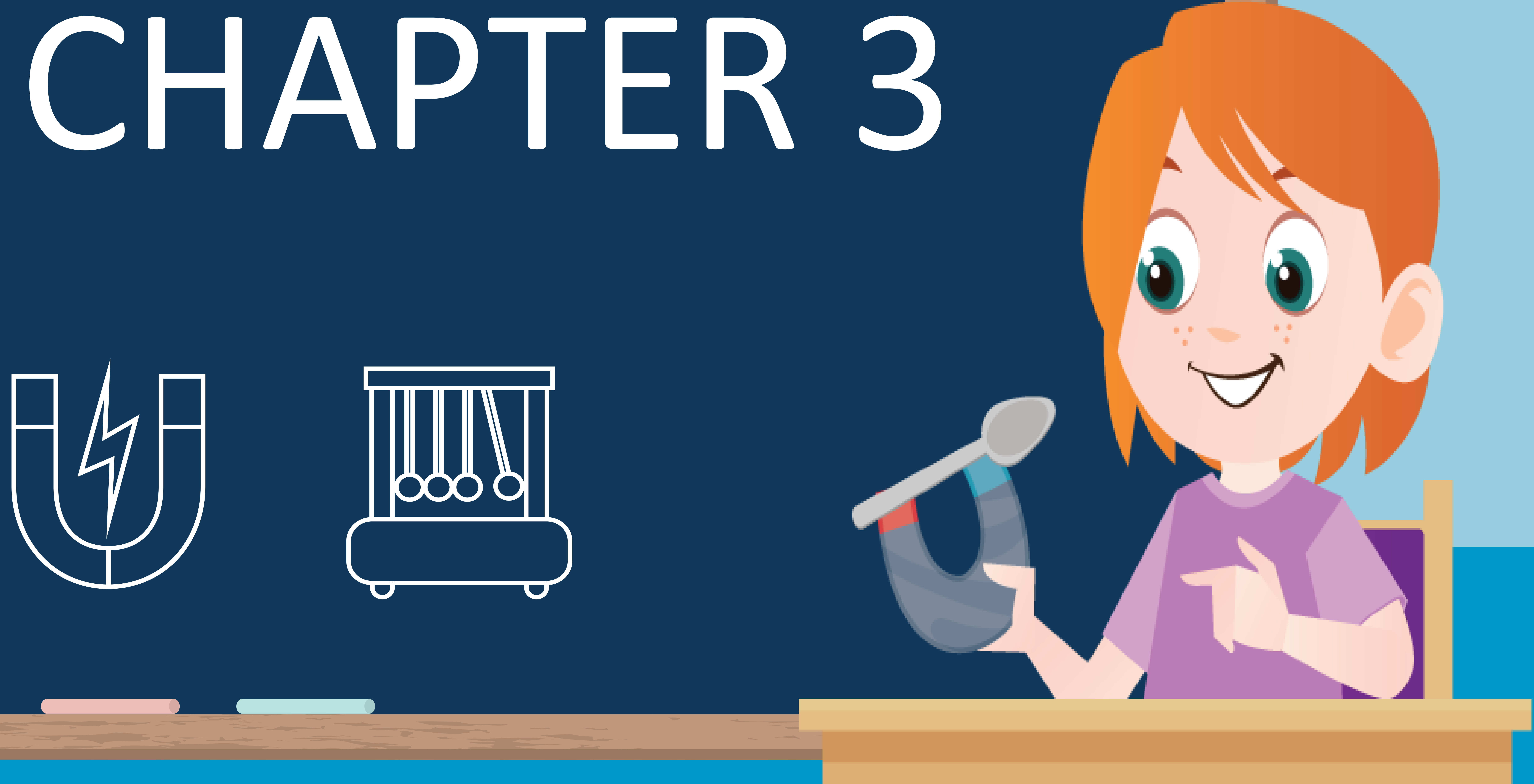

PHYSICS

CHAPTER 3




NUMERICAL
PROBLEMS

QUESTION 1

Q: What are the conditions for using the equations of motion?

Ans:

Object is moving along the straight line.

Acceleration is constant.

