SHORT QUESTIONS

3.1 What is the difference between uniform and variable velocity. From the explanation of variable velocity, define acceleration. Give SI units of velocity and acceleration.

Ans. **Uniform Velocity:** The velocity of a body is said to be uniform if it covers equal displacement in equal interval of time.

Variable Velocity: The velocity of a body is said to be variable if it covers unequal displacement in unequal interval of time.

Acceleration: From the variable velocity, the rate of change of velocity is called acceleration.

Let a body is moving with velocity $\vec{v}_i$. After small time Δt its velocity changes from $\vec{v}_i$ to $\vec{v}_f$ then the change in velocity $\vec{\Delta v} = \vec{v}_f - \vec{v}_i$. So

$$\vec{a} = \frac{\vec{v}_f - \vec{v}_i}{\Delta t}$$

$$\vec{a} = \frac{\vec{\Delta v}}{\Delta t}$$

SI Unit of Velocity: The SI unit of velocity is m/s or km/hr.

SI Unit of Acceleration: The SI unit of acceleration is m/s^2.

3.2 An object is thrown vertically upward. Discuss the sign of acceleration due to gravity, relative to velocity, while the object is in air.

Ans. When an object is thrown vertically upward, the sign of acceleration due to gravity is negative relative to velocity. But when the object is thrown downward, the sign of acceleration due to gravity is taken as positive because velocity and acceleration are in same direction.

3.3 Can the velocity of an object reverse direction when acceleration is constant? If so, give an example.

Ans. Yes, the velocity of an object can reverse its direction when acceleration is constant.

Example: When an object is thrown vertically upward then during upward motion its velocity decreases, the direction of velocity will be in upward while direction of acceleration due to gravity will be in downward and when it reach at the highest point its velocity become zero but during downward of object the direction of velocity will be in downward while direction of acceleration due to gravity will again in downward thus we see that in this case the velocity reverse the direction while acceleration is constant.

3.4 Specify the correct statements:

(a) An object can have a constant velocity even its speed is changing.

(b) An object can have a constant speed even its velocity is changing.

(c) An object can have a zero velocity even its acceleration is not zero.

(d) An object subjected to a constant acceleration can reverse its velocity.

Ans. (a) It is false statement because an object cannot have a constant velocity even its speed is changing.

(b) It is true when the object is moving along a circular path.

(c) It is true because when an object is thrown vertically upward, at maximum height, velocity is zero but acceleration is not zero, it is a = g.

(d) It is true. Yes an object subjected to a constant acceleration can reverse its velocity.

3.5 A man standing on the top of a tower throws a ball straight up with initial velocity v_i and at the same time throws a second ball straight downward with the same speed. Which ball will have larger speed when it strikes the ground? Ignore air friction.

Ans. Both the balls have the same speed on striking the ground but time is different. When the velocity of the ball thrown upward with initial velocity v_i, it will has same velocity v_i when it return back and passes the man so as the initial velocities of a ball is same for both cases, therefore the final velocities will also be same.

3.6 Explain the circumstances in which the velocity "v" and acceleration "a" of a car are:

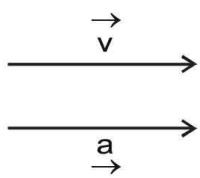
(i) Parallel **(ii) Anti-parallel**

(iii) Perpendicular to one another **(iv) "v" is zero but "a" is not**

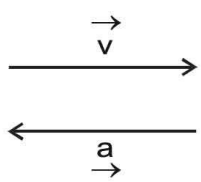
(v) "a" is zero but "v" is not zero

Ans. Following are the circumstances when velocity and acceleration of car:

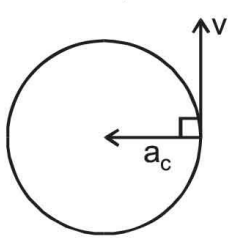
(i) Parallel: When the velocity of a car is increasing along a straight path then velocity and acceleration are parallel to each other.



(ii) Anti-parallel: When the velocity of car is decreasing along the straight line then velocity and acceleration are anti-parallel to each other.



(iii) Perpendicular to one another: The velocity and acceleration of a car are perpendicular to each other when the car is moving along a circular path.



(iv) v is zero but a is not zero: The velocity of a car becomes to zero when the brakes are applied and the car comes to rest due to acceleration in opposite direction.

