlockwise moment

In the figure force F_2 tends to rotate the body in clock wise direction, so clock wise moment is,

$F_2 r_2$

And,

Force F_1 tends to rotate the body A in anticlock wise direction. So, anticlock wise moment is,

$F_1 r_1$

principle of moment:-

↳ It state that, "for a body to be in a rotational equilibrium, the sum of anticlock wise moment is equal to the sum of clockwise moment."

Verification:-

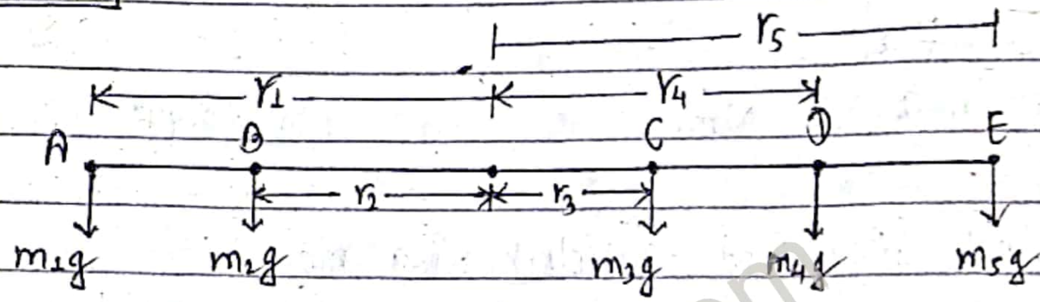


fig: Experimental arrangement for the varification of principle of moment.

★ To verify principle of moment in a lab:-

A scale is taken and pivoted at point O. Masses m_1, m_2, m_3, m_4 & m_5 are suspended on both side as shown in figure above, so that the scale become equilibrium. Let r_1, r_2, r_3, r_4 & r_5 are distance on both side of point O. at which respective masses m_1, m_2, m_3, m_4 & m_5 are placed. Whose weight acting vertically downward.

The weight m_1g and m_2g tends to rotate the scale in anticlockwise direction. So, anticlock wise moment is,

$$m_1gr_1 + m_2gr_2$$

Similarly, the weight m_3g & m_4g & m_5g tends to rotate the scale in clockwise direction. So, clockwise moment is,

$$m_3gr_3 + m_4gr_4 + m_5gr_5$$

If the scale remains in equilibrium than it will be found that;

$$m_1 g r_1 + m_2 g r_2 = m_3 g r_3 + m_4 g r_4 + m_5 g r_5$$

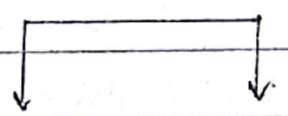
i.e, Anticlockwise moment = Clockwise moment
Which verifies principle of moment.

Parallel forces :-

↳ The forces whose line of action are parallel to each other are called parallel forces.

Types:
1) Like parallel force
2) Unlike parallel force

1) Like parallel force
↳ The forces whose line of action are parallel to each other are called parallel force and the parallel force in same direction is called like parallel force.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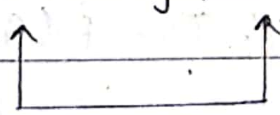
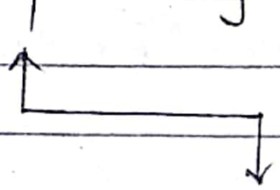


2) Unlike parallel force
↳ The parallel force acting in opposite direction is called unlike parallel force.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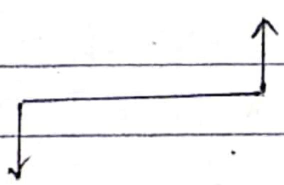
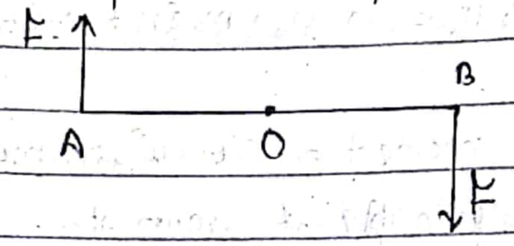


Couple :-

↳ Two equal and unlike parallel force with different line of action produce couple.