Only magnitudes of vectors such as displacement, velocity and acceleration are considered.

These equations are used to calculate magnitude of displacement (s), velocity (initial and final), time (t), and acceleration (a).

Direction of initial velocity and all the quantities which are in the direction of initial velocity are taken as positive.

QUESTION 2

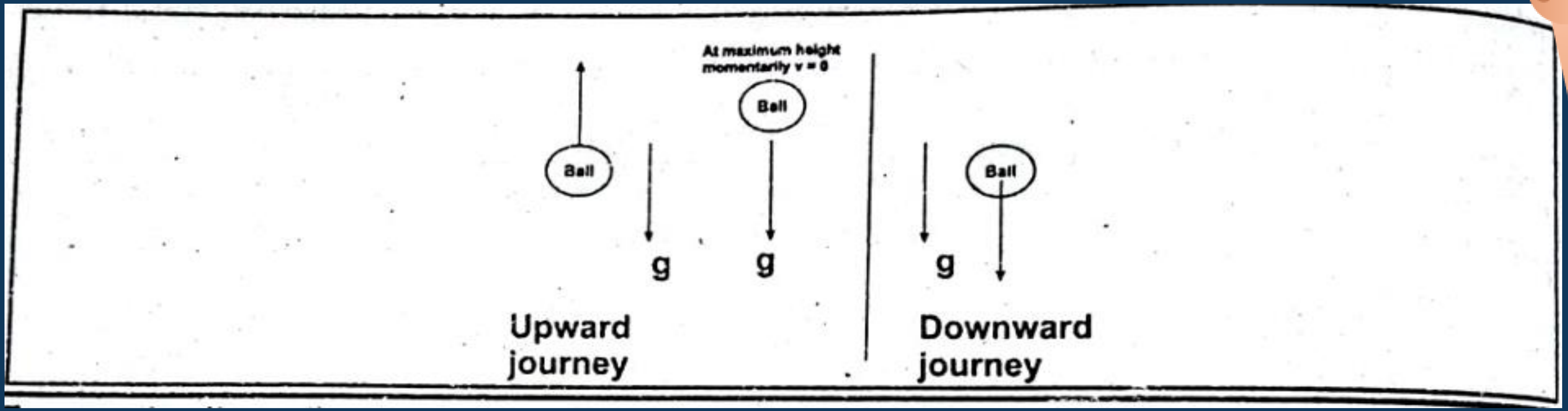
You throw a small ball vertically up in the air. How are the velocity and acceleration of the ball oriented with respect to one another (a) when the ball is going upward (b) when the ball is coming downward?

Ans:

When ball is moving upward the velocity vector is oriented upwards, while the acceleration vector (due to gravity) is oriented downwards.

At the highest point, the velocity vector is momentarily zero, and the acceleration vector is still oriented downwards.

When ball is moving downward, both the velocity and acceleration vectors are oriented in the same direction, downwards.



QUESTION 3

For a projectile motion, is the velocity zero at any instant? Is the acceleration zero at any instant?

Ans:

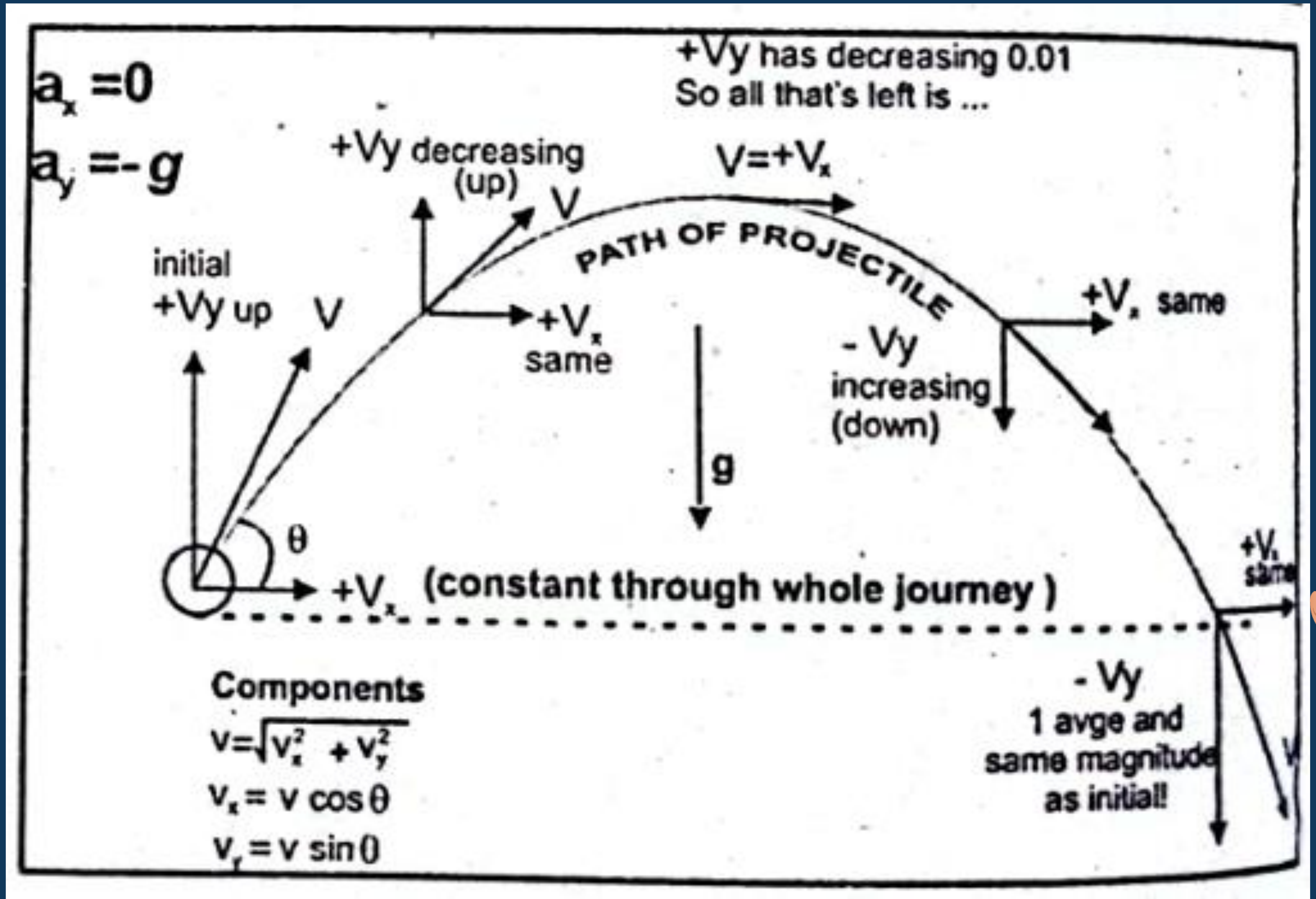
In projectile motion both velocity and acceleration can never be zero during the flight.

a = 0 of oblique projectile.

Explanation:

The velocity of an oblique projectile can never completely be zero because, even at the highest point where the vertical component of the velocity is zero, the horizontal component remains non-zero.

DIAGRAM



QUESTION 4

Construct motion diagrams showing the velocity and acceleration of a projectile at several points along its path, assuming (a) the projectile is launched horizontally and (b) the projectile is launched at an angle θ with the horizontal.

Ans:

The acceleration of projectile is never zero because the vertical component of acceleration due to gravity is always acting on the projectile

