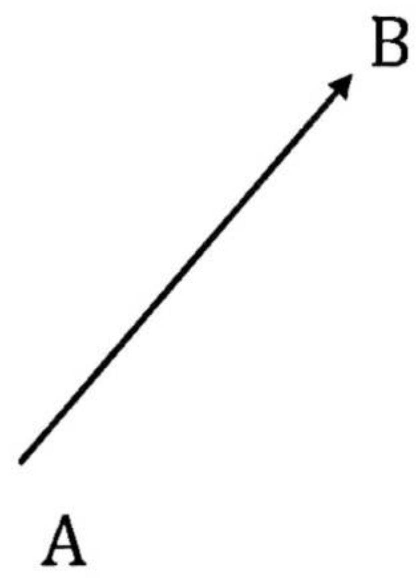
Chapter = 03

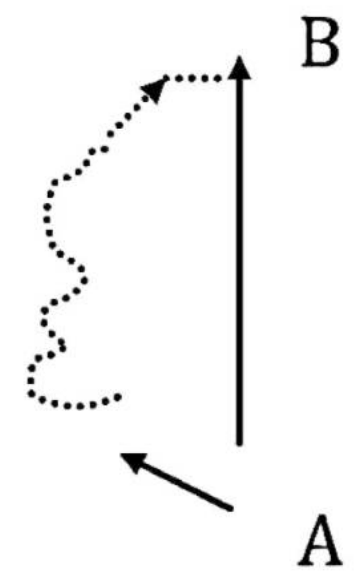
Motion

THEORY NOTES

DISPLACEMENT:

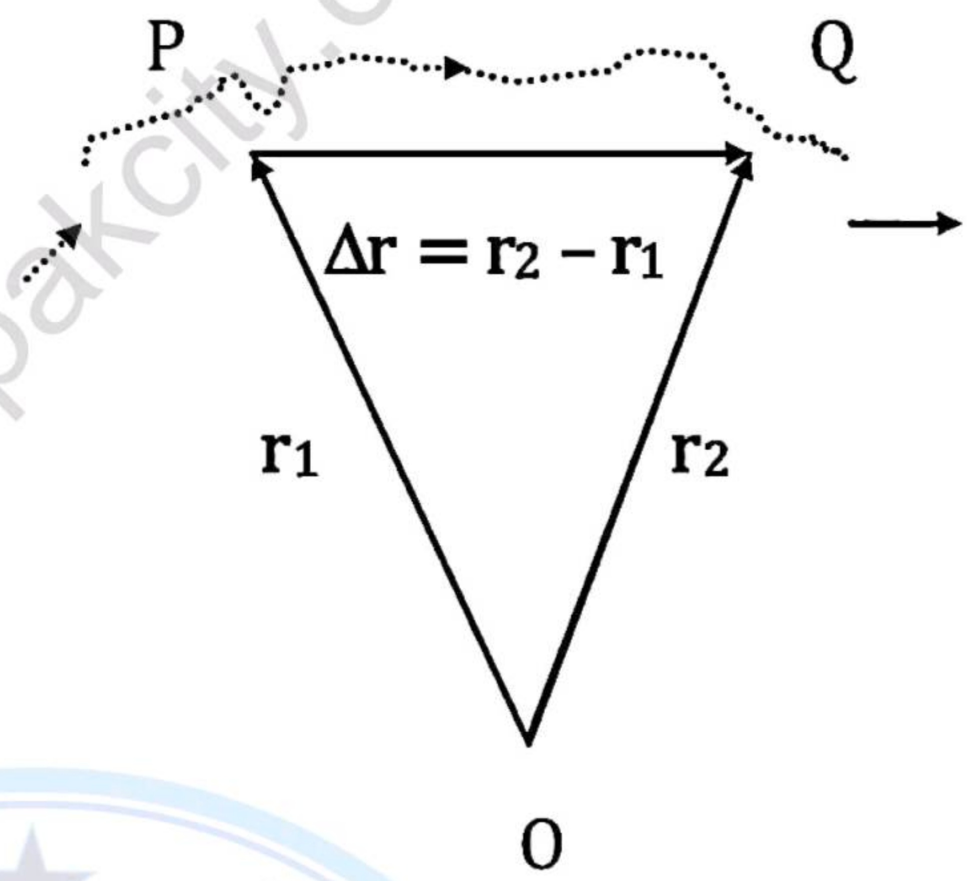
"The change of position of a body in a particular direction is called displacement" .It is the maximum distance between two points. It is a vector quantity.





VELOCITY:

DEFINITION "it is the change in position (or displacement) with respect to time."



EXPLANATION:

From above definition,

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

Consider a body moves along the path AC. Let $\overrightarrow{r1}$ and $\overrightarrow{r2}$ position vectors from origin to the points 'P' ad 'Q'

As the body moves from 'P' to 'Q" in time $\Delta t = t_2 - t_1$ undergoes a change in position $\overrightarrow{\Delta r} = \overrightarrow{r2} - \overrightarrow{r1}$. The average velocity is given by

$$\overrightarrow{V_{av}} = \frac{\overrightarrow{\Delta r}}{\Delta t} = \frac{\text{Displacement}}{\text{Time}}$$

Hence rate of change of position of a body in the direction of displacement is called 'velocity' If time is very small such that $\Delta t \rightarrow 0$, the velocity is called 'instantaneous velocity".

$$\overrightarrow{V_{ins}} = \lim_{\Delta t \rightarrow 0} \frac{\overrightarrow{\Delta r}}{\Delta t}$$

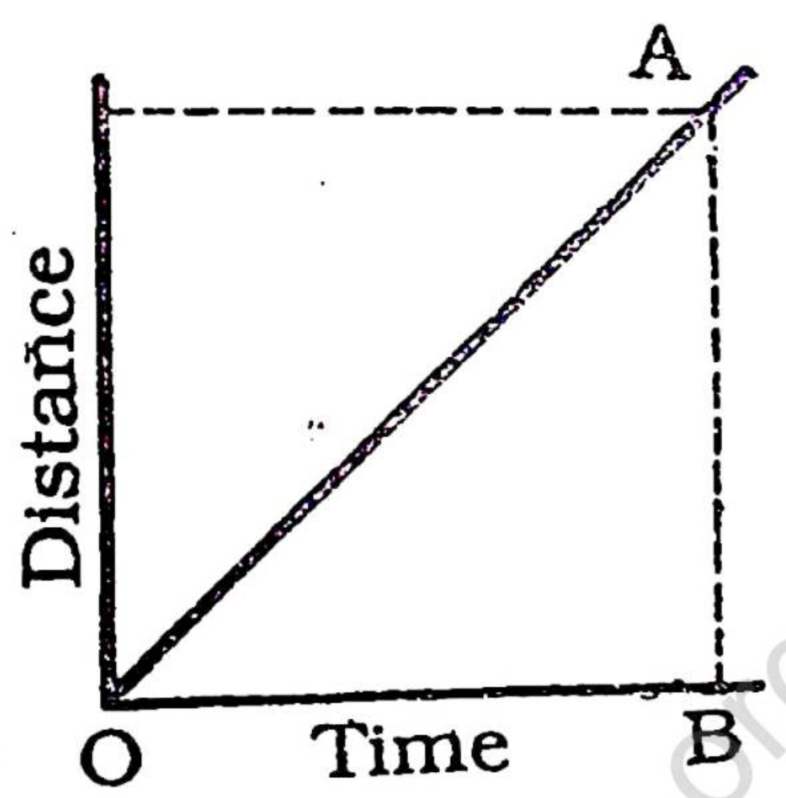
VELOCITY FROM DISTANCE – TIME GRAPH:

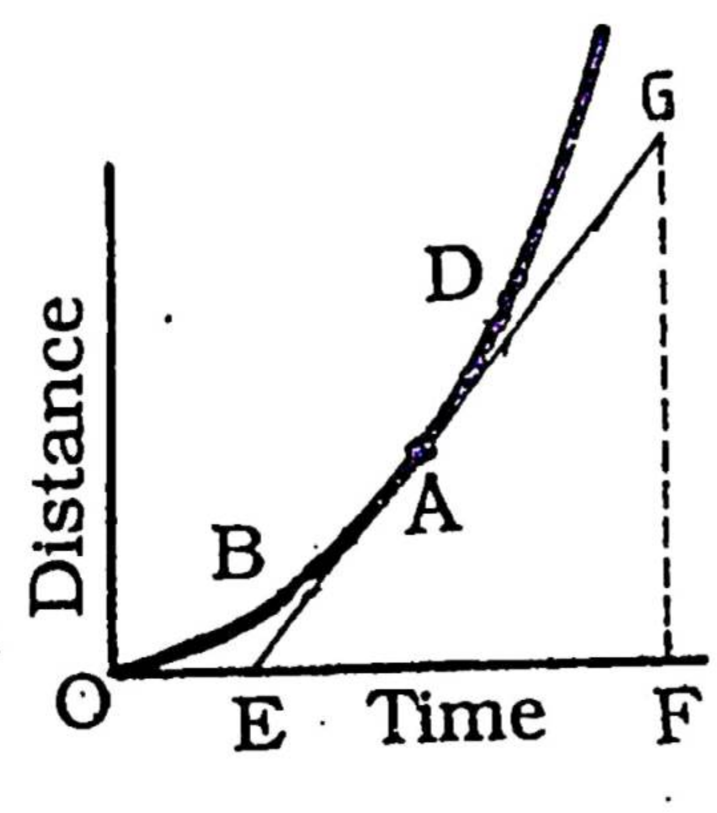
Form figure ,

Velocity = Distance/ Time

$$= \frac{\overrightarrow{AB}}{\overrightarrow{OB}}$$

This graph represents uniform velocity.





For variable velocity,

Velocity at A $= \frac{\overrightarrow{GF}}{\overrightarrow{EF}}$

ACCELERATION:

DEFINITION: The rate of change of velocity of a body is called acceleration.

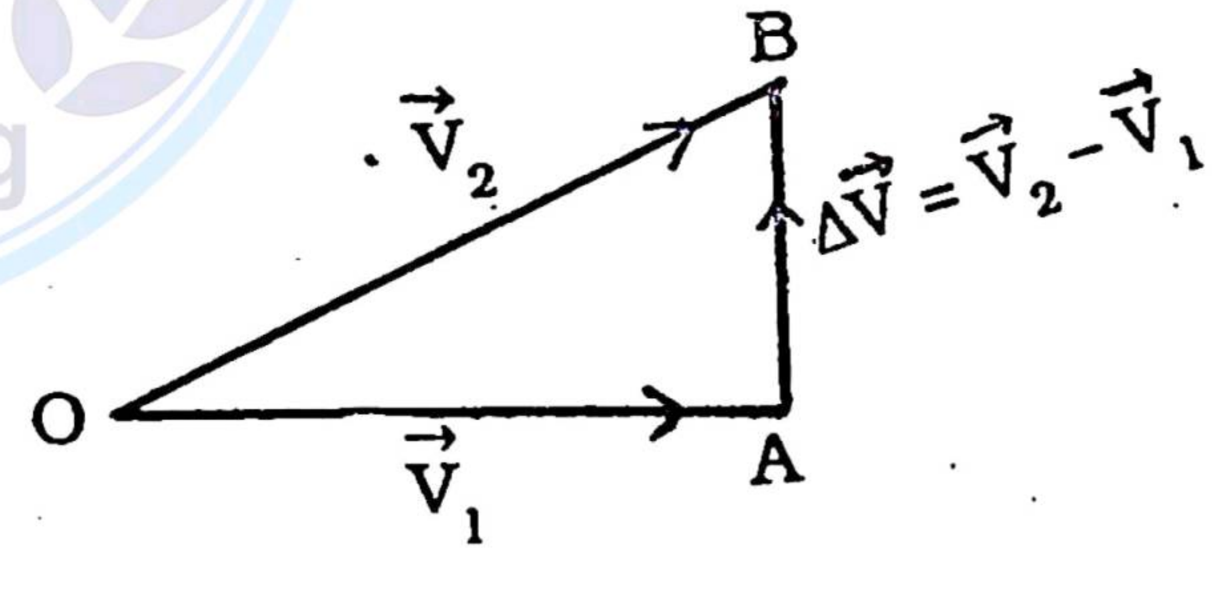
EXPLANATION:

It is a vector quantity and its direction is parallel to the direction of velocity.

$$\text{ACCELERATION} = \frac{\text{CHANGE OF VELOCITY}}{\text{TIME}}$$

Consider a body in motion let Vi be it velocity instant "t_1" and V_2 at instant t_2,The average acceleration during this internal is given by

$$\vec{a}_{av} = \frac{\vec{V}_2 - \vec{V}_1}{t_2 - t_1} = \frac{\overrightarrow{\Delta V}}{\Delta t}$$



If Δt is very small then at Δt→0,

$$\vec{a}_{ins} = \lim_{\Delta t \to 0} \frac{\overrightarrow{\Delta V}}{\Delta t}$$

This acceleration is called instantaneous acceleration.