Consider a couple of force acting on a body pivoted at point O. The torque due to couple is a the sum of torque due to intividual force.

Now,

Torque due to force at point A,

$$\tau_A = F.AO$$

Similarly,

Torque due to force at point B,

$$\tau_B = F.BO$$

therefore, Torque due to couple,

$$\tau = \tau_A + \tau_B$$

$$or, \ \tau = F.AO + F.BO$$

$$\therefore \tau = F(AB)$$

Hence,

Torque due to couple is product of magnitude of force and perpendicular distance between two forces.

Equilibrium:-

↳ A body is said to be equilibrium if net force or net torque acting on a body is equal to zero.

[1] Translation equilibrium

↳ A body is said to be in translation equilibrium if net force acting on a body is equal to zero.

i.e, $\Sigma F = 0$

i.e, acceleration $(a) = 0$

i.e, body is at rest or moving with constant velocity.

⇒ If $\Sigma F = 0$ and body is at rest, it is said to be static translation equilibrium.

⇒ If $\Sigma F = 0$ and body is moving with constant velocity, it is said to be dynamic translation equilibrium.

[2] Rotational equilibrium

↳ A body is said to be in rotational equilibrium if net torque acting on a body is equal to zero.

i.e, $\Sigma \tau = 0$

i.e, angular acceleration $(\alpha) = 0$

i.e, body is at rest or moving with constant angular velocity.

⇒ If $\Sigma \tau = 0$ and body is at rest, it is said to be static rotational equilibrium.

⇒ If $\Sigma \tau = 0$ and body is moving with constant angular velocity it is said to be dynamic rotational equilibrium.

Stable equilibrium:-

↳ The equilibrium in which body returns to it's orginal position by itself after being slidely displaced from initial position is called stable equilibrium.

Unstable equilibrium:-

↳ The equilibrium in which body doesn't returns to it's orginal position by itself after being slidely displaced from intial position is called unstable equilibrium.

Neutral equilibrium:-

↳ The equilibrium in which body always stay in the displaced position after it has been slidely displaced from intial position is called neutral equilibrium.

Centre of mass:-

↳ The point of the body at which whole mass of the body can be consider to be concentrate is called centre of mass. It always lies in the body.

Centre of gravity:-

↳ The centre of gravity is the point at which whole weight of the body act in downward direction. It may or may not lies between the body.
For example:- Centre of gravity of holosphare and ring lies at it's centre where there is no mass.

LQ [6A] A rolar whose diameter is 1 m. Weights 360 N. What horizontal force is necessary to pull the rolar over a brick 0.1 m high. When the force is applied at the centre?

