

Chapter 2

Kinematics

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Short Questions

Q.1 In a park, children are enjoying a ride on a Ferris wheel as shown. What kind of motion does the big wheel have, and what kind of motion do the riders have?

Ans: The big Ferris wheel has rotatory motion, meaning the entire wheel rotates around its central axis. The motion of the riders can be described as translatory motion because they move along with the wheel in a circular path. This circular motion combines both rotation and translation, as the riders change their position continuously but stay in the same relative position on the wheel.

Q.2 A boy moves for some time. Give two situations in which his displacement is zero, but distance is not zero.

Ans:

1. If the boy walks in a circular path (like on a track) and returns to his starting point, his displacement is zero because the initial and final positions are the same. However, the distance covered is the total length of the circular path he walked.
2. If the boy walks in a straight line, turns back, and returns to the starting point, the displacement is again zero as his final position is the same as the initial one. The distance, however, is the total length he walked in both directions.

Q.3 A stone tied to a string is whirling in a circle. What is the direction of its velocity at any instant?

Ans: The velocity of the stone at any given moment is tangential to the circle. This means it is perpendicular to the radius of the circle and points in the direction the stone would move if the string were suddenly cut. The velocity's tangential direction is what ensures the circular motion, and it constantly changes direction as the stone moves along the circular path.

Q.4 Is it possible to accelerate an object without speeding it up or slowing it down?

Ans: Yes, it is possible to accelerate an object without changing its speed. This happens in cases of uniform circular motion, where an object moves at a constant speed around a circular path. In this case, the acceleration occurs because the direction of the velocity vector changes continuously, even though the magnitude of the velocity (the speed) remains constant. The acceleration in such cases is called centripetal acceleration and is directed towards the center of the circle.

Q.5 Can a car moving towards the right have a direction of acceleration towards the left?

Ans: Yes, a car moving to the right can have an acceleration directed towards the left when it is slowing down (decelerating). This is because acceleration is a vector quantity, which means it has both magnitude and direction. In this case, the direction of acceleration is opposite to the direction of motion. For example, when brakes are applied to a car moving forward, the acceleration acts in the opposite direction to reduce the speed.

Q.6 With the help of daily life examples, describe the situations in which:

a. Acceleration is in the direction of motion:

When a car starts moving from rest and the driver presses the accelerator, the car's speed increases in the same direction as its motion. This is an example of acceleration being in the same direction as motion.

b. Acceleration is against the direction of motion:

When a car is moving forward but the brakes are applied, the car slows down. The acceleration in this case is called negative acceleration (or deceleration), and it acts in the opposite direction of motion.

c. Acceleration is zero, and the body is in motion:

When a car moves at a constant speed in a straight line (no change in speed or direction), there is no acceleration. This situation represents uniform motion, where the net acceleration is zero, but the body remains in motion due to its constant velocity.

Q.7 Examine the distance-time graph of a motorcyclist (as shown). What does this graph tell us about the speed of the motorcyclist? Also, plot its velocity-time graph.

Ans: The distance-time graph shows a straight line, which indicates that the motorcyclist is moving with uniform speed. The slope of the graph remains constant, which confirms that there is no change in the speed over time.

To plot the velocity-time graph:

- Since the speed is constant, the velocity-time graph will be a horizontal straight line, parallel to the time axis. This line will indicate the constant value of velocity throughout the journey.
-

Q.8 Which controls in the car can produce acceleration or deceleration in it?

Ans: The following controls in a car can produce acceleration or deceleration:

1. **Accelerator:** Pressing the accelerator increases the speed of the car, causing positive acceleration.
2. **Brake:** Applying the brake reduces the speed of the car, resulting in deceleration (negative acceleration).
3. **Steering Wheel:** Turning the steering wheel changes the car's direction, which causes a change in velocity, thereby producing acceleration due to a change in direction (even if the speed remains constant).