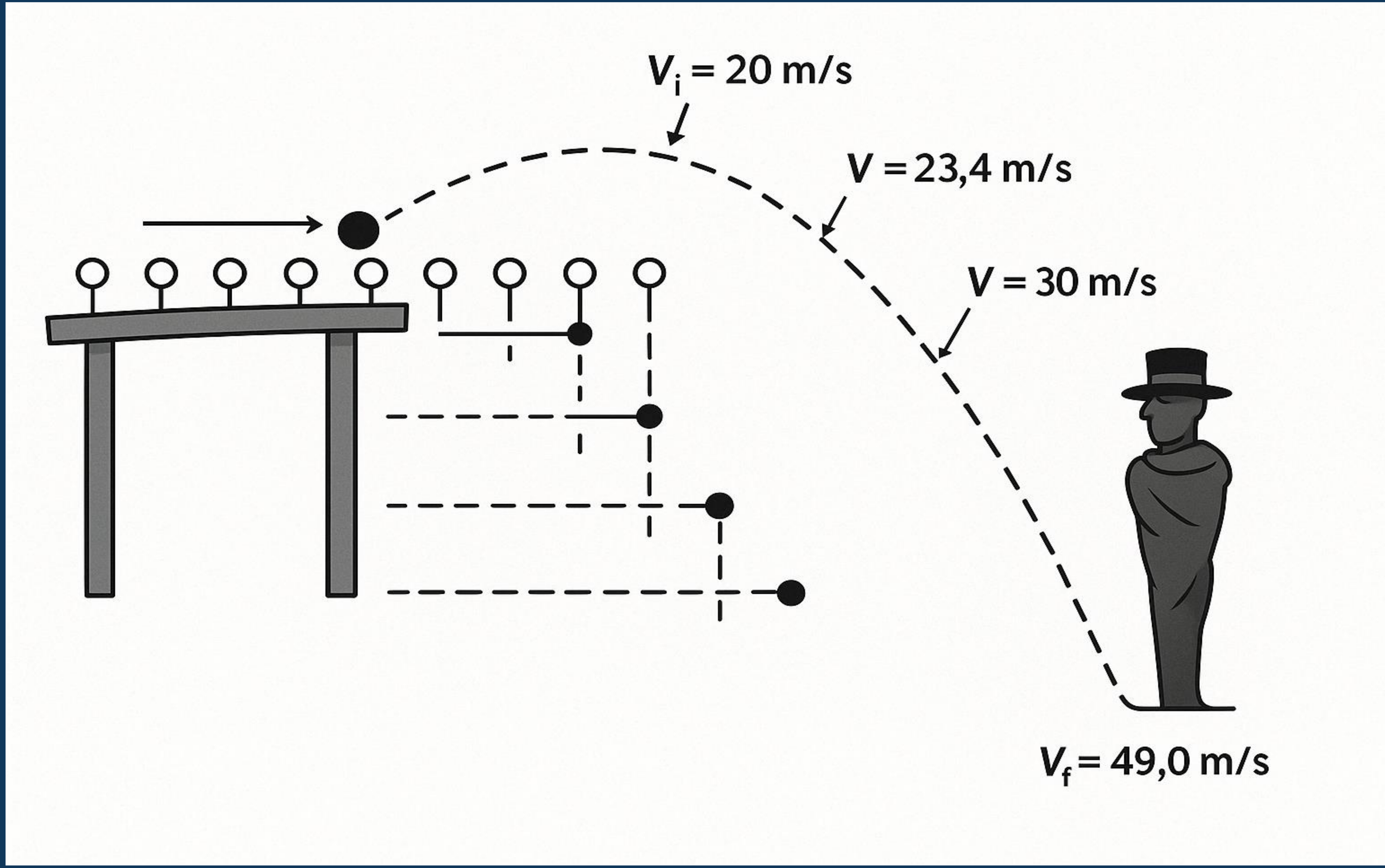
a_y **= - g**

When friction neglected, only horizontal component of acceleration is zero

a_x **= 0** (Constant through whole journey)