☆ Solution:-

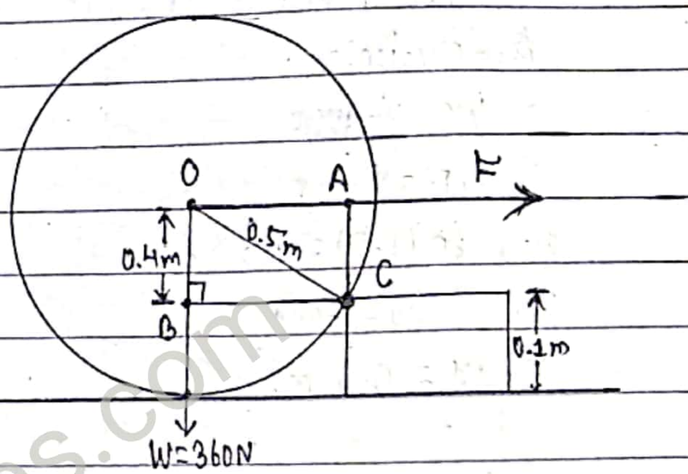
Force (F) = ?,

$OB = AC = (0.5 - 0.1)m = 0.4m$

Weight (W) = 360 N

Now,

$BC = \sqrt{OC^2 - OB^2} = \sqrt{(0.5)^2 - (0.4)^2} = 0.3\ m$



We have,

$F \times AC = W \times BC$

or, $F \times 0.4 = W \times 0.3$

or, $F \times 0.4 = 360 \times 0.3$

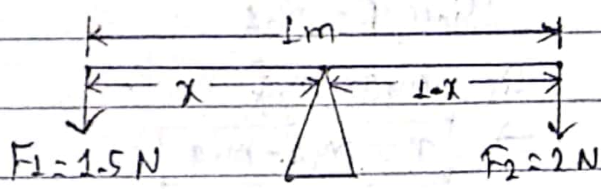
$\Rightarrow F = 270\ N$

Hence, 270 N force is necessary to pull the rolar over a brick.

LQ. [6B] Two forces of 1.5 N and 2 N acts vertically at the two ends of a meter scale. Where and in which direction should a force be applied so that the scale remain's horizontally stable.

☆ Solution:-

From the figure



$F_1 r_1 = F_2 r_2$

or, $1.5x = 2(1-x)$

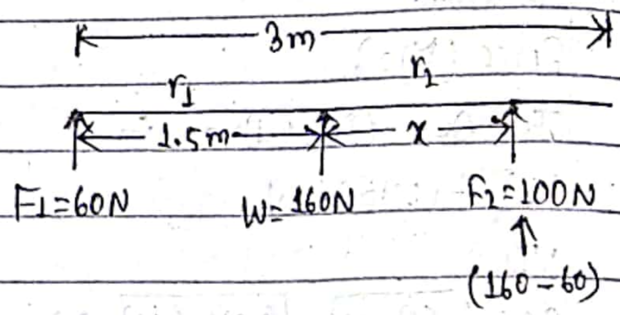
or, $3.5x = 2$

$\Rightarrow x = 0.57\ m$ and $r_2 = 1 - x = 1 - 0.57 = 0.43\ m$

Hence, A force should be 0.57 m from 1.5N & 0.43m from 2 N. #

L8 [6c] Two people are carring a uniform wooden board that is 3m long and weights 160 N. If one person applies an upward force equal to 60 N. at one end, at what position does the other people lift?

★ Solution:-



We have,

$F_1 r_1 = F_2 r_2$

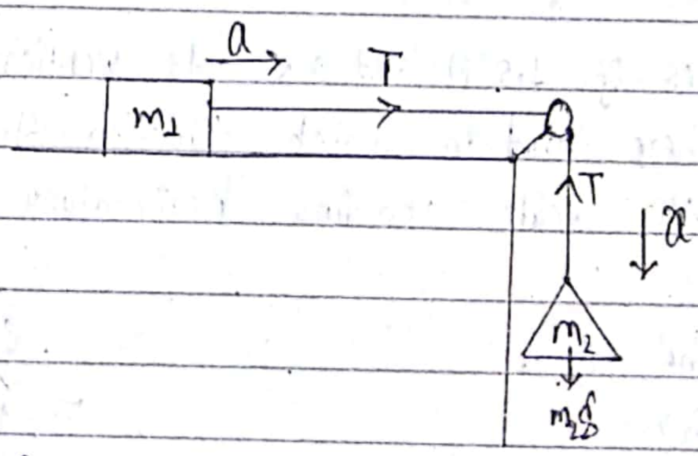
or, $60(1.5) = 100 \times x$

or, $90 = 100x$

$\Rightarrow x = 0.9$ m.