Unit: The S.I unit of acceleration is m/sec^2

ACCELERATION FROM VELOCITY – TIME GRAPH:

i) When the body moves with uniform acceleration the graph between velocity and time is a straight line.

$$\text{Acceleration} = \overrightarrow{PQ} / \overrightarrow{OQ}$$

ii) When the body moves with variable acceleration, the graph is a curve.

$$\text{Acceleration} = \overrightarrow{MN} / \overrightarrow{LN}$$

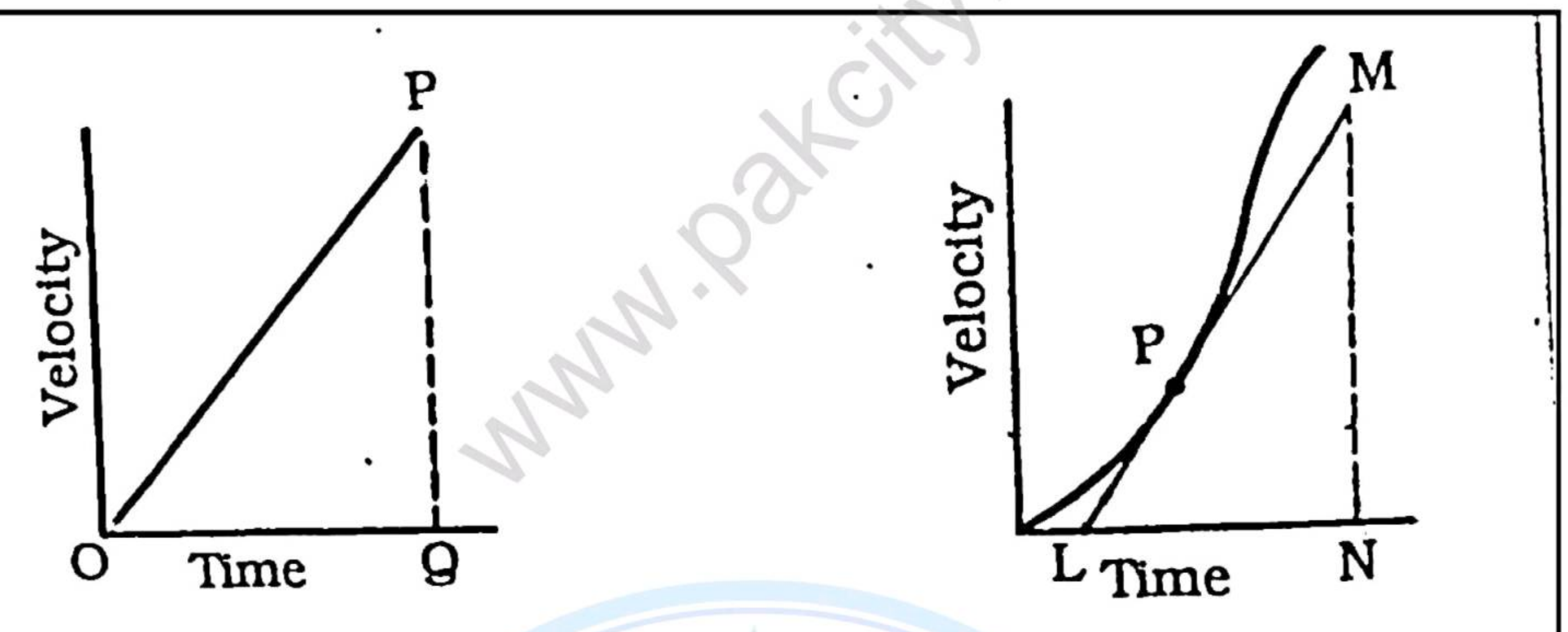


Fig. 3.5 (a) uniform acceleration *(b) Non Uniform acceleration*

EQUATIONS OF UNIFORMLY ACCELERATED RECTILINEAR MOTION:

There are three fundamental equations about uniformly accelerated rectilinear motion,

1. $V_f = V_i + at$
2. $S = V_i t + \frac{1}{2} at^2$
3. $V_f^2 = V_i^2 + 2aS$

In case of motion under gravity with nearly constant acceleration we just replace 'a' with 'g' i.e. acceleration due to gravity in equations of motion, as weight is always directed downwards.

1. $V_f = V_i + gt$
2. $h = V_i t + \frac{1}{2} gt^2$
3. $V_f^2 = V_i^2 + 2gh$

Where $g = 9.8\ m/s^2$
or $=980\ cm/s^2$
$=32 ft/s^2$

The most common example of motion with nearly constant acceleration is that of a body falling towards the earth. This acceleration is due to pull of earth (gravity).If the body moves towards earth, neglecting resistance and small changes in the acceleration with altitude, the body is referred to as free falling body and this motion is called Free Fall. Such type of vertical motion under the action of gravity is a good example of uniformly accelerated motion.

NEWTON'S LAWS OF MOTION

(1) Newton's First Law of Motion:

Newton's first law of motion consists of two parts.

(i) The first part states that a body cannot change its state of rest or uniform motion in straight line itself unless it is acted upon by some unbalanced force to change its state. It can also be stated that a moving body when not acted upon by some net force would have free motion, that is uniform motion in straight line.

(ii) The second part states that force is an agent which changes or tends to change the state of rest or uniform motion i.e. it produces acceleration in the body. The first law of motion is also known as the law of inertia.

Inertia:

Everybody in this universe has a property that it always offers some resistance to the change of its state. This property is known as Inertia and it is because of the mass of body. Therefore we need force to overcome inertia for the change of its state, either rest or motion. Hence Newton's first law of motion is also known as inertia.

(2) Newton's Second Law of Motion:

Newton's second Law states that : "when a force acts upon a certain body, the acceleration produced is proportional to the force and it is in the direction of the force."

$$\vec{F} \propto \vec{a}$$

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

where
F = Net force on the body
m = mass of the body
a = acceleration in the body

It is clear from the above equation that the acceleration for certain force on the body is inversely proportional to the mass of the body.

(3) Newton's Third Law of Motion:

Newton's third law can be stated as "To every action there is a an equal but opposite reaction".

The statement means that in every interaction, there is a pair of forces acting on the two interacting objects. The size of the forces on the first object equals the size of the force on the second object. The direction of the force on the first object is opposite to the direction of the force on the second object. Forces always come in pairs - equal and opposite action-reaction force pairs.

TENSION:

"Tension is the reaction force produced in a string when a mass is, suspended from it.

Motion of bodies connected by a string:

Case I: When both objective move vertically:

Consider two objects of masses 'm_1' and 'm_2' connected by a string which passes over a frictionless pulley, as shown in figure.

Since $m_1 > m_2$

Therefore 'A' moves in downward direction with acceleration 'a' while 'B' moves in upward direction.

i) **Downward motion of Body 'A'**

Since body 'A' is moving downwards, thus,

Net force – weight = Tension

$F_1 = W_1 - T$

$m_1a = m_1g \quad T$ ⟶ (1)

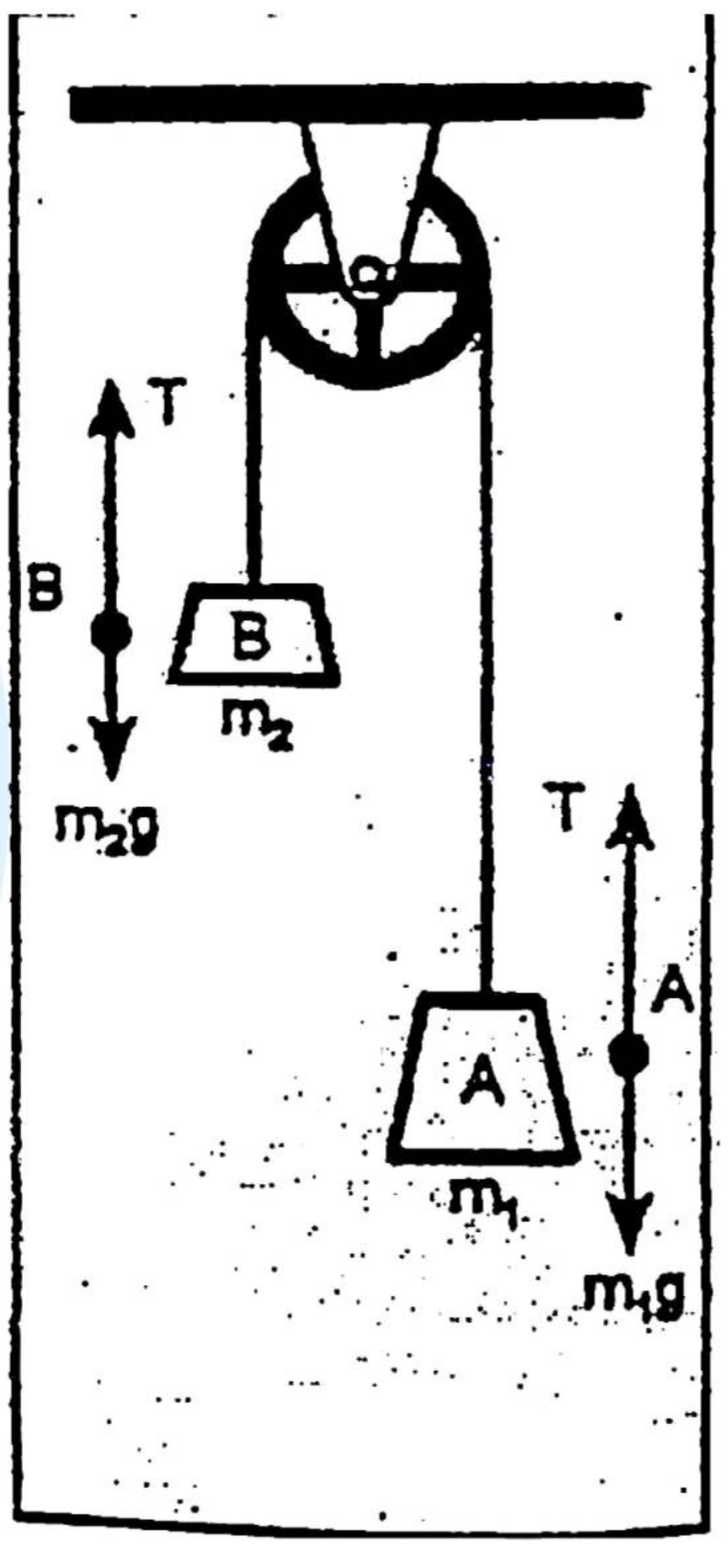
ii) **Upward motion of Body 'B'**

Since body 'B' is moving upwards direction thus,

Net force = Tension – weight

$F_2 = W_2 - T$

$m_2a = m_2g \quad T$ ⟶ (2)



For Accelaration:

Adding eq (!) and eq (2)

$m_1a = m_1g - T$

$+ m_2a = T - m_2g$

$m_1a + m_2a = m_1g - m_2g$

$a(m_1 - m_2) = (m_1 - m_2)g$

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

For Tension:

putting value of 'a 'in eq (2),

$m_2a = T - m_2g \longrightarrow (2)$

$$m_2 \frac{(m_1 - m_2)}{(m_1 + m_2)} g = T - m_2g$$

$$m_2 \frac{(m_1 - m_2)}{(m_1 + m_2)} g + m_2g = T$$

$$T = m_2g \left(\frac{m_1 - m_2}{m_1 + m_2} + 1 \right)$$

$$T = m_2g \left(\frac{m_1 - m_2 + m_1 + m_2}{m_1 + m_2} \right)$$

$$\mathbf{T = \frac{2\, m_1\, m_2 g}{m_1 + m_2}}$$

Case II: When one object moves vertically and other moves on a horizontal surface:

Consider two object of masses 'm1' and 'm2' connected by a string which pass over a frictionless pully. The body B moves on a smooth horizontal surface towards the pully, while 'A' moves vertically.

i) **DOWNWARD MOTION OF BODY 'A"**

Since body 'A' moves in downward direction, Net force = weight – Tension

$F_1 = W_1 - T$

$m_1a = m_1g - T \longrightarrow (1)$

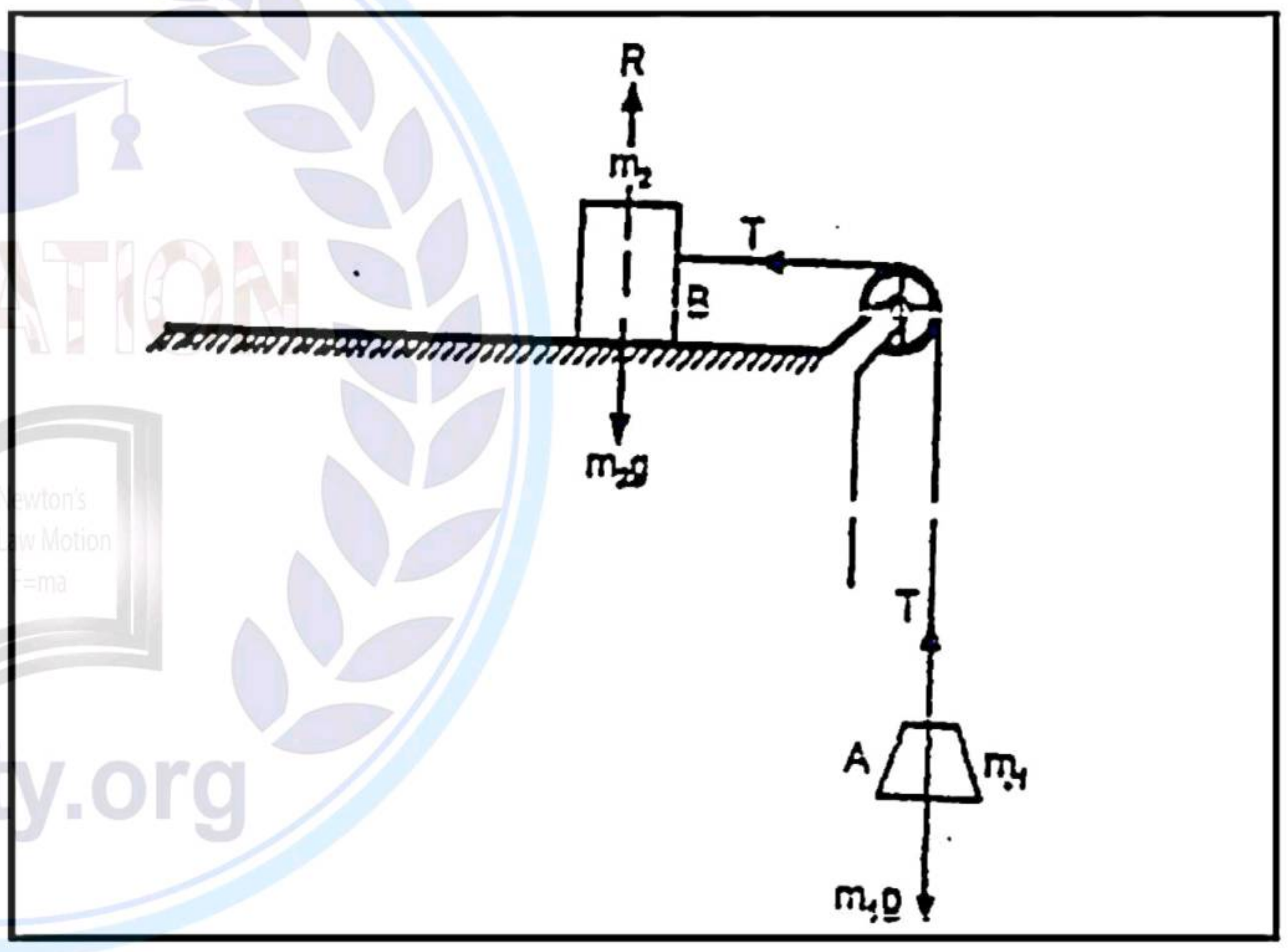
ii) **HORIZONTAL MOTION OF BODY 'B"**

Since body 'A' moves on horizontal direction,

Net force = Tension

$F_2 = T$

$m_2a = T \longrightarrow (2)$



For Acceleration:

While in vertical direction, $R = M_2g$

Where 'R' is the reaction of surface Solution of equations: Adding eq (1) and eq(2)

$m_1a = m_1g - T$

$+ \quad m_2a = T$

$m_1a + m_2a = m_1g$

$a(m_1+m_2) = m_1g$

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

For Tension:

putting the value of 'a' in eq (2),

$m_2 a = T$

$$T = \frac{m_1 m_2 g}{(m1 + m2)}$$

MOMENTUM:

DEFINITION: The product of mass and velocity of a body is called its momentum.'

EXPLANATION: Let 'm' be the mass of a body, moving with velocity 'V' then it is a momentum 'P' is

$$P = mv$$

Momentum is a vector quantity and its direction is parallel to the direction of the velocity.

LAW OF CONSERVATION OF MOMENTUM

STATEMENT:

The law of conservation of momentum states that:

"When some bodies constituting an isolated system act upon one another, the total momentum of the system remains constant."

OR

"The total momentum of an isolated system of interacting bodies remains co nstant."

OR

"Total momentum of an isolated system before collision is always equal to total momentum after collision."

EXPLANATION:

Consider an isolated system of the interacting bodies 'A' and 'B' of masses 'm_1' and 'm_2' colliding with velocities U_1 and U_2 after colliding they move with velocities V_1 and V_2

Therefore,

Total momentum of the system before collision = $m_1u_1 + m_2u_2$ and total momentum of the bodies collide with each other they come in contact for a time interval 's'. During the interval the average force exerted by the body 'A' on body 'B' is F.

According to the third law of motion, the body 'B' will also exert a force (-F) on the body 'A'.

The average force acting on the body 'B' is equal to the rate of change of its momentum.

$$\vec{F}_{A\ on\ B} = \underline{m_2v_2 - m_2u_2}$$

$$t$$

Similarly the average force acting on body ‘A’ is,

$$\vec{F}_{B\,on\,A} = \frac{m_1v_1 - m_1u_1}{t}$$

Since,

$$\vec{F}_{B\,on\,A} = \vec{F}_{A\,on\,B}$$

$$\frac{m_2v_2 - m_2u_2}{t} = \frac{m_1v_1 - m_1u_1}{t}$$

$$\boxed{m_1u_1 + m_2u_2 = m_2v_1 + m_2v_2}$$

This proves that,
The total momentum of the system remains constant.

ELASTIC COLLISION:

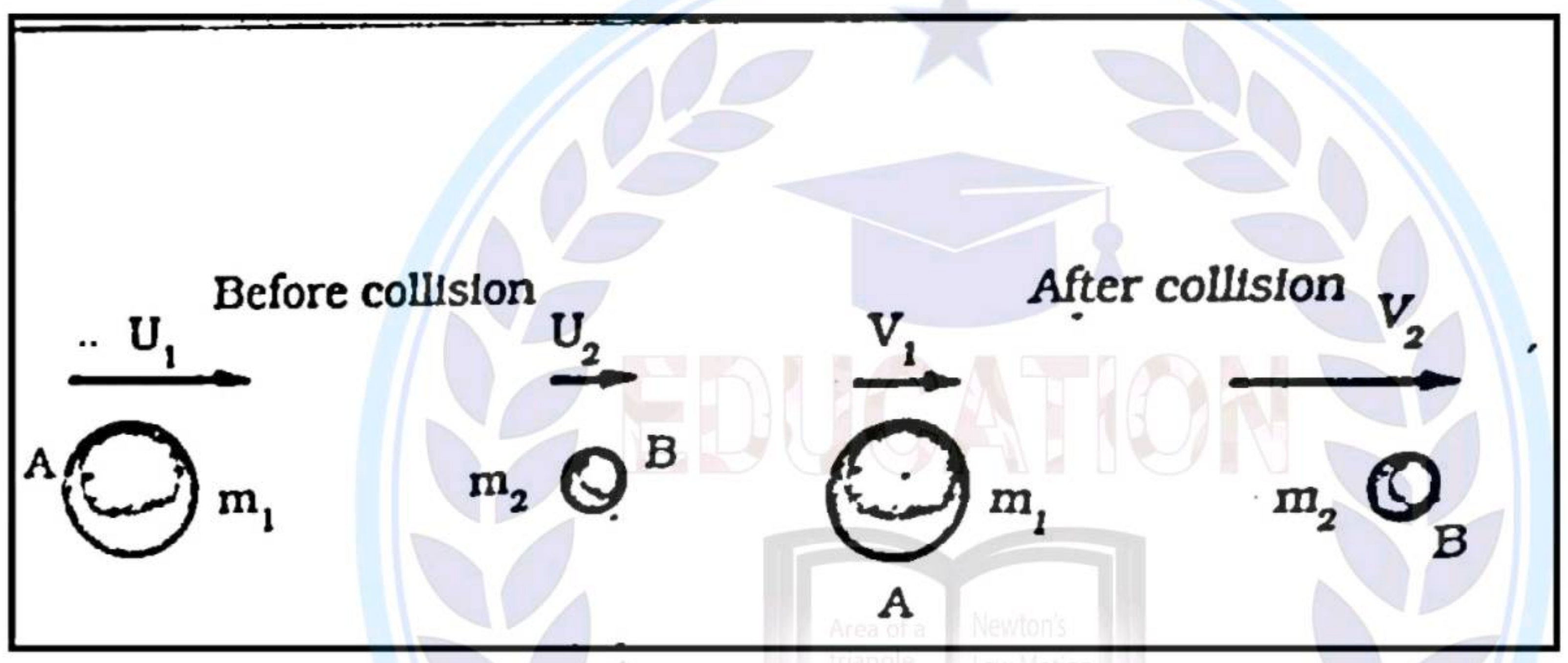
It is the collision in which momentum as well as kinetic energy of the system before and after collision is conserved.

INELASTIC COLLISION:

It is the collision in which momentum of the system remains conserved but kinetic energy before and after collision changes.

ELASTIC COLLISION IN ONE DIMENSION:

Consider two unequal, non rotating spheres of masses ‘m_1’ and ‘m_2’ moving with initial velocities ‘u_1’ and ‘u_2’. If $u_1 > u_2$, the body ‘A’ will collide with body ‘B” and both moves with velocities ‘V_1’ and ‘V_2’ in the line and direction as shown. According to the law of conservation of momentum,



Initial momentum of the system = Final momentum of the system.

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2 \quad \text{-----------------------(1)}$$

or $\quad m_1u_1 - m_1v_1 = m_2v_2 - m_2u_2$

or $\quad m_1(u_1 - v_1) = m_2(v_2 - u_2) \longrightarrow (2)$

And for elastic collision,

Total K.E of the system = Total K.E of the system
Before collision after collision

$$\frac{1}{2}m_1u_1^2 + \frac{1}{2}m_2u_2^2 = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2$$

$$m_1u_1^2 + m_2u_2^2 = m_1v_1^2 + m_2v_2^2$$

$$m_1u_1^2 - m_2u_2^2 = m_1v_1^2 - m_2v_2^2$$

$$m_1(u_1^2 - v_1^2) = m_2(v_2^2 - u_2^2)$$

$$m_1(u_1 + v_1)(u_1 - v_1) = m_2(v_2 + u_2)(v_2 - u_2) \longrightarrow (3)$$

Dividing eq (2) by eq (1),

$$\frac{\cancel{m_1}(u_1 + v_1)\cancel{(u_1 - v_1)}}{\cancel{m_1(u_1 - v_1)}} = \frac{\cancel{m_2}(v_2 + u_2)\cancel{(v_2 - u_2)}}{\cancel{m_2(v_2 - u_2)}}$$

$$u_1 + v_1 = v_2 + u_2 \longrightarrow (4)$$

FOR V_1:

From eq (3),

$$v_2 = u_1 + v_1 - u_2$$

putting the value of 'V_2' in eq (1),

$$m_1u_1 + m_2u_2 = m_2v_1 + m_2(u_1 + v_1 - u_2)$$

$$m_1u_1 + m_2u_2 = m_2v_1 + m_2u_1 + m_2v_1 - m_2u_2$$

$$m_1u_1 + m_2u_2 - m_2u_1 + m_2u_2 = m_2v_1 + m_2v_1$$

$$(m_1 - m_2)u_1 + 2m_2u_2 = (m_2 + m_2)v_1$$

$$\boxed{\frac{(m_1 - m_2)}{(m_1 + m_2)}u_1 + \frac{2m_2u_2}{(m_1 + m_2)} = V_1} \longrightarrow (A)$$

FOR V_2:

From eq (3),

$v_1 = v_2 + u_2 - u_1$

putting the value of 'V₁' in eq (1),

$m_1u_1 + m_2u_2 = m_1(v_2 + u_2 - u_1) + m_2v_2$

$m_1u_1 + m_2u_2 = m_1v_2 + m_1u_2 - m_1u_1 + m_2v_2$

$m_1u_1 + m_1u_2 - m_1u_2 + m_1u_1 = m_1v_2 + m_2v_2$

$2m_1u_1 + (m_1 - m_1)u_2 = (m_1 + m_2)v_2$

$$v_2 = \frac{2m_1u_1}{(m_1 + m_2)} + \frac{(m_1 - m_2)u_2}{(m_1 + m_2)} \longrightarrow (B)$$

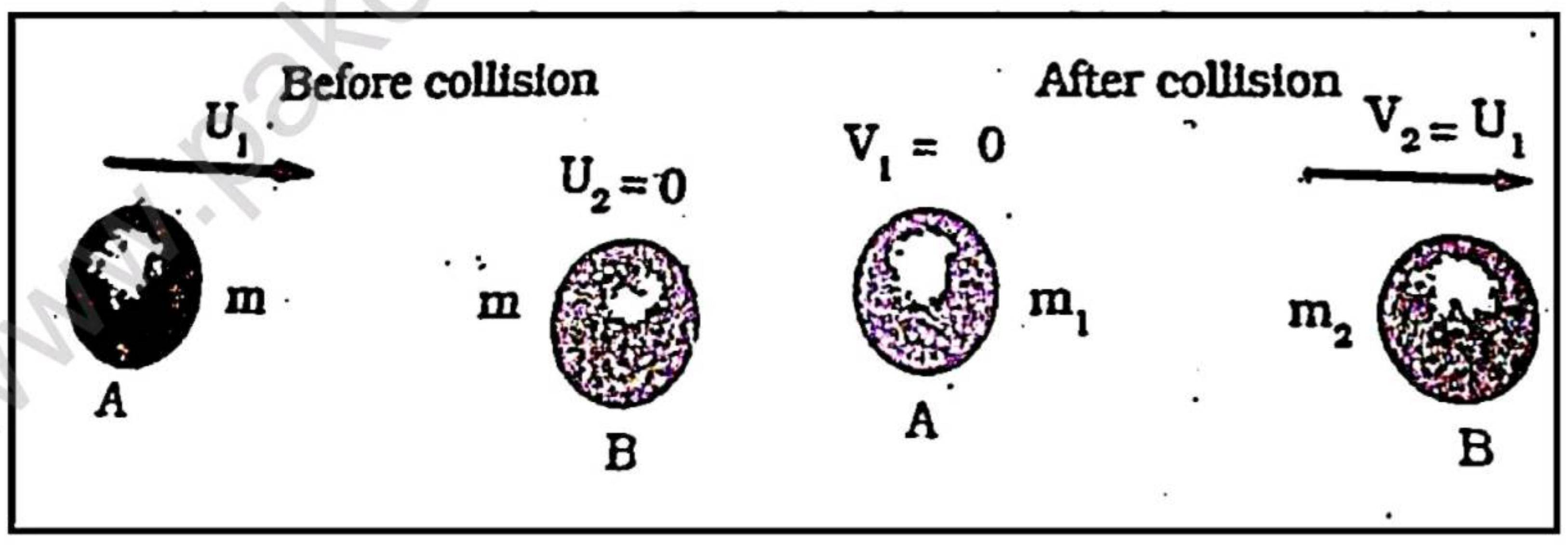
SPECIAL CASES OF ELASTIC COLLISIONS

Case I: if $m_1 = m_2$,

Let $m_1 = m_2 = m$

Then from equ (A)

$$\frac{(m_1 - m_2)u_1}{(m_1 + m_2)} + \frac{2m_2u_2}{(m_1 + m_2)} = V_1$$



Thus,

$$v_1 = \frac{(m - m)u_1}{(m + m)} + \frac{2mu_2}{(m + m)}$$

$$v_1 = 0 + \frac{2mu_2}{2m}$$

$$v_1 = u_2$$

And from eq (B),

$$v_2 = \frac{2m_1u_1}{(m_1 + m_2)} - \frac{(m_1 - m_2)u_2}{(m_1 + m_2)}$$

Thus,

$$v_2 = \frac{2mu_1}{(m+m)} - \frac{(m-m)u_2}{(m+m)}$$

$$v_2 = \frac{2mu_1}{2m}$$

$$\boxed{v_2 = u_1}$$

This shown that the bodies interchange their velocities after the collision.