(v) a is zero but v is not zero: Acceleration is zero when the car is moving with uniform acceleration.

3.7 Motion with constant velocity is a special case of motion with constant acceleration. Is this statement true? Discuss.

Ans. Yes, the motion with constant velocity is a special case of motion with constant acceleration. This statement is true.

Explanation: we know that when a body moves with constant velocity then its acceleration will be zero i.e., there is no rate of change of velocity so whenever it moves with constant velocity its acceleration will remain zero that is constant here zero is also a constant quantity. Therefore motion with constant velocity is a special case of motion with constant acceleration.

3.8 Find the change in momentum for an object subjected to a given force for a given time and state law of motion in terms of momentum.

Ans. Consider a body of mass "m" moving with velocity v_i. Let a force F is applied on the body which changes the velocity from v_i to v_f then according to 1st equation of motion.

$$v_f = v_i + at$$

$$a = \frac{v_f - v_i}{t}$$

But from Newton's second law of motion

$$F = ma$$

$$F = m\left(\frac{v_f - v_i}{t}\right)$$

$$F = \frac{mv_f - mv_i}{t}$$

Where mv_f is the final momentum and mv_i is the initial momentum so,

$$\frac{mv_f - mv_i}{t} = \text{Rate of change of momentum}$$

$$F = \text{Rate of changed momentum}$$

Newton's Second Law of Motion in Terms of Momentum: Newton's second law of motion in terms of momentum states, "the rate of change of momentum is equal to applied force".

3.9 Define impulse and show that how it is related to linear momentum?

Ans. **Impulse:** When a very large force acts on a body for a very short interval of time then the product of such a force and time is called impulse. It is a vector quantity

$$\text{Impulse} = I = \text{Force} \times \text{Time}$$

$$I = F \times \Delta t$$

As we know that

$$F \times \Delta t = mv_f - mv_i$$

So

$$I = mv_f - mv_i$$

$$\vec{I} = m\vec{\Delta v}$$

$$\vec{I} = \vec{\Delta P} = \text{Change in momentum}$$

This shows that impulse is equal to change in momentum.

3.10 State the law of conservation of linear momentum, pointing out the importance of isolated system. Explain, why under certain conditions, the law is useful even though the system is not completely isolated?

Ans. **Law of Conservation of Linear Momentum:** This law states that the total linear momentum of an isolated system remains constant.

Importance of an Isolated System: This law holds good only for isolated system. An isolated system is one at which there is no external force acting. If the system is not isolated but the external forces are very small as compared to interacting forces so this law can also be applied on such a system.

3.11 Explain the difference between elastic and inelastic collisions. Explain how would a bouncing ball behave in each case? Give plausible reasons for the fact that K.E is not conserved in most cases?

Ans. **Elastic Collision:** These collision in which kinetic energy remains constant is called elastic collisions.

Inelastic Collision: These collision in which kinetic energy does not remain constant is called inelastic collisions.

In Case of Bouncing Ball: If the ideal bouncing ball returns to the same height where it is dropped then the collision is elastic collision. If the bouncing ball will not returned to the same height then the collision is inelastic. So due to change of energy, kinetic energy does not remain constant.

For example; when a heavy ball is dropped on to the surface of earth, it rebounds upto very little height because maximum K.E is lost due to friction and also changes into heat and sound energies. So in most cases, the K.E is not conserved. Thus momentum and K.E are conserved in all types of collisions. However the K.E is conserved only in elastic collision.

3.12 Explain what is meant by projectile motion. Derive expressions for

(a) The time of flight (b) The range of projectile.

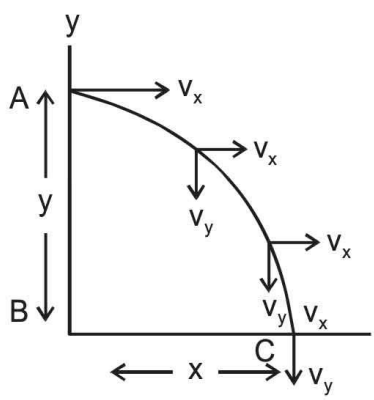
Show that the range of projectile is maximum when projectile is thrown at an angle of 45° with the horizontal.