Q.9 If two stones of 10 kg and 1 kg are dropped from a 1 km high tower, which will hit the ground with greater velocity? Which will hit the ground first? (Neglect the air resistance)

Ans:

- **Which will hit the ground with greater velocity?** Both stones will hit the ground with the **same velocity** because, in the absence of air resistance, gravitational acceleration is the same for all objects regardless of their masses.
- **Which will hit the ground first?** Both stones will hit the ground at the **same time**, as the time of free fall depends only on the height of the fall and gravitational acceleration, not the mass of the object.

Q.10 A 100 g ball is just released (from rest) and another is thrown downward with a velocity of 10 m/s. Which will have greater acceleration? (Neglect the air resistance)

Ans:

Both balls will have the **same acceleration**, which is equal to the **gravitational acceleration (g)**, approximately 9.8 m/s^2 . The acceleration due to gravity is constant for all objects in free fall, regardless of whether they are dropped from rest or given an initial velocity.

However, the ball thrown downward will have a **greater velocity** at any given time since it starts with an initial velocity of 10 m/s in addition to the velocity gained due to acceleration.

Long Questions

Q.1 Differentiate between rest and motion. With the help of examples, show that rest and motion are relative to the observer.

Ans: Rest and motion describe the state of an object relative to a reference point.

- **Rest:**

An object is at rest if it does not change its position concerning a reference point over time.

Example: A book placed on a table is at rest concerning the table.

- **Motion:**

An object is in motion if it changes its position concerning a reference point over time.

Example: A car moving on a road is in motion concerning a stationary observer on the sidewalk.

Relative Nature of Rest and Motion:

Rest and motion are relative because they depend on the observer's frame of reference.

Example 1: A person sitting inside a moving train appears to be at rest to another passenger but is in motion relative to an observer standing outside the train.

Example 2: A person standing on Earth appears at rest relative to the ground but is in motion relative to an observer in space because Earth rotates and revolves around the Sun.

Thus, rest and motion are not absolute but depend on the chosen reference point.

Q.2 What are different types of motion? Define each type of motion with examples from daily life.

Ans: Motion can be classified into the following types:

1. **Translatory Motion:** All parts of an object move the same distance in a given time.
 - **Rectilinear Motion:** Motion along a straight line.
Example: A car driving on a straight road.
 - **Curvilinear Motion:** Motion along a curved path.
Example: A ball thrown in a parabolic path.
2. **Rotatory Motion:** When an object rotates around a fixed axis.
Example: A spinning top or a rotating ceiling fan.
3. **Oscillatory Motion:** Repetitive motion about a mean position.
Example: The swing of a pendulum.
4. **Vibratory Motion:** Rapid back-and-forth motion around a mean position.
Example: Vibrations of a guitar string.
5. **Random Motion:** Irregular or unpredictable motion.
Example: Movement of smoke particles in the air.

Combination of Motions: Many objects exhibit multiple types of motion simultaneously.

Example: The wheels of a moving bicycle show both translatory and rotatory motion.

Q.3 What are scalars and vectors? Give examples. How are vectors represented symbolically and graphically?

Ans:

- **Scalars:** Quantities that have magnitude but no direction.
Examples: Distance (10 meters), time (5 seconds), speed (20 m/s).
- **Vectors:** Quantities that have both magnitude and direction.
Examples: Displacement (10 meters north), velocity (20 m/s east), force (50 Newtons upwards).

Representation of Vectors:

- **Symbolic Representation:** Vectors are denoted by letters with an arrow on top (e.g., $\vec{A}$, $\vec{v}$).
- **Graphical Representation:** A vector is represented as an arrow.
 - **Tail:** The starting point of the arrow.
 - **Head:** The pointed end of the arrow.
 - **Length:** Indicates magnitude.
 - **Direction:** Points in the vector's direction.

Example: A displacement of 5 meters north is represented by an arrow of proportional length pointing upwards.

Vectors are essential in physics as they represent quantities requiring both magnitude and direction for accurate calculations.

Q.4 Define the term position. Differentiate between distance and displacement.

Ans:

- **Position:** Position refers to the location of an object relative to a reference point.
Example: A car 10 km east of a city center has a position of 10 km east.