Hence, the position of other people lift $(1.5+0.9) = 2.4$ m from 60 N. #

Body moving on a smooth horizontal surface:-



For m_2:-

$F = m_2 g - T$

Since, $F = m_2 a$

or, $m_2 a = m_2 g - T$

$\Rightarrow \boxed{T = m_2 g - m_2 a}$

For m_1:-

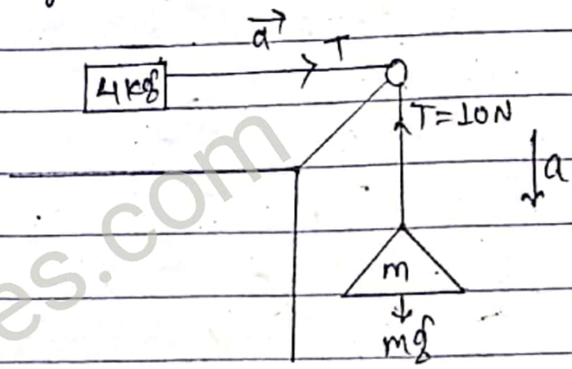
$F = T - m_1 g = T - m_1(0) = T$

Since, $F = m_1 a$

$\Rightarrow \boxed{T = m_1 a}$

LQ.[7A] A light rope is attached to a block with mass 4 kg that rests a frictionless, horizontal Surface. The horizontal rope passes over a frictionless pulley and a block with mass m is Suspended from other end. When the blocks are released, the tension in the rope is 10 N. Draw free body diagrams and Calculate the acceleration of eithers block and the mass of the hanging block.

★ Solution:-



We have,

$F = mg - T$

or, $ma = m(10) - 10$

or, $ma = 10m - 10$ ---(i)

And,

$F = T = 10$

or, $4(a) = 10$

$\Rightarrow a = 2.5\ ms^{-2}$

from eqn (i)

$m(2.5) = 10m - 10$

or, $10 = 7.5m$

$\Rightarrow m = 1.33$ kg

Hence, acceleration due to gravity is $2.5 ms^{-2}$ & mass of hanging block is 1.33kg

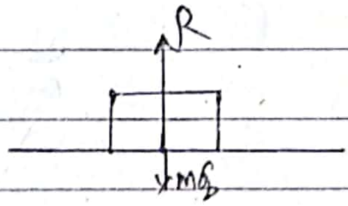
Friction:-
↳ The force which comes between two surface in contact and tends to oppose the relative motion between them is called frictional force.

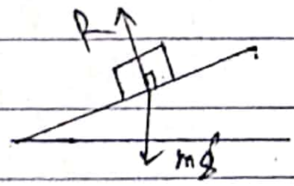
Types of friction:-

⟨1⟩ Static friction:-
↳ The force of friction acting between two surface when they are at rest is called static friction. The maximum value of static friction is called limiting friction.

⟨2⟩ Kinetic or dynamic friction:-
↳ The force of friction acting between two surface when they are at motion is called kinetic or dynamic friction.

☆ Terms in friction:-
[1] Normal reaction(R):-
↳ The reaction acting perpendicular to the surface of contact of 2 bodies is called Normal reaction.





[2] Co-efficient of friction(μ):-
↳ The ratio between force of friction (frictional force) to the normal reaction is called co-efficient of friction. It is denoted by μ and given by