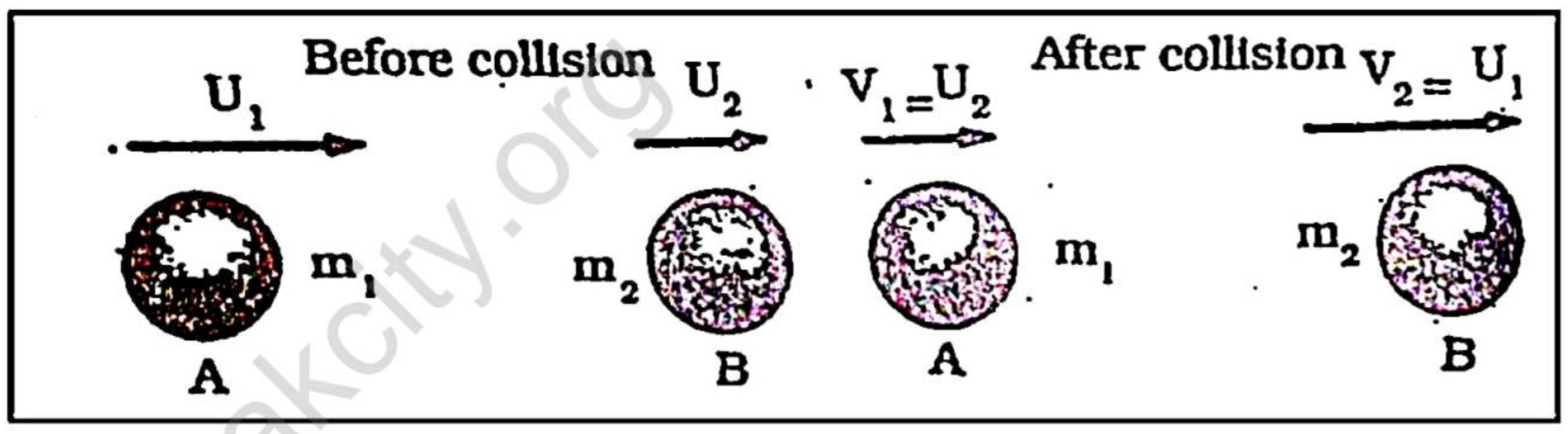
Case II: if $m_1 = m_2$ and $u_2 = 0$

let $m_1 = m_2 = m$, $u_2 = 0$

Then,

$$\frac{(m_1 - m_2)\,u_1}{(m_1 + m_2)} + \frac{2m_2u_2}{(m_1 + m_2)} = V_1$$

$$\frac{(m - m)\,u_1}{(m + m)} + \frac{2m(0)}{(m + m)} = V_1$$



$$\boxed{v_1 = 0}$$

And,

$$V_2 = \frac{2mu_1}{(m+m)} + \frac{(m-m) \times 0}{(m+m)}$$

$$\boxed{v_2 = u_1}$$

This means that body 'A' will stop after collision and 'B' will move with the initial velocity of A.

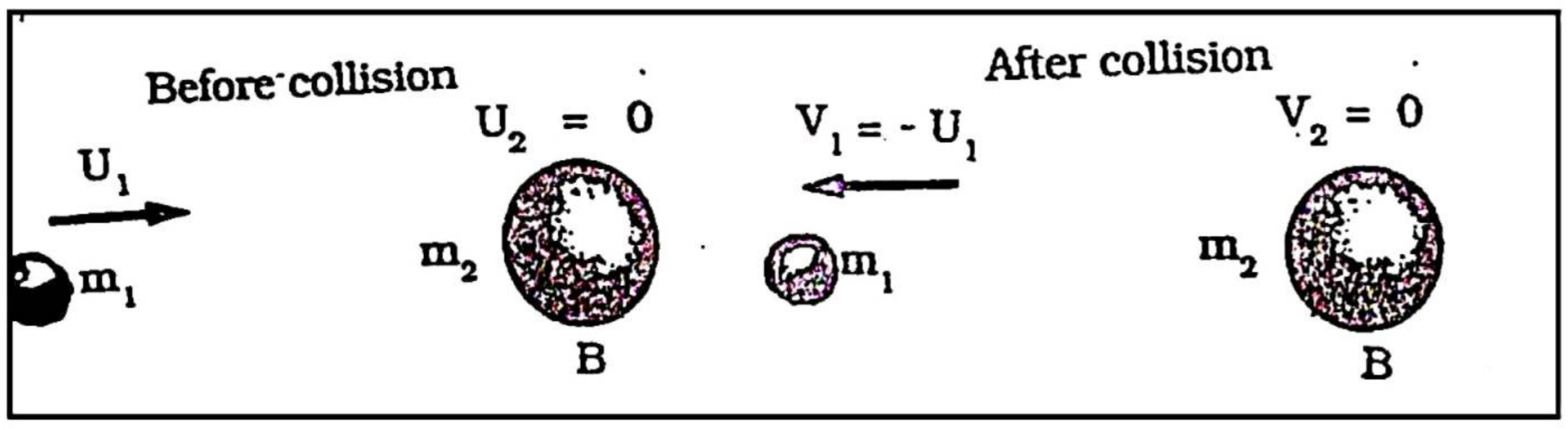
Case III: if $m_1 << m_2$ and $u_2 = 0$ (Massive body at rest)

Now, m_1 can be neglected

Since,

$$v_1 = \frac{(m_1 - m_2)\,u_1}{(m_1 + m_2)} + \frac{2m_2u_2}{(m_1 + m_2)}$$

$$v_1 = \frac{(0 - m_2)}{(0 + m_2)} u_1 + \frac{2m_2(0)}{(0 + m_2)}$$



$$\boxed{v_1 = -u_1}$$

and

$$v_2 = \frac{2m_1u_1}{(m_1 + m_2)} + \frac{(m_1 - m_2)u_2}{(m_1 + m_2)}$$

$$v_2 = \frac{2(0)\ u_1}{(0 + m_2)} + \frac{(0 - m_2)(0)}{(0 + m_2)}$$

thus,

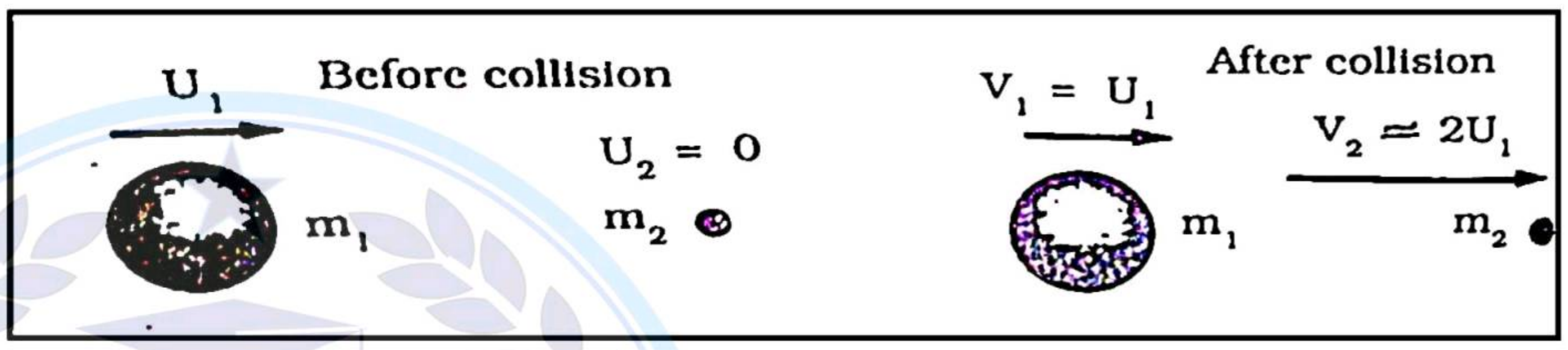
$$\boxed{v_2 = 0}$$

This means that body lighter body "A" will comes back with its initial velocity and the massive body "B" will remain at rest.

Case IV: if $m_1 >> m_2$, and $u_2 = 0$

then m_2 can be neglected,
Thus

$$v_1 = \frac{(m_1 - m_2)}{(m_1 + m_2)} u_1 + \frac{2m_2u_2}{(m_1 + m_2)}$$



$$v_1 = \frac{(m_1 - 0)}{(m_1 + 0)} u_1 + \frac{2(0)(0)}{(m_1 + 0)}$$

$$\boxed{v_1 = u_1}$$

And,

$$v_2 = \frac{2m_1u_1}{(m_1 + m_2)} + \frac{(m_1 - m_2)u_2}{(m_1 + m_2)}$$

$$v_2 = \frac{2m_1u_1}{(m_1 + 0)} + \frac{(m_1 - 0)(0)}{(m_1 + 0)}$$

$$V_2 = 2u_1$$

This means that body 'A' will continues its motion with the same velocity and 'B' will move with double the velocity of body A.

FORCE OF FRICTION

Definition:

When a body slides over another body, it gets resistance in its motion. It means a force is set up between the surfaces in contact which tends to oppose the motion. This force between the two surfaces in contact is called force of friction and this is because of roughness of the material surfaces in contact. The force of friction always acts parallel to the surfaces in contact and opposite to the direction of motion.

Explanation:

Suppose a rectangular block is placed on a horizontal surface. Forces acting on the block are its weight 'mg' downward, and reaction of the horizontal surface 'R' upward.If the block is at rest "mg" is balanced by "R". Now small force F is applied on block parallel to surfaces. If the block is still at rest then some force F is set up between surfaces which are opposing the motion. This force F is equal to applied force F and known as static friction. Now on increasing the applied force gradually , opposing force between surfaces will also go on increasing upto the value, when the block is just about to move. This maximum value of force of friction is called limiting friction.

If external force applied on block is R further increased, equilibrium will be lost and it will start moving. The force of friction f between surfaces in this situation is called F sliding friction or kinetic friction. If one body rolls over the surface, then force of friction is called rolling friction. Sliding friction is always less than limiting friction. Whereas rolling friction is less than sliding friction. The angl e .between resultant force of limiting friction and normal reaction "R" is called angle of friction.

Coefficient of Friction:

It is observed experimentally that limiting friction between surfaces is directly proportional to normal reaction "R" i.e.

$$F \propto R$$

$$=> F = \mu R$$

or

$$\mu = F/R$$

Where, μ is the constant of proportionately called co-efficient of friction.

Merits & Demerits of Friction:

Friction plays very important role in our daily life. It is advantageous as well as disadvantageous depending upon desired results. Friction between rubber and ground is desirable, without this it is impossible to walk, to drive vehicles. Friction between moving parts of different machines or engines is undesirable, because it affects the efficiency. For reducing it different lubricants are used. Another astonishing feature of frictional force is that it is a self adjusting force i.e. ‘it varies with external force and it depends upon the nature of the two surfaces in contact.

Fluid Friction & Viscosity:

A thick layer of liquid consists of large number of microscopic layers of molecules. When liquid flows each of its layers slides over the other, experiences force which opposes their motion. This internal friction between layers of same liquid, which makes it to flow slowly or resists in flow is called Viscosity: This property is found in all fluids. It is found that opposing tangential force between last stationary layer and any upper layer of given liquid is directly proportional to area of contact, velocity of layer and inversely proportional to distance of layer from stationary layer.

$$F \propto \frac{Av}{d}$$

$$F = \eta \frac{Av}{d}$$

Where η the constant of proportionality is called co-efficient of viscosity of given liquid.

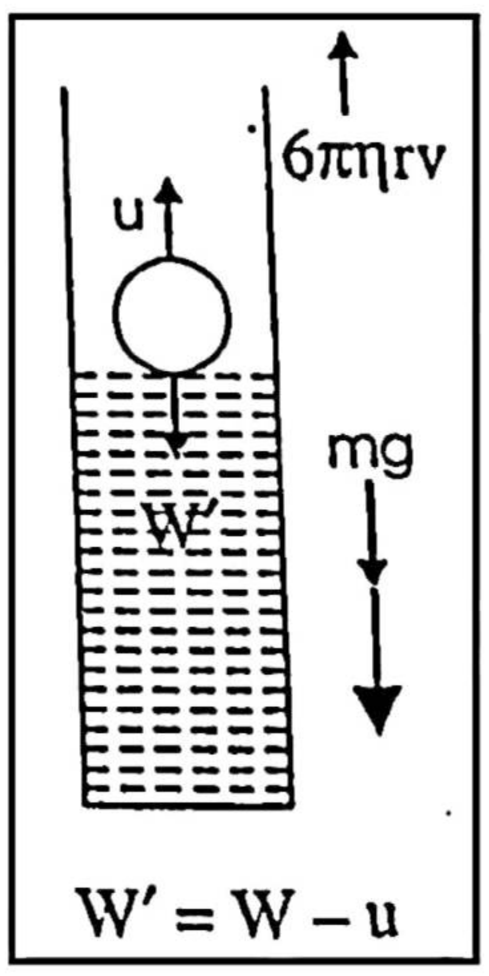
Fluid Friction or Viscous Drag:

When bodies are allowed to move through liquid or gases, they experience force which opposes their motion. This opposing force offered by liquid or gases is called viscous drag or fluid friction.