Ans. **Projectile Motion:** When an object is thrown in air making a certain angle with horizontal, so that object moves under the action of gravity and moves along a curved path, is called as "projectile". Its motion is called "projectile motion". Its path is called trajectory. Its path is parabolic. **(OR)** Projectile motion is two dimensional motion under constant acceleration due to gravity.

The body thrown is called projectile and the curved path followed by it is called trajectory.

Examples:

1. Motion of football kicked off by a player.
2. A ball thrown by a cricketer.
3. Missile fired from launching pad.



Consider a body thrown in horizontal direction with horizontal velocity v_x from point A having vertical height 'y'. In the absence of horizontal force, the horizontal components v_x remain constant all along the motion. If the body hits at point 'C' the horizontal distance 'x' covered by the body is given by

$$x = v_x t$$

Where 't' is the time taken by body to move from A to C.

The body not only covers distance in forward direction but also moves down under the action of gravity. The downward vertical velocity of body under the action of gravity goes on increasing continuously. This vertical motion is same as for freely falling body. The distance covered by body in downward direction is AB = y and is given by

$$S = y = v_{iy}t + \frac{1}{2}at^2$$

As the ball at 'A' has only the horizontal velocity so

$$v_{iy} \text{ (initial vertical velocity)} = 0 \quad \text{and} \quad a = g$$

So $$y = \frac{1}{2} gt^2$$

$$\boxed{y = \frac{1}{2} gt^2}$$

Time of Flight of Projectile: The time taken by body to cover the distance from place of projection to the place where it hits the ground, is called time of flight of projectile. The time of flight can be calculated by using 2nd equation of motion:

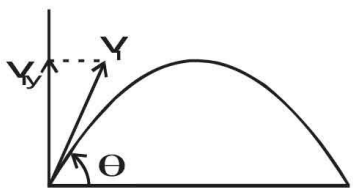
$$S = v_i t + \frac{1}{2} gt^2$$

As the ball returns to ground, so net vertical distance is zero. i.e.,

$$S = 0 \quad \text{and} \quad v_i = v_{iy} = v_i \sin \theta$$

The above equation becomes

$$0 = v_i \sin \theta t - \frac{1}{2} gt^2$$



$$\frac{1}{2} gt^2 = v_i \sin \theta t \quad \text{or} \quad \frac{1}{2} gt = v_i \sin \theta$$

or $$t = \frac{2v_i \sin \theta}{g}$$

Where 't' is the time of flight of projectile.

Range of Projectile: Max. distance which a projectile conversion the horizontal direction is called the range of projectile. In order to find R

$$R = v_{ix} \times t$$

$$= \frac{v_i \cos \theta \times 2v_i \sin \theta}{g}$$

$$= \frac{v_i^2}{g} 2 \sin \theta \cos \theta$$

$$R = \frac{v_i^2}{g} \sin 2\theta$$

The formula for the **range of projectile** is

$$R = \frac{v_i^2 \sin 2\theta}{g}$$

For maximum horizontal range sin 2θ must have maximum value and we know that the maximum value of sin 2θ is 1.

$\because$ $$\sin 2\theta = 1$$

$$\sin 2\theta = \sin 90°$$

$$2\theta = 90°$$

$$\theta = 45°$$

So above equation becomes

$$R_{max.} = \frac{v_i^2 \sin 2(45°)}{g}$$

$$R_{max.} = \frac{v_i^2 \sin 90°}{g}$$

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

So the range of projectile is maximum when projectile is thrown at an angle of 45° with the horizontal.

3.13 At what point or points in its path does a projectile have its minimum speed, its maximum speed?

Ans. The speed of the projectile is maximum at the point of projection and also at the point where it hits the ground. While the speed of projectile is minimum when it reaches the maximum height.

3.14 Each of the following questions is followed by four answers, one of which is correct answer. Identified that answer.

(i) What is meant by a ballistic trajectory?

(a) The paths followed by an un-powered and unguided projectile is called ballistic trajectory.

(b) The path followed by the powered and unguided projectile is called ballistic trajectory.

(c) The path followed by un-powered but guided projectile.

(d) The path followed by powered and guided projectile.

(ii) What happens when two-body system undergoes elastic collision?

(a) The momentum of the system changes.

(b) The momentum of the system does not change.

(c) The bodies come to rest after collision.

(d) The energy conservation law is violated.

Ans. (i) (a) is correct.

(ii) (b) is correct.