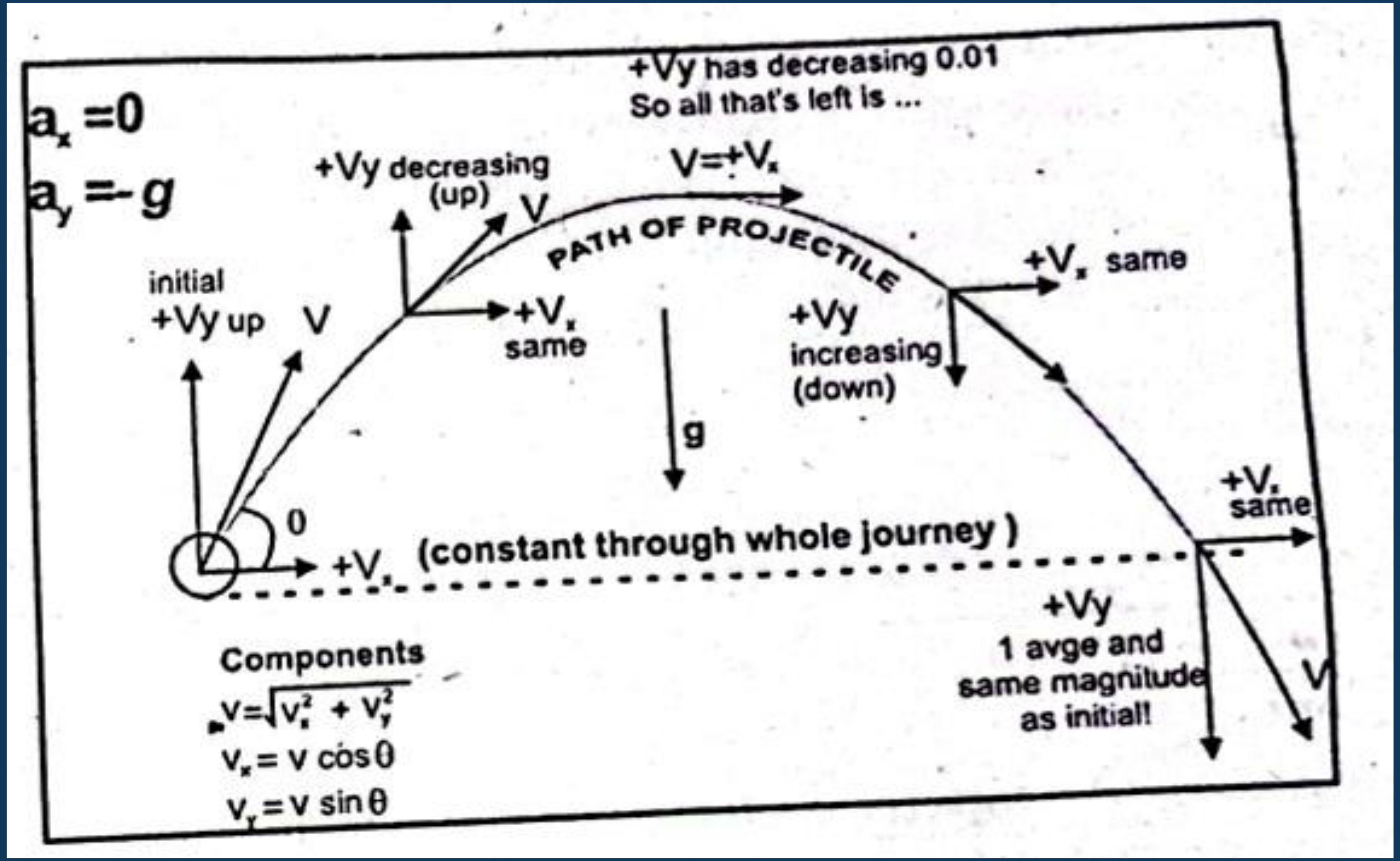
(a) Horizontally Launched Projectiles:

A ball rolling off the table is an excellent example of an object thrown into the air with horizontal initial velocity (velocity at the time when the object is launched). The ball becomes airborne when leaving the table.



QUESTION 4

If the ball rolls along the table with constant horizontal velocity, then the moment it leaves the table, it has same horizontal velocity with which it rolled along the table and zero vertical velocity.
A cannonball is launched horizontally with an initial velocity of 20 m/s. Gravity causes it to accelerate downwards at 9.8 m/s², causing a 9.8 m/schange in vertical velocity.
The horizontal velocity remains constant and horizontal component of acceleration is zero.
Vertical velocity increases by **9.8 m/s**
(b) Oblique Projectile:
When oblique projectile is projected at angle with horizontal then horizontal velocity remains constant and horizontal component of acceleration is zero
a_x **= 0**
When projectile is moving upward then vertical component of velocity decreases.
At the point of maximum height the vertical velocity is zero.
The path of the projectile is symmetrical.