Stoke studied the effect of viscous drag on small spheres falling through liquids. He found that sphere of radius “r” falling through liquids of viscosity η with velocity v experience retarding force “F” given by,

F= $6\pi\eta r v$

This is called Stoke’s law. This equation shows that retarding force on sphere depends upon velocity “v”. Forces acting on the falling sphere in liquid are mg downward and retarding force $6\pi\eta r v$ upward.Net force with which spheres falls in liquid is mg - $6\pi\eta r v$

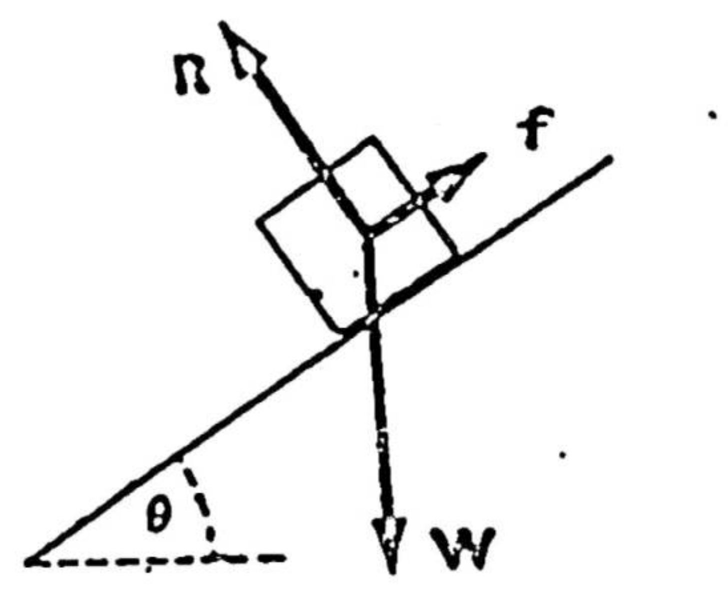


Retarding $6\pi\eta r v$ increases with increase in velocity. After falling through some distance, velocity of sphere attains such a value that force ($6\pi\eta r v$ becomes equal to mg).Under this condition sphere starts falling down with constant velocity. This constant velocity of sphere in a given liquid at which mg becomes equal to retarding force is called terminal velocity denoted by Vt.

INCLINED PLANE

Definition:

Such a surface which makes an angle θ with horizontal such that, $0° < \theta < 90°$ is called an inclined plane.



Explanation:

Since heavy load may be lifted more easily by pulling it along an inclined plane than by lifting it vertically. Therefore, it is treated as simple machine. Let us consider a block of mass 'm' placed on an inclined surface which makes an angle θ with the horizontal. Here there are three force acting the block i.e.

(i) Frictional force between block and the inclined plane ("f")

(ii) Reaction of the surface on the block (R)

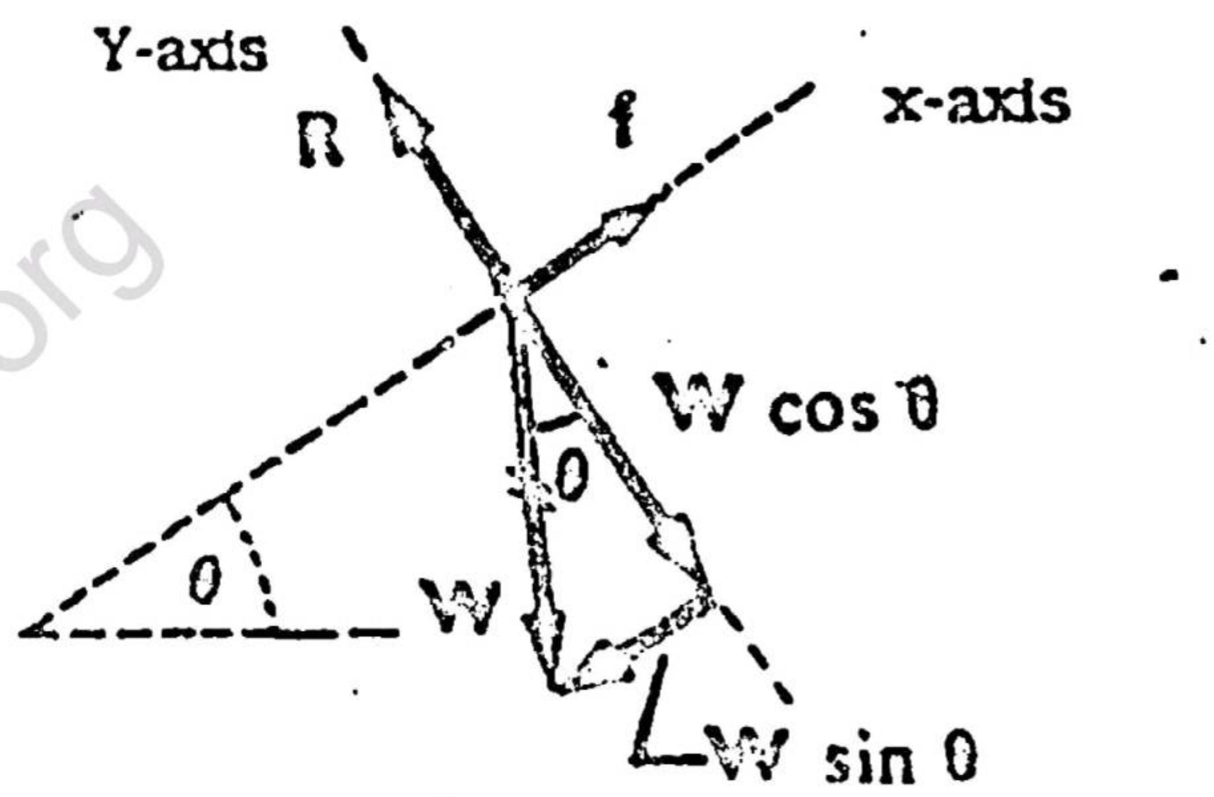
(iii) Weight of the body (W)

The weight W of the block can be resolved into two components and for this purpose.We take x-axis parallel to the inclined plane and y-axis perpendicular .Now the components of weight perpendicular and parallel to the surface are

$$\cos\theta = \frac{W_\perp}{W}$$

or

$$\boxed{W_\perp = W\cos\theta}$$



and

$$\sin\theta = \frac{W_\parallel}{W}$$

or

$$\boxed{W_\parallel = W\sin\theta}$$

It is clear from fig. that block will remain at rest if it fulfils conditions of equilibrium i.e. opposite force should be equal to each other i.e

$$f = W_\parallel$$

or

$$\boxed{f = W\sin\theta}$$

and

$$R = W_\perp$$

or

$$\boxed{R = W\cos\theta}$$

Equation no (i) and (ii) are conditions under which block remains at rest.Now, if force of friction between block and inclined plane becomes small then block can slide down with an acceleration a under the net force,

$$F = W_\parallel - f$$

or

$$ma = W\sin\theta - f$$

or

$$ma = mg\sin\theta - f$$

or

$$a = \frac{mg\sin\theta - f}{m}$$

or

$$\boxed{a = g\sin\theta - \frac{f}{m}} \text{ ---------(i)}$$

This equation represents the acceleration of the body sliding down on an inclined plane having friction "f".

If Friction is Absent:

If $f = 0$,then eq(i) becomes

$$\boxed{a = g\sin\theta} \text{ ----------(ii)}$$

Special Cases:

(i) If $\theta = 0°$

then eq (ii) => $a = g \sin 0°$

$$a = g\,(0)$$

$$\boxed{a = 0}$$

(ii) If $\theta = 90°$

then Eq (ii) => $a = g \sin 90°$

$$a = g\,(1)$$

$$\boxed{a = g}$$

i.e. Free Fall Motion.

M.C.Qs.

1. The area between a velocity time graph and the time axis is equal to the:

(a) Velocity (b) Distance
(c) Displacement (d) Acceleration

2. Swimming is possible on account of:

(a) First law of motion
(b) Second law of motion
(c) Third law of motion
(d) Newton's law of gravitation

3. Inertia of a body is measured in terms of
(a) its weight (b) its applied force
(c) its reaction (d) its mass

4. During free fall, of air friction is negligible then acceleration of bodies of different masses is:
(a) The same for all the masses
(b) Different for different masses
(c) Different for different vertical positions.
(d) Both A & B

5. The frictional resistance between its various layers of fluids is called:
(a) Viscous drag (b) Viscosity
(c) Friction (d) Up thrust

6. If two bodies of equal mass collide elastically then:
(a) their velocities are added to each other
(b) their velocities are subtracted
(c) their velocities do not changed
(d) they exchange their velocities

7. To produce same acceleration in the bodies of masses 10 kg and 20 kg the force applied on the second body should be:
(a) Halved (b) Equal to that on first body
(c) Doubled (d) Three times

8. A truck covers a distance of 360km in 5 hrs. its speed will be:
(a) 180 km/h (b) 360 km/h
(c) 72 km/h (d)36km/h

9. How long does it take by a car going at 30 m/s to stop if it decelerates at 7m/s2:
(a) 4s (b) 5s
(c) 6s (d) 7s

10. Stoke's law holds for:
(a) bodies of all shapes
(b) Motion through free space
(c) horizontal motion of particles
(d) motion through a viscous medium

11. The coefficient of frictional force between two surfaces in contact does NOT depends upon.
(a) The normal force passing one against the other (b) The area of surfaces
(c) Whether the surfaces are stationary or in relative motion
(d) whether a lubricant is used or not.

12. If the time interval is very small ($\Delta t \to 0$), the rate of change of velocity of a body is called:
(a) Average acceleration
(b) acceleration
(c) instantaneous acceleration
(d) constant acceleration

13. If velocity of a body is decreasing, the direction of acceleration is:
(a) in the direction of velocity
(b)opposite to the direction of velocity
(c) perpendicular to the direction of velocity
(d) 60° to the direction of velocity

14. Kinetic friction is always:
(a) greater than static friction
(b) Equal to static friction
(c) less than static friction
(d) zero

15. If 'F' be the limiting friction and 'R' the normal reaction. Then co-efficient of static friction 'μ' is:
(a) μ= F/R (b) μ= R/F
(c) μ=FR (d) μ= 1/FR

16. A body falls freely .The distance covered by it in 2 sec is:
(a) 9.8 m (b) 19.6 m
(c)39.2 m (d) 100 m

17. The acceleration of body moving down a

frictionless plane inclines at 30^0 will be:
(a) 4.9 m/s^2 (b) 9.8 m/s^2
(c) 98 m/s^2 (d) 10 m/s^2

18. If the rate of change momentum with respect to time is zero then.
(a) The momentum is a function of time
(b) The momentum is not conserved
(c) The momentum is constant
(d) Some force acts

19. Which of the following changes when a particle is moving with uniform velocity?
(a) Speed (b) Velocity
(c) Acceleration (d) Position vector

20. If linear momentum of a particle in doubled, its kinetic energy will.
(a) be double (b) be halved
(c) be quadrupled (d) Remains unchanged

21. A collision in which momentum conserved but K.E is not conserved is called:
(a) Elastic collision (b) In elastic collision
(c) Both A & B (d) either A or B

22. A passenger in a moving bus is thrown forward when the bus is suddenly stopped. This is explained
(a) by Newton's first law
(b) by Newton's second law
(c) by Newton's third law
(d) by the principle of conservation of momentum

23. A gun of mass 1000 kg fires a projectile of mass 1 kg with a horizontal velocity of 100 m/s. The velocity of recoil of the gun in the horizontal direction is
(a) 5 m/s (b) 0.1 m/s
(c) 15 m/s (d) 20 m/s

24. A block of wood is placed on a surface. A force is applied parallel to the surface to move the body. The frictional force developed acts
(a) normal to the surface upwards
(b) normal to the surface downwards
(c) along the direction of the applied force
(d) opposite to the direction of the applied force

25. The inherent property, with which a body resists any change in its state of motion is known as
(a) Force (b)Momentum
(c)Inertia (d)Acceleration

26. 1 Newton = ————-
(a) 1 Newton = 1 kg x 1 m/s2
(b) 1 Newton = 1 kg
(c) 1 Newton = 1 kg x 1 m/s
(d) 1 Newton = m/s2

27. When the body is stationary:
(a) There is no force acting on it
(b) The force acting on it are not in contact each other
(c) The forces acting on it are balanced with it
(d) The body is in vacuum

PAST PAPER M.C.Qs.