Difference Between Distance and Displacement:

- **Distance:**
The total path length covered by an object.
Example: A person walks 3 km east and 4 km west, covering a total distance of 7 km.
- **Displacement:**
The shortest straight-line distance between the initial and final positions of the object, including direction.
Example: For the same person walking 3 km east and 4 km west, the displacement is 1 km west.

Key Differences:

1. Distance is a scalar quantity, while displacement is a vector.
2. Distance can only be positive, while displacement can be positive, negative, or zero.
3. Distance gives no information about direction, whereas displacement specifies direction.

These distinctions are crucial for understanding motion and solving physics problems.

Q.5 Differentiate between speed and velocity. Also define average speed, average velocity, uniform and variable speeds, and uniform and variable velocities.

Ans:

Speed

Speed is the distance traveled by an object per unit of time. It is a **scalar quantity**, which means it only has magnitude and no direction.

Example: A car traveling 60 km in 1 hour has a speed of 60 km/h.

Velocity

Velocity is the rate of change of displacement with respect to time. It is a **vector quantity**, meaning it has both magnitude and direction.

Example: A car moving 60 km/h towards the east has a velocity of 60 km/h east.

Key Differences Between Speed and Velocity:

1. Speed is scalar, while velocity is vector.
2. Speed does not include direction; velocity does.
3. Speed can never be negative, but velocity can be positive, negative, or zero depending on direction.

Types of Speed:

- **Average Speed:** The total distance traveled divided by the total time taken.
Example: If a car travels 90 km in 2 hours, its average speed is 45 km/h.
- **Uniform Speed:** Speed remains constant over time.
Example: A train moving at 80 km/h for the entire journey.
- **Variable Speed:** Speed changes over time.
Example: A car that accelerates or decelerates during a trip.

Types of Velocity:

- **Average Velocity:** The total displacement divided by the total time taken.
Example: If a car displaces 50 km east in 2 hours, its average velocity is 25 km/h east.
- **Uniform Velocity:** Velocity remains constant in magnitude and direction.
Example: A car moving straight at 60 km/h.
- **Variable Velocity:** Velocity changes either in magnitude or direction or both.
Example: A car turning while maintaining speed.

These distinctions are essential in physics for understanding motion comprehensively.

Q.6 What are freely falling bodies? What is gravitational acceleration? Write down sign conventions for gravitational acceleration. Write three equations of motion for a freely falling body.

Ans:

Freely Falling Bodies:

Freely falling bodies are objects that move under the influence of gravity alone, without any other forces like air resistance acting on them. Such objects accelerate towards the Earth due to gravity.

Example: A stone dropped from a height is a freely falling body.

Gravitational Acceleration:

Gravitational acceleration (g) is the acceleration experienced by an object due to the Earth's gravity. It has an approximate value of 9.8 m/s^2 near the Earth's surface.

Sign Conventions for Gravitational Acceleration:

1. If the object is falling downwards, g is positive because the motion is in the direction of gravity.
2. If the object is thrown upwards, g is negative because the motion is opposite to gravity.

Equations of Motion for a Freely Falling Body:

1. $v = u + gt$
Where v is the final velocity, u is the initial velocity, g is gravitational acceleration, and t is time.
2. $s = ut + \frac{1}{2}gt^2$
Where s is the displacement.
3. $v^2 = u^2 + 2gs$

Example of Use:

If a ball is dropped from rest ($u = 0$), after 2 seconds its velocity is:

$$v = 0 + 9.8 \times 2 = 19.6 \text{ m/s}$$

These equations are fundamental for solving problems involving free fall.

Q.7 Draw distance-time graphs for rest, uniform speed, increasing speed, and decreasing speed.

Ans:

1. Rest:

In the case of rest, the object does not change its position over time. The distance-time graph is a horizontal line parallel to the time axis.

Example: A parked car's position remains constant.

2. Uniform Speed:

For uniform speed, the distance-time graph is a straight line with a constant slope. The slope

represents speed, which remains unchanged.

Example: A train moving at a constant speed of 60 km/h.

3. Increasing Speed:

When speed increases, the slope of the distance-time graph becomes steeper with time, forming a curve.

Example: A car accelerating from rest.

4. Decreasing Speed:

For decreasing speed, the slope of the graph becomes less steep over time, showing that the object is slowing down.