QUESTION 5

Q: An aero plane while flying horizontally drops a bomb when reaches exactly above the target, but missed it. Explain why?

Ans:

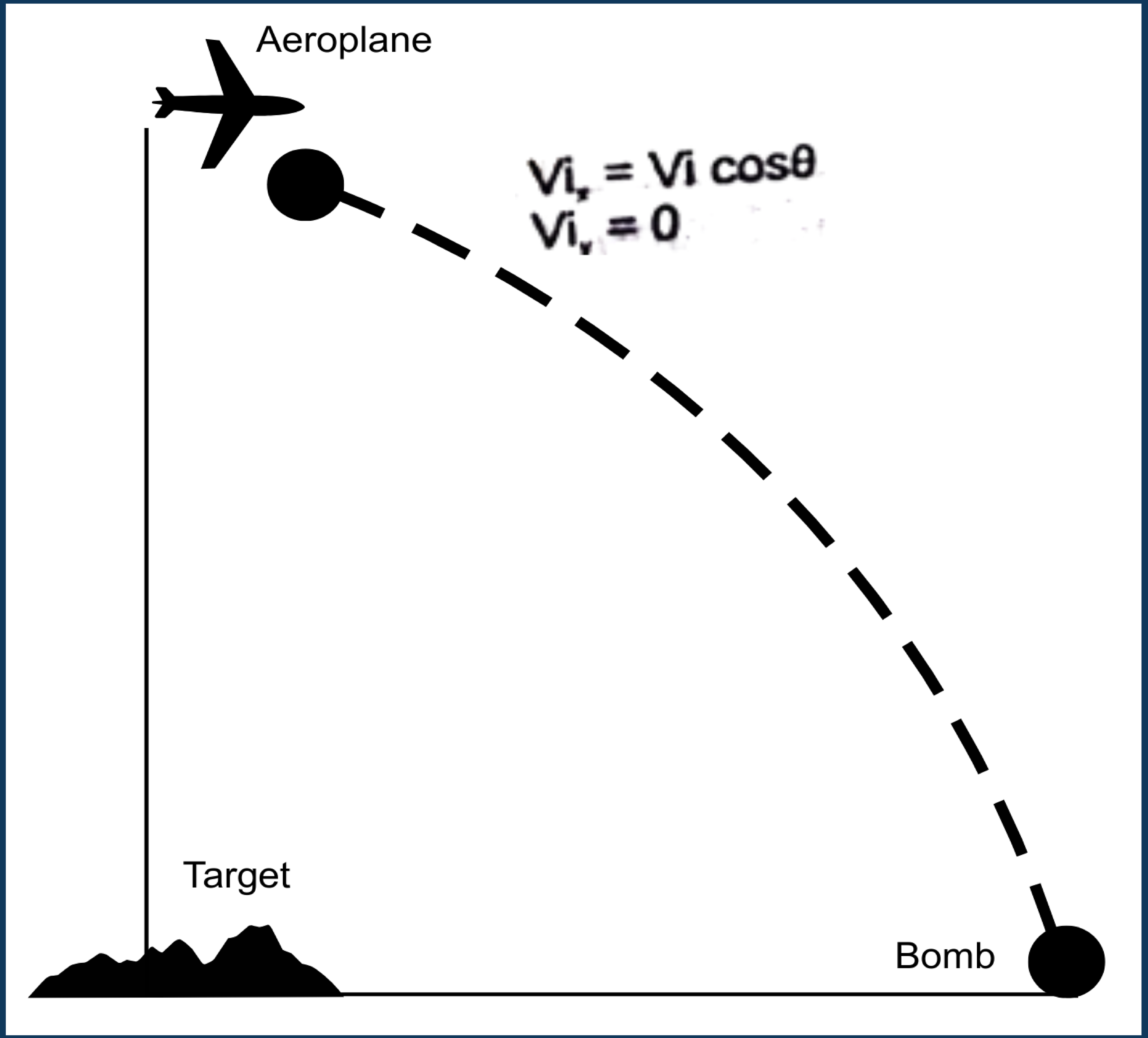
When a bomb is dropped from the aero-plane, it has same velocity as that of aero plane.