2022

6.An object is falling through a fluid with terminal velocity, its velocity is
* zero *decreased * increased **_* constant_**

13. A truck covers a distance of 360km in 5 hrs. its speed will be:

* 180 km/h *360 km/h **<u>*72 km/h</u>** *36km/h

27.A ball is dropped from a height of 100m, its acceleration at half of height will be:
<u>* 9.8 m/s²</u> * 4.9 m/s² *10 m/s² * 5 m/s²

2021

(ii) To produce same acceleration in the bodies of masses 10 kg and 20 kg the force applied on the second body should be:
*Halved *Equal to that on first body **<u>*Doubled</u>** *Three times

(iii) A truck covers a distance of 360km in 5 hrs. its speed will be:
* 180 km/h *360 km/h **<u>*72 km/h</u>** *36km/h

(iv) How long does it take by a car going at30m/s to stop if it decelerates at $7 m/s^2$:
<u>*4s</u> *5s *6s *7s

(v) The force acting on a body of 1 kg mass falling freely will be:
*5 N *19.6 N **<u>*9.8 N</u>** * Zero N

(xxvi) The acceleration of a body moving down a frictionless plane inclined at 30° will be:
<u>*4.9m/sec²</u> *9.8m/sec² *98m/sec³ *10m/sec²

38 .If 'F' be the limiting friction and 'R' the normal reaction. Then co-efficient of static friction`μ' is:

<u>* $\mu = \frac{F}{R}$</u> * $\mu = \frac{R}{F}$ * $\mu = FR$ * $\mu = \frac{1}{FR}$

2019

4.If 'F' be the limiting friction and 'R' the normal reaction. Then co-efficient of static friction`μ' is:

<u>* $\mu = \frac{F}{R}$</u> * $\mu = \frac{R}{F}$ * $\mu = FR$ * $\mu = \frac{1}{FR}$

16. If the time interval is very small ($\Delta t \to 0$), the rate of change of velocity of a body is called:
*Average acceleration *acceleration
<u>*instantaneous acceleration</u> *constant acceleration

2018

13. A bullet is fired horizontally with 20 m/s, the absence of air friction, its horizontal velocity component after 2 s will be:
*40m/s **<u>*20m/s</u>** * 10 m/s * 5 m/s

16.An object is falling through a viscous fluid with terminal velocity,its velocity:
*is increasing *is decreasing **<u>* remains same</u>** * becomes zero

2017

1. A bus of weight 30000 N is moving with uniform velocity of 14 m/s, its acceleration is:

*14 m/s^2 ***zero** *7 m/s^2 *9.8 m/s^2

17. Stokes law is applicable to the:

*bodies resting on the surface of liquid

***moving bodies through the viscous medium**

*moving bodies through the non viscous medium

*moving bodies through vacuum

2016

2. If velocity of a body is decreasing, the direction of acceleration is:

*in the direction of velocity ***opposite to the direction of velocity**

*perpendicular to the direction of velocity *60° to the direction of velocity

17. Kinetic friction is always:

*greater than static friction *Equal to static friction

***less than static friction** *zero

2015

4. The rate of change of linear momentum is:

*acceleration * torque ***force** * velocity

5. If 'F' be the limiting friction and 'R' the normal reaction. Then co-efficient of static friction 'μ' is:

***μ= F/R** *μ= R/F *μ=FR *μ= 1/FR

2013

2. If the average and instantaneous velocities of a body are the same, the body will move with:

*Variable velocity ***Uniform velocity**

*Uniform acceleration *Variable acceleration

6. A body falls freely .The distance covered by it in 2 sec is:

*9.8 m ***19.6 m** *39.2 m *100 m

2012

5. The property of fluids due to which they resists their flow is called:

*co efficient of friction * static friction

*** viscosity** * terminal velocity

17. A helicopter weighing 3920 N is moving up with a constant speed of 4 m/s. The force on the helicopter is:

*4720 N *** 3920N** * 3924 N * 3916N

2011

5. A one kilogram stone, falling freely from a height of 10 meter, strikes the ground with a velocity of:

***14 m/s** *10 m/s *98 m/s *19.6 m/s

14. The acceleration of body moving down a frictionless plane inclines at 30° will be:

***4.9 m/s^2** * 9.8 m/s^2

*98 m/s^2 *10 m/s^2

2010

15. Stokes's law holds good for:
* the bodies of all shapes
* motion through non viscous medium
* motion through vacuum
* **motion through viscous medium**

16. How many meters will a 20 kg ball, starting from rest, falls freely in one second?
* 19.6 m
* **9.8 m**
* 4 m
* 4.9 m

TEXTBOOK NUMERICALS

Q.1: In an electron gun of a television set, an electron with an initial speed of 10^3 m/s enters region where it is electrically accelerated. It emerges out of this region after 1 micro second with speed of $4\text{x}10^5$ m/s. What is the maximum length of the electron gun? Calculate the acceleration.

Data:

Initial Speed $= v_i = 10^3 m/s$

Time $= t = 1\ \mu S = 1 \times 10^{-6} s$

Final Speed $= v_f = 4 \times 10^5 m/s$

Length of Gun $= S = ?$

Acceleration $= a = ?$

Solution:

Using First Equation of Motion

$$\mathrm{v_f = v_i + at}$$

$$4 \times 10^5 = 10^3 + \mathrm{a}(1 \times 10^{-6})$$

$$\mathrm{a} = \frac{4\times10^5 - 10^3}{1\times10^{-6}}$$

$$\boxed{\mathrm{a} = 3.99 \times 10^{11} m/s^2}$$

Now,

$$2aS = V_f^2 - V_i^2$$

$$2(3.99 \times 10^{11})S = (4 \times 10^5)^2 - (1 \times 10^3)^2$$

$$S = \frac{(4\times10^5)^2 - (1\times10^3)^2}{2(3.99\times10^{11})}$$

$$\boxed{S = 0.2\ m}$$

Result: The maximum length of the electron gun is 0.2 m and the acceleration is $3.99 \times 10^{11} m/s^2$

Q.2: A car is waiting at a traffic signal and when it turns green, the car stats ahead with a constant acceleration of 2 m/s^2 . At the same time a bus traveling with a constant speed of 10 m/s overtakes and passes the car. (a) How far beyond its starting point will the car overtake the bus? (b) How fast will the car be moving?

Data:

Intial Speed of car $= v_i = 0$

Acceleration of car $= a = 2\ m/s^2$

Speed of Bus $= v = 10\ m/s$

Distance $= S = ?$

Final speed of car $= v_f = ?$

Solution:

For Car:

$$S = v_i t + \frac{1}{2}at^2$$

$$S = 0 \times t + \frac{1}{2}(2)t^2$$

$S = t^2$ --- (i)

For Bus:

$$S = v \times t$$

$S = 10\ t$ ----- (ii)

Comparing eq (i) and eq (ii)

$$t^2 = 10\ t$$

$$\boxed{t = 10\ sec}$$

Putting in eq (ii)

$$\boxed{S = 10 \times 10 = 100\ m}$$

Final Velocity of Car:

$$v_f = v_i + at$$

$$v_f = 0 + 2 \times 10$$

$$\boxed{v_f = 20\ m/s}$$

Result: The bus overtakes at 100 m distance from starting point and car was moving with 20 m/s.

Q.3: A helicopter ascending at a rate of 12 m/s. At a height of 80m above the ground, a package is dropped.How long does the package take to reach the ground?

Data:

Intial Speed $= v_i = 12\ m/s$

Initial Height $= H = 80\ m$

Total time $= t = ?$

Solution:

During upward Motion

For t_1:

$$v_f = v_i + at$$

$$0 = 12 + (-9.8)t_1$$

$$\boxed{t_1 = \frac{12}{9.8} = 1.22\ sec}$$

For S_1:

$$S = v_i t + \frac{1}{2}at^2$$

$$S_1 = 12 \times 1.22 + \frac{1}{2}(-9.8)(1.22)^2$$

$$S_1 = 14.64 - 7.29$$

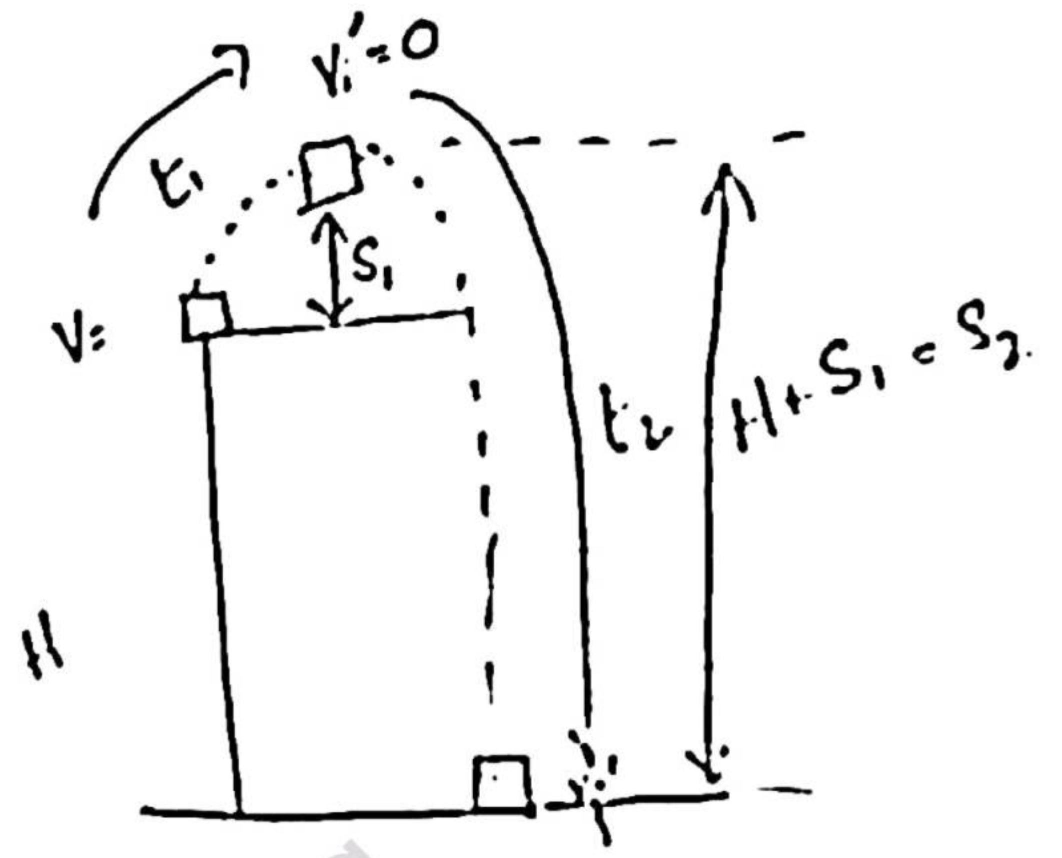
$$\boxed{S_1 = 7.35\ m}$$

During Downward Motion

For t_2:

$$S = v_i t + \frac{1}{2}at^2$$

Or



$$S_1 + H = 0 \times t_2 + \frac{1}{2}(9.8){t_2}^2$$

$$7.35 + 80 = (4.9){t_2}^2$$

$$87.35 = 4.9t_2^2$$

$${t_2}^2 = 17.82$$

Taking square root

$$\boxed{t_2 = 4.22\ sec}$$

Now, Total time is given by

$$\boxed{t = t_1 + t_2 = 1.22 + 4.22 = 5.44\ sec}$$

Result: The total time taken will be 5.44 sec.

Q.4: A boy throws a ball upward from the top of a cliff with a speed of 14.7 m/s. On the way down it just misses the thrower and fall the ground 49 metres below. Find (a) How long the ball rises? (b) How high it goes? (c) How long it is in air and (d) with what velocity it strikes the ground.

Data:

Intial Speed $= v_i = 14.7\ m/s$

Height $= H = 49\ m$

(a) Time for Upward flight $= t_1 = ?$

(b) Height gained by ball $= h_2 = ?$

(c) Total Time $= t = ?$

(d) Final Speed $= v_f = ?$

Solution:

During upward Motion

For t_1:

$$v_f = v_i + at$$

$$0 = 14.7 + (-9.8)t_1$$

$$\boxed{t_1 = \frac{14.7}{9.8} = 1.5\ sec}$$

For S_1:

$$S = v_i t + \frac{1}{2}at^2$$

$$S_1 = 14.7 \times 1.5 + \frac{1}{2}(-9.8)(1.5)^2$$

$$S_1 = 22.05 - 11.025$$

$$\boxed{S_1 = 11.025 \text{ m}}$$

During Downward Motion

For t_2:

$$S = v_i t + \frac{1}{2}at^2$$

Or $S_1 + H = 0 \times t_2 + \frac{1}{2}(9.8){t_2}^2$

$$11.025 + 49 = (4.9){t_2}^2$$

$$60 = 4.9t_2^2$$

$${t_2}^2 = 12.24$$

Taking square root

$$\boxed{t_2 = 3.5 \text{ sec}}$$

Now, Total time is given by

$$\boxed{t = t_1 + t_2 = 1.5 + 3.5 = 5 \text{ sec}}$$

For Final Velocity:

$$v_f = v_i + at$$

$$v_f = 0 + (9.8)t_2$$

$$v_f = 9.8 \times 3.5$$

$$\boxed{v_f = 34.3 \text{ m/s}}$$

Result: The ball rises 1.5 sec and it goes 11.025 m. It is in air for 5 sec and with 34.3 m/s velocity it strikes the ground

Q.5: A helicopter weighs 3920 Newton. Calculate the force on it if it is ascending up at a rate of 2 m/s². What will be force on helicopter if it is moving up with the constant speed of 4 m/s?

Data:

Weight of Helicopter $= W = 3920N$

(a) Acceleration $= a = 2\ m/s^2$

Force on Helicopter $= F = ?$

(b) Speed of Helicopter $= v = 4\ m/s$

Force on Helicopter $= F = ?$

Solution:

$$m = \frac{W}{g} = \frac{3920}{9.8} = 400\ kg$$

(a) $Force\ applied\ by\ engine = weight + acceleration\ producing\ force$

$$F = W + ma$$

$$F = 3920 + 400 \times 2$$

$$\boxed{F = 4720\ N}$$

(b)

$Force\ applied\ by\ engine = weight(\ acceleration = 0)$

$$F = W$$

$$\boxed{F = 3920\ N}$$

Result: The force on helicopter when accelerated is 4720 N and when velocity is constant it is 3920 N.