$$\mu = \frac{F_f}{R}$$

[3] Angle of friction:-

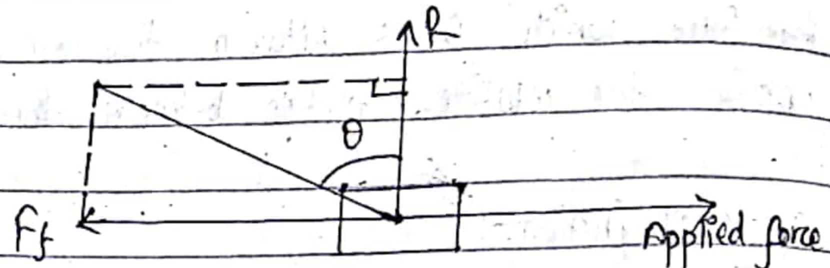


fig: Angle of friction

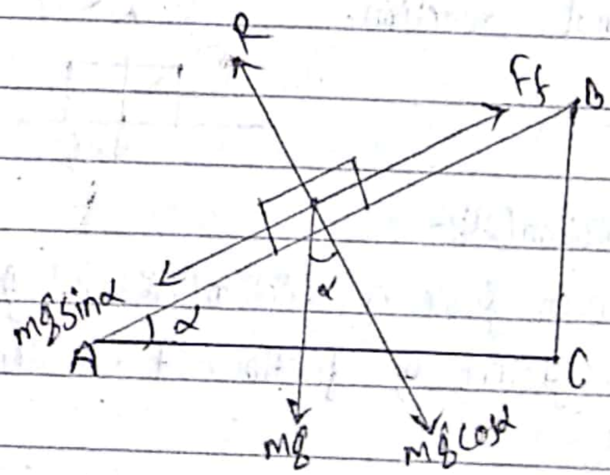
↳ the angle made by resultant of Normal reaction and frictional force to normal reaction is called angle of friction.
In above figure, θ is angle of friction;
then,

$$\tan\theta = \frac{F_f}{R}$$

Since, $\mu = \frac{F_f}{R}$

$$\therefore \boxed{\tan\theta = \mu} \longrightarrow (A)$$

[4] Angle of Repose :-
↳ the minimum angle of inclined Surface with horizontal such that a body played on which just begins to slide down by itself is called angle of repose.



Let us Consider an object of mass m is kept on a plane Surface ABC it's inclination is slowly increased such that the object slide downward then it's weight mg acts vertically downward can be resolved into two

Components $mg\cos\alpha$ (opposite to normal reaction) and other is $mg\sin\alpha$ (opposite to frictional force) which balance each other.

At equilibrium,

$$mg\sin\alpha = F_f \quad \text{--- (i)}$$

$$mg\cos\alpha = R \quad \text{---- (ii)}$$

Dividing eq^n (i) & (ii); we get;

$$\tan\alpha = \frac{F_f}{R}$$

Since, $\frac{F_f}{R} = \mu$

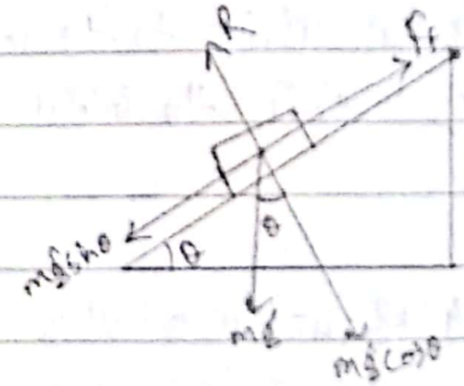
$$\therefore \boxed{\tan\alpha = \mu} \quad \text{—— (B)}$$

Comparing equation (A) & (B), we get;

$$\Rightarrow \alpha = \theta$$

i.e, $\boxed{\text{Angle of Repose = Angle of friction}}$

For downward motion:-



$$F = mg\sin\theta - F_f$$

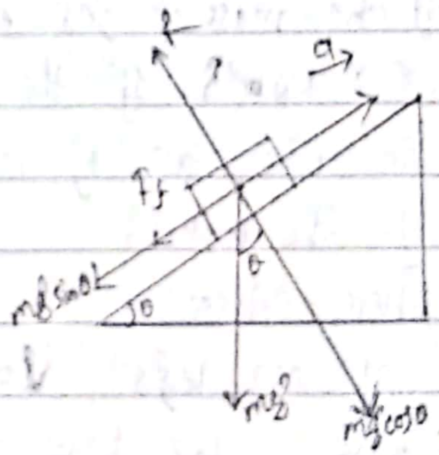
or, $F = mg\sin\theta - \mu R \quad [\because \mu = \frac{F_f}{R}]$