If the bomb is dropped when the aero-plane is vertically above the target, it will strike a point ahead of the target due to constant horizontal velocity component and inertia.

The bomb misses the target if it is dropped vertically above the target because it moves like a projectile as shown in fig.

It will not hit the target but it will hit a point ahead of target at point T.

To accurately hit the target, the pilot must release the bomb at a calculated position before reaching directly above the target, taking into account the speed of the aero-plane and the altitude of release.



QUESTION 6

What is the difference between explosion and collision? Give one example of each.
Ans: Here's a tabular comparison between explosions and collisions along with examples for each:

Aspect	Collision	Explosion
Definition	An event where two or more bodies exert forces on each other for a relatively short time, leading to a change in their momentum.	A rapid increase in volume and release of energy in an extreme manner, often resulting in the breaking apart of objects.
Energy Source	External interaction between bodies (e.g., mechanical contact).	Internal energy release (e.g., chemical, nuclear).
Result	Alteration in the velocities and trajectories of the bodies involved.	Dispersion of fragments and energy outward from a central point.
Nature	Can be either destructive or non-destructive energy transferred between bodies.	Often destructive, with energy spreading outward.
Example	A car crash where two vehicles collide.	A dynamite explosion demolishing a building.

QUESTION 7

Why do a slow-moving loaded truck and a speeding rifle bullet each have a large momentum?
Ans:
Momentum is the product of an object's mass and its velocity:
$P = m \times v$
Both a slow-moving loaded truck and a speeding rifle bullet can have a large momentum, but they do so for different reasons:

Aspect	Mass (m)	Velocity (v)	Momentum (p)
Slow-Moving Loaded Truck	Very large	Relatively low	Large due to large mass
Speeding Rifle Bullet	Very small	Very high	Large due to high velocity

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QUESTION 9

Can objects in a system have momentum while the momentum of the system is zero? Explain.
Ans:
Yes, the individual particles in a system can have momentum while the total momentum of the system is zero.
This is because momentum is a vector quantity, and the total momentum is the vector sum of individual momenta.
If the momenta of individual objects are equal in magnitude but opposite in direction, they cancel out, making the net momentum zero, but each object still has individual momentum.

QUESTION 10

We know that:
An object that has the largest kinetic energy:
Let two objects (one lighter, one heavier) have the same momentum. Energy and mass are inversely proportional to each other if momentum is kept constant.
So, the lighter body will have greater kinetic energy.
Let for lighter body:

$$E_1 = \frac{(p^2)}{(2m_1)}$$

This shows that kinetic energy and mass of a body are inversely proportional if p is constant.

$$\frac{E_1}{E_2} = \frac{m_2}{m_1}$$

Therefore, small mass has greater K.E. and greater mass has smaller K.E. when both have equal momentum.

QUESTION 11

For any specific velocity of projection, prove that the maximum range is equal to four times the corresponding height.

Ans:

Maximum range of a projectile is at θ = 45°

$$R_{max} = \frac{{v_i}^2}{g}$$

Height of the projectile: $\frac{{v_i}^2}{g} sin^2\theta$

At θ = 45°,

$= \frac{{v_i}^2}{2g} sin^2(45)$

$H = \frac{{v_i}^2}{2g} \left(\frac{1}{\sqrt{2}}\right)^2$

$H = \frac{{v_i}^2}{2g} \left(\frac{1}{2}\right) = \frac{{v_i}^2}{4g}$

Then,

$H = \frac{1}{4}\frac{{v_i}^2}{g} \quad => \quad \frac{1}{4} R_{max}$

Therefore,

$R_{max} = 4H$

Hence proved.

QUESTION 12

Is momentum conserved when a bat hits a ball?

Ans:

Yes, momentum is conserved when a bat hits a ball, provided we consider the entire system (bat + ball).

When the bat strikes the ball, it transfers momentum to the ball.

The change in momentum of the bat and ball are equal in magnitude and opposite in direction.

Assuming no external force acts on the system (like friction or air resistance), total momentum remains conserved.