Q.6: A bullet having a mass of 0.005 kg is moving with a speed of 100 m/s. It penetrates into a bag of sand and is brought to rest after moving 25cm into the bag. Find the deceleration force on the bullet. Also calculate the time in which it is brought to rest.

Data:

Mass of Bullet $= m = 0.005\ kg$

Initial Speed of Bullet $= v_i = 100\ m/s$

Final Speed of Bullet $= v_f = 0$

Distance covered $= S = 25\ cm = 0.25\ m$

Decelerating Force $= F = ?$

Time $= t = ?$

Solution:

As we know that

$$F = ma \text{ --- (i)}$$

For Acceleration:

$$2aS = V_f^2 - V_i^2$$

$$2a(0.25) = (0)^2 - (100)^2$$

$$a(0.5) = -10000$$

$$\boxed{a = -20000\ m/s^2}$$

Putting values in eq (i)

$$F = ma$$

$$F = 0.005 \times (-20000)$$

$$\boxed{F = -100\ N}$$

For Time:

$$v_f = v_i + at$$

$$0 = 100 + (-20000) \times t$$

$$t = \frac{100}{20000}$$

$$\boxed{t = 0.005\ sec}$$

Result: The deceleration force on the bullet is 100 Nand the time in which it is brought to rest is 0.005 sec.

Q.7: A car weighing 9800 N is moving with a speed of 40 km/h. On the application of the brakes it comes to rest after traveling a distance of 50 metres. Calculate the average retarding force.

Data:

Weight of Car $= W = 9800\ N$

Initial Speed of Car $= v_i = 40\frac{km}{h} = \frac{40\times1000}{3600} = 11.11\ m/s$

Final Speed of Car $= v_f = 0$

Distance covered $= S = 50\ m$

Retarding Force $= F = ?$

Solution:

$$m = \frac{W}{g} = \frac{9800}{9.8} = 1000\ kg$$

As we know that

$$F = ma \text{ --- (i)}$$

For Acceleration:

$$2aS = V_f^2 - V_i^2$$

$$2a(50) = (0)^2 - (11.11)^2$$

$$a(100) = -123.43$$

$$\boxed{a = -1.234\ m/s^2}$$

Putting values in eq (i)

$$F = ma$$

$$F = 1000 \times (-1.234)$$

$$\boxed{F = -1234\ N}$$

Result: The retarding force on the car is 1234 N.

Q.8: An electron in a vacuum tube starting from rest is uniformly accelerated by an electric field so that it has a speed 6x10^6 m/s after covering a distance of 1.8cm. Find the force acting on the electron. Take the mass of electron as 9.1x10^{-31} kg.

Data:

Mass of Electron $= m = 9.1\text{x}10^{-31}$ kg

Initial Speed of Bullet $= v_i = 0$

Final Speed of Bullet $= v_f = 6\times10^6 m/s$

Distance covered $= S = 1.8\ cm = 0.018\ m$

Force $= F = ?$

Solution:

As we know that

$$F = ma \text{ --- (i)}$$

For Acceleration:

$$2aS = V_f^2 - V_i^2$$

$$2a(0.018) = (6\times10^6)^2 - (0)^2$$

$$a(0.036) = 3.6\times10^{13}$$

$$\boxed{a = 1\times10^{15}\ m/s^2}$$

Putting values in eq (i)

$$F = ma$$

$$F = 9.1\text{x}10^{-31} \times (1\times10^{15})$$

$$\boxed{F = 9.1\text{x}10^{-16}\ N}$$

Result: The force acting on the electron is $9.1\text{x}10^{-16}\ N$.

Q.9: Two bodies A & B are attached to the ends of a string which passes over a pulley, so that the two bodies hang vertically. If the mass of the body A is 4.8 kg. Find the mass of body B which moves down with an acceleration of 0.2 m/s^2 . The value of g can be taken as 9.8 m/s^2 .

Data:

Mass of Body A (Lighter body) $= m_2 = 4.8$ kg

Mass of Body B (Havier body) $= m_1 = ?$

Acceleration $= a = 0.2\ m/s^2$

Acceleration due to gravity $= g = 9.8\ m/s^2$

Solution:

As we know that

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

$$0.2 = \left(\frac{m_1 - 4.8}{m_1 + 4.8}\right) 9.8$$

$$0.2(m_1 + 4.8) = (m_1 - 4.8)9.8$$

$$0.2m_1 + 0.96 = 9.8\text{m}_1 - 47.04$$

$$0.2m_1 - 9.8\text{m}_1 = -47.04 - 0.96$$

$$-9.6\text{m}_{1=} - 48$$

$m_1 = 5\ kg$

Result: The mass of body B which moves down is 5 kg.

Q.10: Two bodies of masses 10.2 kg & 4.5 kg are attached to the ends of a string which passes over a pulley in such a way that the body of mass 10.2 kg lies on a smooth surface and the other body hangs vertically. Find the acceleration of the bodies and tension of the string and also the force, which the surface exerts, on the body of mass 10.2 kg.

Data:

Mass of Body A $= m_2 = 10.2$ kg

Mass of Body B $= m_1 = 4.5$ kg

Acceleration $= a = ?$

Tension $= T = ?$

Force on $m_2 = R = ?$

Solution:

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

$a = \left(\frac{4.5}{4.5+10.2}\right) 9.8$

$a = 3\ m/s^2$

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

$T = \left(\frac{4.5\times10.2}{4.5+10.2}\right) 9.8$

$T = 30.6\ N$

(iii) $R = w_2 = m_2 g$

$R = 10.2 \times 9.8$

$R = 99.96\ N$

Result: The acceleration of the bodies is 3 m/s^2 and tension of the string is 30.6 N.The force, which the surface exerts, on the body of mass 10.2 kg is 99.96 N

Q.11: A 100 grams bullet is fired from a 10 kg gun with a speed of 1000 m/s. What is the speed of recoil of the gun?

Data:

Mass of Bullet $= m_1 = 100$ g $= 0.1$ kg

Mass of Gun $= m_2 = 10$ kg

Initial Speed of Bullet $= u_1 = 0$

Initial Speed Gun $= u_2 = 0$

Final Speed of Bullet $= v_1 = 1000\ m/s$

Final Speed of Gun $= v_2 = ?$

Solution:

According to law of Conservation of Momentum

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$(0.1)(0) + (10)(0) = (0.1)(1000) + (10)v_2$

$0 + 0 = 100 + (10)v_2$

$v_2 = -\frac{100}{10} = -10\ m/s$

Result: The speed of recoil of gun is 10 m/s.

Q.12: A 50 grams bullet is fired into a 10 kg block that is suspended by a long cord so that it can swing as a pendulum. If the block is displaced so that its centre of gravity rises by 10cm, what was the speed of the bullet?

Data:

Mass of Bullet $= m_1 = 50$ g $= 0.05$ kg

Mass of Block $= m_2 = 10$ kg

Height covered by block $= h = 10\ cm = 0.1\ m$

Initial Speed of Bullet $= u_1 = ?$

Solution:

According to law of Conservation of Momentum

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

$0.05 \text{ x } u_1 + 10 \text{ x } 0 = 0.05 \text{ x v} + 10 \text{ x v}$

$0.05 \text{ x } u_1 = 10.05 \text{ x v}$

$u_1 = \frac{10.05}{0.05} \text{ x v}$ ------ (i)

According to law of Conservation of Energy

Loss in K.E. = Gain in P.E

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

$v^2 = 2gh \quad => v = \sqrt{2gh}$

$v = \sqrt{2 \times 9.8 \times 0.1} = \sqrt{1.96}$

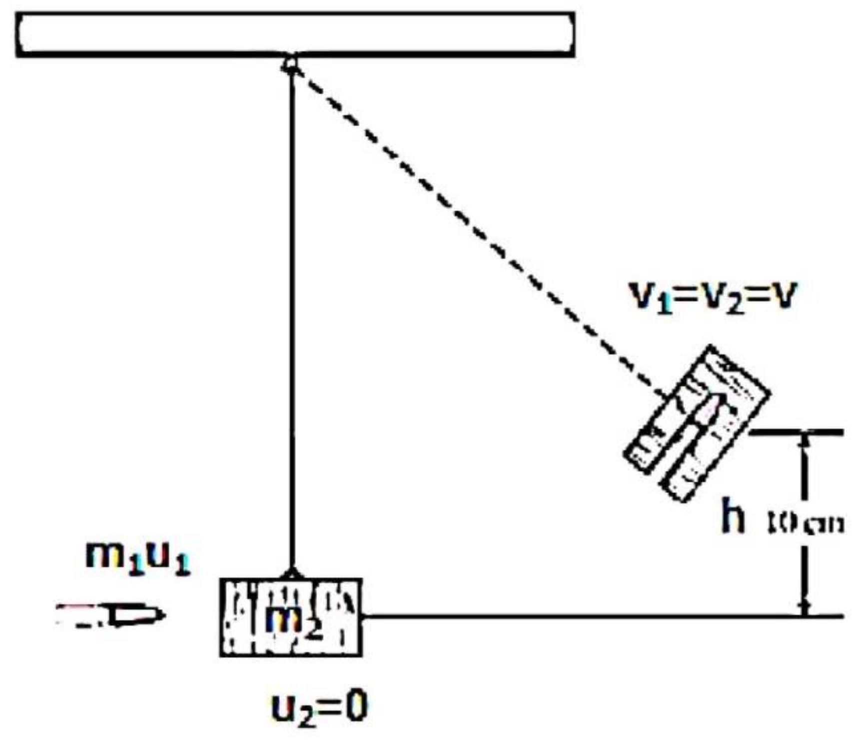
$v = 1.4\ m/s$

Putting in eq (i)

$u_1 = \frac{10.05}{0.05} \text{ x } 1.4$

$u_1 = 281.4$ m/s

Result: The Initial speed of bullet is 281.4 m/s.



Q.13: A machine gun fires 10 bullets per second into a target. Each bullet weighs 20 gm and had a speed of 1500 m/s. Find the force necessary to hold the gun in position.

Data:
No. of Bullet $= n = 10$
Time $= t = 1\ sec$
Mass of Bullet $= m = 20$ g $= 0.02$ kg
Initial Speed of Bullet $= v_i = 1500\ m/s$
Final Speed of Bullet $= v_f = 0$
Force $= F = ?$

Solution:
According to the definition of Force
$$F = \frac{\Delta P}{\Delta t}$$
Force due to one bullet is
$$f = \frac{m v_f - m v_i}{t}$$
$$f = \frac{0.02 \times 0 - 0.02 \times 1500}{1}$$
$$\boxed{f = -30\ N}$$
Now Force due to "n" Bullets
$$F = f \times n$$
$$F = -30 \times 10$$
$$\boxed{F = -300\ N}$$
Result: The force necessary to hold the gun in position is 300N

Q.14: A cyclist is going up a slope of 30° with a speed of 3.5 m/s. If he stops pedaling, how much distance will he move before coming to rest? (Assume the friction to be negligible).

Data:
Slope $= \theta = 30°$
Initial Speed of cyclist $= v_i = 3.5\ m/s$
Final Speed of cyclist $= v_f = 0$
Distance covered $= S = ?$

Solution:
Using 3rd equation of motion
$$2aS = V_f^2 - V_i^2 \text{ --- (i)}$$
When friction is absent
$$a = g\ Sin\theta$$
$$a = -9.8 \times\ Sin30°$$
$$\boxed{a = -4.9\ m/s^2}$$
Putting in eq (i)
$$2(-4.9)S = (0)^2 - (3.5)^2$$
$$-9.8 \times S = -12.25$$
$$\boxed{S = 1.25\ m}$$
Result: He will move1.25 m before coming to rest.

Q.15: The engine of a motorcar moving up 45° slope with a speed of 63 km/h stops working suddenly. How far will the car move before coming to rest? (Assume the friction to be negligible).

Data:
Slope $= \theta = 45°$
Initial Speed of Motor car $= v_i = 63\frac{km}{h} = \frac{63 \times 1000}{3600} = 17.5\ m/s$
Final Speed of Motor Car $= v_f = 0$
Distance covered $= S = ?$

Solution:
Using 3rd equation of motion
$$2aS = V_f^2 - V_i^2 \text{ --- (i)}$$
When friction is absent
$$a = a\ Sin\theta$$

$$a = -9.8 \times Sin45°$$

$$\boxed{a = -6.92\ m/s^2}$$

Putting in eq (i)

$$2(-6.92)S = (0)^2 - (17.5)^2$$

$$-13.84 \times S = -306.25$$

$$\boxed{S = 22.1\ m}$$

Result: The car will move 22.1 m before coming to rest.

Q.16: In question no. 15, find the distance that the car moves, if it weighs 19,600N and the frictional force is 2000 N.

Data:

Slope $= \theta = 45°$

Initial Speed of Motor car $= v_i = 63\frac{km}{h} = \frac{63 \times 1000}{3600} = 17.5\ m/s$

Final Speed of Motor Car $= v_f = 0$

Weight of Motor car $= W = 19600\ N$

Friction $= f = 2000N$

Distance covered $= S = ?$

Solution:

$$m = \frac{W}{g} = \frac{19600}{9.8} = 2000\ kg$$

Using 3rd equation of motion

$$2aS = V_f^2 - V_i^2 \text{ --- (i)}$$

When friction is Present

$$a = g\ Sin\theta - \frac{f}{m}$$

$$a = -9.8 \times Sin45° - \frac{2000}{2000}$$

$$\boxed{a = -7.92\ m/s^2}$$

Putting in eq (i)

$$2(-7.92)S = (0)^2 - (17.5)^2$$

$$-15.84 \times S = -306.25$$

$$\boxed{S = 19.3\ m}$$

Result: The car will move 19.3 m before coming to rest.