or, $F = mg\sin\theta - \mu\, mg\cos\theta$

or, $ma = mg\sin\theta - \mu mg\cos\theta \quad [\because F = ma]$

$$\Rightarrow \boxed{a = g\sin\theta - \mu g\cos\theta}$$

For upward motion;-



$$F = mg\sin\theta + F_f$$

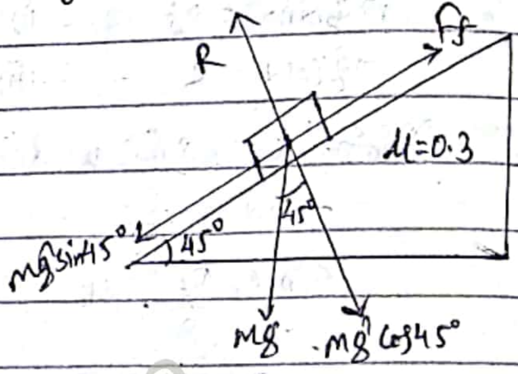
$$\Rightarrow \boxed{a = g\sin\theta + \mu g\cos\theta}$$

Numericals

LQ.[8A] What would be the acceleration of a block sliding down an inclined plane that makes an angle of 45° with the horizontal if the coefficient of sliding friction between two surfaces is 0.3?

[IMP]

☆ Solution:-



We have,

$F = mg\sin45° - F_f$

or, $F = mg\sin45° - \mu R$

or, $F = mg\sin45° - \mu mg\cos45°$

or, $ma = mg\sin45° - \mu mg\cos45°$

or, $a = g\sin45° - \mu g\cos45°$

or, $a = 10 \times \frac{1}{\sqrt{2}} - (0.3 \times 10) \times \frac{1}{\sqrt{2}}$

or, $a = 7.07 - 2.12$

$\therefore$ $\boxed{a = 4.9\ ms^{-2}}$

Hence, acceleration of the block is $4.9\ ms^{-2}$ #

LQ.[8B] The mass of gas emitted from the rear of toy rocket is initially 0.2 kg/s. If the speed of the gas relative to the rocket is 40 m/s and the mass of rocket is 4 kg, what is the initial acceleration of the rocket?

☆ Here, Given;

$\frac{m}{t} = 0.2\ kgs^{-1}$, $v = 40\ ms^{-1}$, $m = 4\ kg$, $a = ?$, $u = 0\ ms^{-1}$

Now, We have, $F = ma$

or, $ma = m\frac{v-u}{t}$

$\Rightarrow F = \frac{v-u}{1} \times \frac{m}{t} = \frac{40-0}{1} \times 0.2 = 40(0.2)$

or, $ma = 40(0.2)$

or, $4a = 40(0.2)$

or, $\boxed{a = 2 ms^{-2}}$

Hence, the initial acceleration of the toy rocket is $2 ms^{-2}$ #

LQ.[8C] A ball of mass 0.05 kg strikes a smooth wall normally four times in 2 seconds with a velocity of 10 ms^{-1}. Each time the ball rebounds with the same speed of 10 ms^{-1}. Calculate the average force on the wall?

☆ Solution:-

Here, Given; $m = 0.05$ kg, $t = 2$ sec., $u = 10\ ms^{-1}$

Now,

For each time,

$m = 0.05$ kg, $t = 2$ sec; $u = 10\ ms^{-1}$, $v = -10\ ms^{-1}$

We have, $F = ma$

$$= m \cdot \left[\frac{v-u}{t}\right]$$

$$= 0.05\left[\frac{-10-10}{2}\right]$$

$$= -0.5\ N$$

$$\therefore f = |F| = |-0.5| = 0.5\ N$$

Again, For 4 times ball strikes wall,

therefore, Average force $= F \times 4 = 0.5 \times 4 = 2$ N #

LQ[8D] Suppose you try to move a crate by tying a rope around it and pulling on the rope at an angle of 30° above the horizontal. What is the tension required to keep the crate moving with constant velocity? Assume weight of the crate 'w' = 500 N. and coefficient of dynamic friction $\mu_K = 0.40$.