Example: A bicycle coming to a stop.

Graphical representations are crucial for visualizing these motion types and are commonly used in physics to interpret the behavior of moving objects.

Q.8 Draw speed-time graphs for zero acceleration, uniform acceleration, and uniform deceleration. Also show that the area under the speed-time graph represents the distance covered by the body.

Ans:

1. Zero Acceleration:

In the case of zero acceleration, the speed remains constant over time. The speed-time graph is a horizontal straight line.

Example: A car traveling at a constant speed of 50 km/h.

2. Uniform Acceleration:

For uniform acceleration, the speed-time graph is a straight line with a positive slope, indicating a steady increase in speed.

Example: A car accelerating at a constant rate of 5 m/s^2 .

3. Uniform Deceleration:

In uniform deceleration, the speed-time graph is a straight line with a negative slope, representing a steady decrease in speed.

Example: A vehicle braking at a constant rate.

Area Under the Graph:

The area under the speed-time graph represents the **distance traveled** by the object. This is because distance is the integral of speed with respect to time.

Example: For a car with a constant speed of 60 km/h for 2 hours, the area under the graph forms a rectangle:

$\text{Distance} = \text{Speed} \times \text{Time} = 60 \times 2 = 120 \text{ km}$
 $\text{Distance} = \text{Speed} \times \text{Time} = 60 \times 2 = 120 \text{ km}$

These graphs help visualize motion and provide insights into the relationship between speed, time, and distance.

Kinematics: Numerical Response Questions

Kinematics: Numerical Response Questions

1. Convert the following:

a. 160 km/h into m/s

b. 36 m/s into km/h

c. 15 km/h² into m/s²

d. 1 m/s² into km/h²

a. To convert 160 km/h into m/s:

$$\text{Speed (m/s)} = 160 \times 1000 / 3600 = 44.44 \text{ m/s}$$

b. To convert 36 m/s into km/h:

$$\text{Speed (km/h)} = 36 \times 3600 / 1000 = 129.6 \text{ km/h}$$

c. To convert 15 km/h² into m/s²:

$$\text{Acceleration (m/s}^2\text{)} = 15 \times 1000 / (3600 \times 3600) = 0.001 \text{ m/s}^2$$

d. To convert 1 m/s² into km/h²:

$$\text{Acceleration (km/h}^2\text{)} = 1 \times 3600 \times 3600 / 1000 = 12,960 \text{ km/h}^2$$

2. In 10 seconds, a cyclist increases its speed from 5 km/h to 7 km/h, while a car moves from rest to 20 km/h in the same time. Calculate and compare acceleration in each case.

Cyclist:

$$\text{Acceleration} = (\text{Final Speed} - \text{Initial Speed}) / \text{Time}$$

$$= (7 - 5) \times (1000/3600) / 10$$

$$= 0.055 \text{ m/s}^2$$

Car:

$$\text{Acceleration} = (\text{Final Speed} - \text{Initial Speed}) / \text{Time}$$

$$= (20 - 0) \times (1000/3600) / 10$$

$$= 0.55 \text{ m/s}^2$$

Comparison: The car's acceleration is 10 times that of the cyclist.

3. A ball is thrown straight up such that it took 2 seconds to reach the top after which it started falling back. What was the speed with which the ball was thrown up?

The time taken to reach the top = 2 s

At the top, final velocity (v) = 0 m/s

Acceleration due to gravity (g) = -9.8 m/s²

Using $v = u + g \times t$:

$$u = v - g \times t$$

$$u = 0 - (-9.8 \times 2)$$

$$u = 19.6 \text{ m/s}$$

Speed with which the ball was thrown up: 19.6 m/s.

4. A car is moving with uniform velocity of 20 m/s for 20 seconds. Then brakes are applied and it comes to rest with uniform deceleration in 30 seconds. Plot the graph to calculate the distance traveled.