PAST PAPER NUMERICALS

2022

iv) A cyclist is going up a slope of 30° with a speed of 3.5 m/s. if he stops pedalling, how much distance will he move before coming to rest? (Assume, friction in negligible).

Data:

Slope $= \theta = 30°$

Initial Speed of cyclist $= v_i = 3.5\ m/s$

Final Speed of cyclist $= v_f = 0$

Distance covered $= S = ?$

Solution:

Using 3rd equation of motion

$$2aS = V_f^2 - V_i^2 \text{ --- (i)}$$

When friction is absent

$$a = g\ Sin\theta$$

$$a = -9.8 \times Sin30°$$

$$\boxed{a = -4.9\ m/s^2}$$

Putting in eq (i)

$$2(-4.9)S = (0)^2 - (3.5)^2$$

$$-9.8 \times S = -12.25$$

$$\boxed{S = 1.25\ m}$$

Result: He will move1.25 m before coming to rest.

2019

2(i) A body starts from rest and moves with constant acceleration of 10 m/s^2.How much distance will it travel in the 4th second of its motion?

Data:
Initial velocity= $v_i = 0$ m/s
Acceleration= $a = 10$ m/s^2
Distance during 4th sec = $S_4 - S_3$ =?
Solution:

(i) When t= 3 sec

$$S = v_i t + \frac{1}{2}at^2$$

$$S_3 = 0 + \frac{1}{2}(10)(3)^2$$

$$\boxed{S_3 = 5 \times 9 = 45\ m}$$

(ii) When t= 4 sec

$$S = v_i t + \frac{1}{2}at^2$$

$$S_4 = 0 + \frac{1}{2}(10)(4)^2$$

$$\boxed{S_4 = 5 \times 16 = 80\ m}$$

$$\therefore S_4 - S_3 = 80 - 45 = 35\ m$$

Result: Distance travelled during 4th second is equal to 35 m

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Q.2 (xv) Textbook Numerical 12

2018

Q. 2(v) A brick of mass 2 kg is dropped from a height of 5m above the ground. What is its velocity at a height of 3m above the ground?

Data:
Mass = m = 2kg
Initial Height = h_1=5m
Final Height = h_2=3m
Initial Velocity = $v_i = 0$ m/s
Final Velocity = $v_f = ?$
Solution:

$$h = h_1 - h_2 = 5 - 3 = 2\ m$$

According to Third equation of motion

$$2as = v_f^2 - v_i^2$$

$$2(9.8)(2) = v_f^2 - (0)^2$$

$$39.2 = v_f^2$$

Taking square root on both sides

$$\sqrt{39.2} = \sqrt{v_f^2}$$

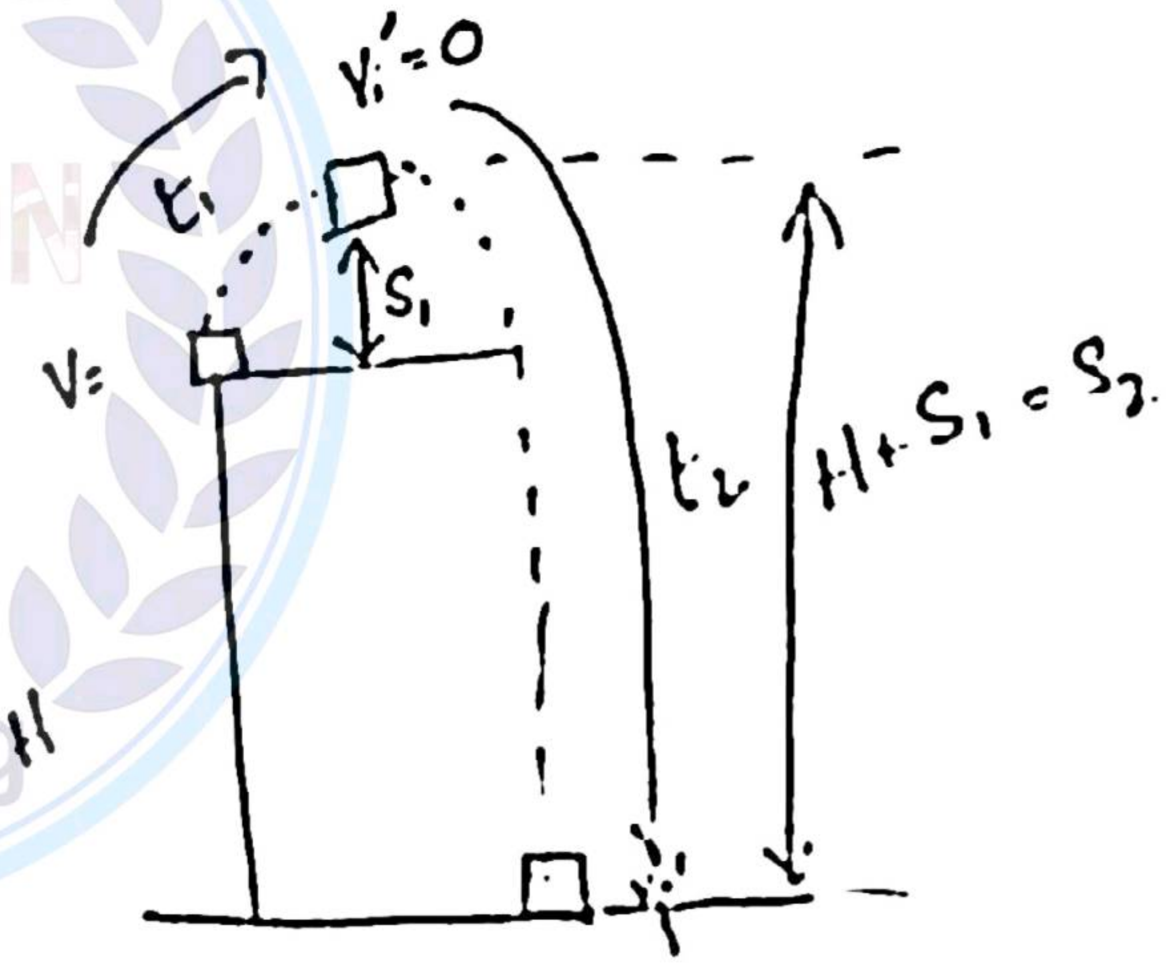
Or

$$\boxed{v_f = 6.26\ m/s}$$

Result: The velocity of block will be 6.26 m/s.

Q.2(xiii) A balloon tied up with a wooden piece is moving upward with velocity of 15 m/s. At a height of 300 m above the ground, the wooden piece is detached from the balloon. How much time will it take to reach the ground?

Data:
Initial Velocity = V_i=15 m/s
Final Velocity = V_f = 0 m/s
Height = H = 300 m
Total time = t = ?



Solution:

During upward Motion

For t_1:

$$v_f = v_i + at$$
$$0 = 15 + (-9.8)t_1$$
$$\boxed{t_1 = \frac{15}{9.8} = 1.5\ sec}$$

For S_1:

$$S = v_i t + \frac{1}{2}at^2$$
$$S_1 = 15 \times 1.5 + \frac{1}{2}(-9.8)(1.5)^2$$
$$S_1 = 22.5 - 11.025$$
$$\boxed{S_1 = 11.475\ m}$$

During Downward Motion

For t_2:

$$S = v_i t + \frac{1}{2}at^2$$

Or $$S_1 + H = 0 \times t_2 + \frac{1}{2}(9.8){t_2}^2$$
$$11.475 + 300 = (4.9){t_2}^2$$
$$311.475 = 4.9t_2^2$$
$${t_2}^2 = 63.56$$

Taking square root

$$\boxed{t_2 = 7.9\ sec}$$

Now, Total time is given by

$$\boxed{t = t_1 + t_2 = 1.5 + 7.9 = 9.4\ sec}$$

Result: The total time taken will be 9.4 sec.

2017

No Numerical

2016

Q.2 (xii) A car starts from rest and moves with a constant acceleration. During the 5th second of its motion, it covers a distance of 36 m. Calculate: (a) Acceleration of the car (b) Distance covered by the car during this time.

Data:

Initial velocity= $v_i = 0$

Acceleration= a =?

Distance during 5th sec = $S_5 - S_4$ =36 m

Total distance in 5 sec = S_5 = ?

Solution:

When t= 4 sec

$$S = v_i t + \frac{1}{2}at^2$$
$$S_4 = 0 + \frac{1}{2}(a)(4)^2$$
$$\boxed{S_4 = 8a} \text{ ---- (i)}$$

When t= 5 sec

$$S = v_i t + \frac{1}{2}at^2$$
$$S_5 = 0 + \frac{1}{2}(a)(5)^2$$
$$\boxed{S_5 = 12.5a} \text{ ---- (ii)}$$

$$\therefore S_5 - S_4 = 12.5a - 8a$$
$$36 = 4.5a$$
$$\boxed{a = 8\ m/s^2}$$

Putting value in eq (ii)

$$\boxed{S_5 = 12.5a = 12.5 \times 8 = 112.5\ m}$$

Result: The acceleration of body is 8 m/s^2 and Distance travelled in 5 seconds is equal to 100 m.

2015

Q.2 xiii) Textbook Numerical 11

2014

Q.2 (iv) A car starts from rest and moves with a constant acceleration. During the 4th second of its motion, it covers a distance of 24 meters. Calculate the acceleration and the total distance covered by the car during this time.

Data:

Initial velocity= $v_i = 0$

Acceleration= a =?

Distance during 4th sec = $S_4 - S_3$ =24 m

Total distance in 4 sec = S_4 = ?

Solution:

When t= 4 sec

$$S = v_i t + \frac{1}{2}at^2$$

$$S_4 = 0 + \frac{1}{2}(a)(4)^2$$

$$\boxed{S_4 = 8a} \text{ ---- (i)}$$

When t= 3 sec

$$S = v_i t + \frac{1}{2}at^2$$

$$S_3 = 0 + \frac{1}{2}(a)(3)^2$$

$$\boxed{S_3 = 4.5a} \text{ ---- (ii)}$$

$$\therefore S_4 - S_3 = 8a - 4.5a$$

$$24 = 3.5a$$

$$\boxed{a = 6.85\ m/s^2}$$

Putting value in eq (i)

$$\boxed{S_4 = 8a = 8 \times 6.85 = 54.8\ m}$$

Result: The acceleration of body is 6.85 m/s^2 and Distance travelled in 4 seconds is equal to 54.8 m.

2013

Q.2 (vi) A stone if dropped from the peak of a hill. It covers a distance of 30 meters in the last second of its motion. Find the height of the peak.

Data:

Initial velocity= v_i = 0 m/s

Acceleration= g = 9.8 m/s^2

Distance during last sec = $S_t - S_{(t-1)}$ = 30 m

Height of peak = S_t = ?

Solution:

(i) When t= t sec

$$S = v_i t + \frac{1}{2}at^2$$

$$S_t = 0 + \frac{1}{2}(9.8)(t)^2$$

$$\boxed{S_t = 4.9t^2} \text{ ---- (i)}$$

(ii) When t= (t-1) sec

$$S = v_i t + \frac{1}{2}at^2$$

$$S_{t-1} = 0 + \frac{1}{2}(9.8)(t-1)^2$$

$$S_{t-1} = 4.9(t^2 - 2t + 1)$$

$$\boxed{S_{t-1} = 4.9t^2 - 9.8t + 4.9}$$

$$\therefore S_t - S_{t-1} = 4.9t^2 - (4.9t^2 - 9.8t + 4.9)$$

$$30 = 4.9t^2 - 4.9t^2 + 9.8t - 4.9$$

$$30 = 9.8t - 4.9$$

$$t = \frac{34.9}{9.8} = 3.56\ s$$

Putting in eq (i)

$$S_t = 4.9(3.56)^2$$

$$\boxed{S_t = 62.1\ m}$$

Result: The height of the peak is 62.1 m.

Q.2 (ix) A car is waiting at a traffic signal. As it turns green, the car starts ahead with a constant acceleration of 3 m/s^2. At the same time, a bus travelling with a constant speed of 20 m/s overtakes and passes the car.

(a) How far beyond the starting point will the car overtake the bus?

(b) What will be the velocity of the car at that time?

Data:

Initial Velocity of car = v_i = 0

Acceleration of car = a = 3 m/s^2

Speed of Bus = v = 20m/s

Distance from signal = S = ?

Final Velocity of car = v_f = ?

Solution:

For Car:

$$S = v_i t + \frac{1}{2}at^2$$

$S = 0 \times t + \frac{1}{2}(3)t^2$

$S = 1.5t^2$ --- (i)

For Bus:

$S = v \times t$

$S = 20\ t$ ----- (ii)

Comparing eq (i) and eq (ii)

$1.5t^2 = 20\ t$

$\boxed{t = 13.33\ sec}$

Putting in eq (ii)

$\boxed{S = 20 \times 13.33 = 266.6\ m}$

Final Velocity of Car:

$v_f = v_i + at$

$v_f = 0 + 3 \times 13.33$

$\boxed{v_f = 39.99\ m/s}$

Result: The bus overtakes at 266.6 m distance from starting point and car was moving with 39.9 m/s.

2012

No Numerical

2011

Q.2(vii) **Textbook Numerical 12**

2010

Q.2 (ix) **Textbook Numerical 5**