IMP

☆ Solⁿ:- We have, $F = T\cos 30° - f_f$

or, $ma = T\cos 30° - \mu R$

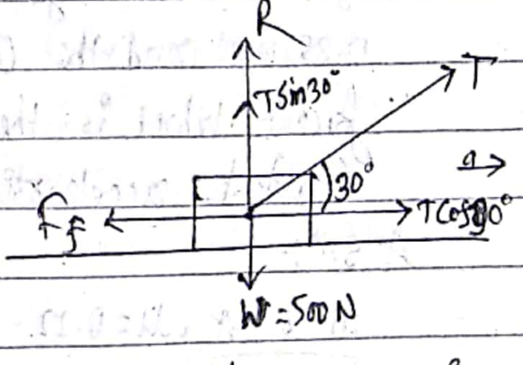
or, $ma = T\cos 30° - \mu(w - T\sin 30°)$

or, $0 = T \times \sqrt{3}/2 - [0.4][500 - T \times \frac{1}{2}]$

or, $200 - 0.2T = 0.86T$

or, $200 = 1.06\ T$

$\Rightarrow \boxed{T = 187.6\ N}$



Hence, the required tension is 187.6 N. #

LQ. [8E] An iron block of mass 10 kg rests on a wooden plane inclined at 30° to the horizontal. It is found, that the least force parallel to the plane which causes the block to slide up is 100 N. Claculate the coffiecient of friction between the two surfaces.

☆ Solution:-

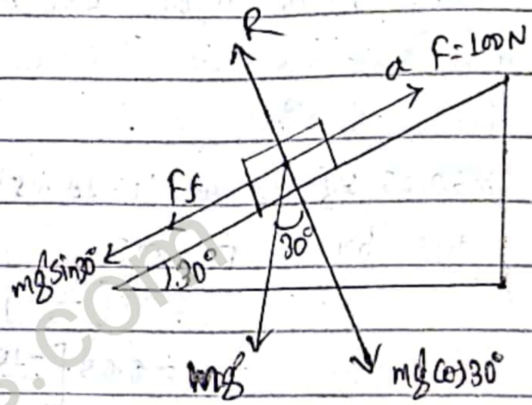
We have,

$F = mg\sin 30° + F_f$

or, $F = mg\sin 30° + \mu R$

or, $F = mg\sin 30° + \mu(mg\cos 30°)$

or, $ma = mg\sin 30° + \mu mg\cos 30°$



Since, $F = ma$

or, $100 = 10 \times a$

$\Rightarrow a = 10\ ms^{-2}$

$\therefore a = g\sin 30° + \mu g\cos 30°$

or, $10 = 10 \times \frac{1}{2} + \mu \cdot 10 \cdot \frac{\sqrt{3}}{2}$

or, $5 = \mu \times 0.866$

$\Rightarrow \boxed{\mu = 0.577}$

Hence, Coefficient of friction $(\mu) = 0.577$ #

LQ. [8F] In a physics lab experiment, a 6 kg box is pushed across a flat table by a horizontal force F. If the box is moving at a constant speed of $0.35\ ms^{-1}$ and the coefficient of kinetic friction is 0.12, find the magnitude of force F. What is the magnitude of force F if the box is moving with a constant acceleration $0.18\ ms^{-2}$?

☆ Soln:-

$m = 6$ kg, $\mu = 0.12$

Case I: When body is moving with constant speed; i.e, $a=0$

so, $F = F_f = \mu R = (0.12)(mg) = (0.12)(6)(10) = 7.2\ N$

Again, $\boxed{\text{Case II}}$: When, body is moving with Constant 'a', $a = 0.18\ ms^{-2}$

$F = ma + F_f$

$= 6(0.18) + \mu R$

$= 6(0.18) + (0.12)(mg)$

$= 6(0.18) + (0.12)(6)(10)$

$= 1.08 + 7.2$

$\therefore F = 8.28\ N$

Thus, when, speed is Constant ~~magt~~ magnitude of $F = 7.2N$ & a is Constant then

$F = 8.28\ N$ #

law of friction:-

- The force of friction between two surface depends upon the nature of Surface.
- The force of limiting friction is directly proportional to the normal reaction. i.e, $F_f \propto R$
- The force of limiting friction is independent to the area of contact between two Surface.
- The kinetic friction is independent to the relative velocity of two surface.

Verification of law of friction:-

[I] To verify $F_f \propto R$;

- Let us take two block A & B of masses m_1 & m_2 placed on horizontal table with a pulley at one end. A rope with one in attached to the block and running over pulley with another end attached to scale pan on which load can be placed. The load on the scale pan required to just slide the block along the table are noted. Let W_1 & W_2 are the

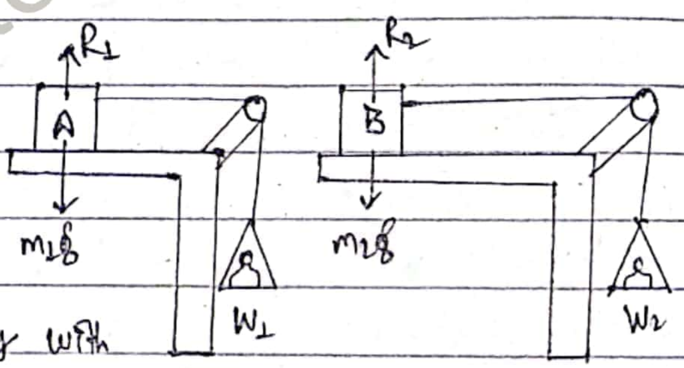


fig: experimental verification of law of friction

weight on the Scale pan required to just slide the block A & B of weight m_1g & m_2g respectively. Such that normal reactions $R_1 = m_1g$ & $R_2 = m_2g$. Then it will be found that;

$$\frac{W_1}{R_1} = \frac{W_2}{R_2}$$

$$\frac{W}{R} = \text{constant}$$

Since; at limiting friction applied force, must be equal to frictional force;

i.e, $W = F_f$

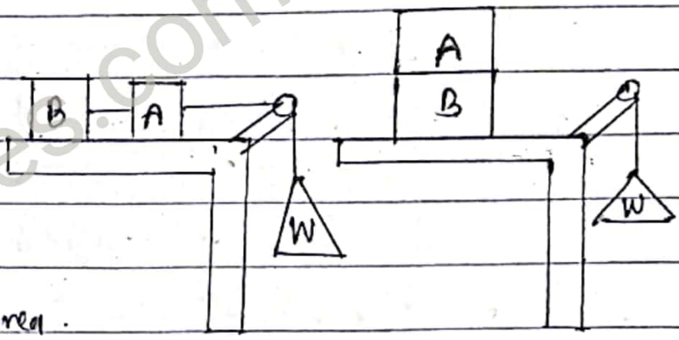
$$\therefore \frac{F_f}{R} = \text{Constant}$$

or, $F_f = \text{Constant } R$

$\Rightarrow F_f \propto R$

[II] To verify force of limiting friction is independent of area of contact between two Surface;

↳ Simplarly to verify force of limiting friction is independent to the area of contact, Let us join two block A&B placed separately on a table. Here area of contact is equal to sum of area



of contact of block A&B. In this case weight to just slide the blocks A&B must be noted, let it be W now in second case the block B is placed over block A and in this case area of contact is less then first case also note the weight required to just slide them and let it be also be same weight(W). the force of friction is equal to applied load in case of limiting friction. Which verifies above law because area of contact in both cases are different but force of limiting friction is same.