The distance traveled during uniform velocity (first 20 seconds):

$$\text{Distance} = \text{Velocity} \times \text{Time}$$

$$= 20 \times 20$$

$$= 400 \text{ m}$$

The distance traveled during deceleration (next 30 seconds):

Using $s = ut + 0.5at^2$, where $u = 20 \text{ m/s}$, $v = 0 \text{ m/s}$, $t = 30 \text{ s}$:

Deceleration (a) = $(v - u) / t = (0 - 20) / 30 = -0.667 \text{ m/s}^2$

Distance = $20 \times 30 + 0.5 \times (-0.667) \times (30)^2$
= 300 m

Total distance traveled = $400 + 300 = 700 \text{ m}$.

5. A girl starts her motorbike at a speed of 50 km/h. If she stops after 60 s, what is her acceleration?

Initial speed (u) = $50 \times (1000/3600) = 13.89 \text{ m/s}$

Final speed (v) = 0 m/s

Time (t) = 60 s

Using $a = (v - u) / t$:

$a = (0 - 13.89) / 60$

$a = -0.23 \text{ m/s}^2$

Acceleration = 0.23 m/s^2 (negative indicates deceleration).

6. Consider the following speed-time graph. Tell:

a. Which part of the graph is showing acceleration, deceleration, and zero acceleration?

b. Calculate covered distance from 10 seconds to 20 seconds from the graph.

a. Acceleration: OA (0 to 10 seconds, increasing speed)

Zero Acceleration: AB (10 to 20 seconds, constant speed)

Deceleration: BC (20 to 30 seconds, decreasing speed)

b. Distance from 10 to 20 seconds:

Speed = 60 m/s (constant), Time = 10 s

Distance = Speed $\times$ Time

= 60×10

= 600 m .

Extera Short Questions (Topic Wise)

2.1 Rest and Motion

Q1: Define rest and motion with examples.

Ans:

- **Rest:** An object is at rest if it does not change its position concerning a reference point over time.
Example: A book on a table is at rest relative to the table.
 - **Motion:** An object is in motion if it changes its position concerning a reference point over time.
Example: A car moving on the road is in motion relative to a stationary observer.
-

Q2: Explain how rest and motion are relative with examples.

Ans:

Rest and motion depend on the observer's frame of reference.

Example 1: A person sitting in a moving train is at rest relative to another passenger but in motion relative to an observer on the platform.

Example 2: The Earth appears stationary to us but is in motion relative to the Sun.

Q3: Differentiate between translatory motion and rotatory motion.

Ans:

- **Translatory Motion:** All parts of the object move the same distance in the same direction.
Example: A moving car on a straight road.
 - **Rotatory Motion:** The object rotates about a fixed axis.
Example: The spinning of a fan.
-

Q4: What is oscillatory motion? Give examples.

Ans:

Oscillatory motion is repetitive motion about a mean position.

Examples:

1. The swing of a pendulum.
 2. The vibrations of a spring.
-

2.2 Distance and Displacement

Q1: Define distance and displacement with examples.

Ans:

- **Distance:** The total path length covered by an object.
Example: Walking 5 km in a circular track has a distance of 5 km.

- **Displacement:** The shortest straight-line distance between the initial and final positions of an object.

Example: If the starting and ending points are the same, displacement is 0.

Q2: How can displacement be zero but distance not?

Ans:

Displacement is zero when the initial and final positions are the same, while the distance depends on the actual path traveled.

Example: A person walks 3 km east and then 3 km west. Distance = 6 km, Displacement = 0.

Q3: Compare scalar and vector quantities with examples.

Ans:

- **Scalar Quantities:** Have only magnitude.
Example: Distance, speed.
 - **Vector Quantities:** Have both magnitude and direction.
Example: Displacement, velocity.
-

Q4: Calculate the displacement if an object moves 4 km north and then 3 km east.

Ans:

Using Pythagoras' theorem:

Displacement = $\sqrt{4^2 + 3^2} = \sqrt{16 + 9} = 5$ km.

2.3 Speed and Velocity

Q1: Define speed and velocity with examples.

Ans:

- **Speed:** Distance traveled per unit time (scalar).
Example: A car moves at 60 km/h.
 - **Velocity:** Displacement per unit time (vector).
Example: A car moves 60 km/h east.
-

Q2: Differentiate between uniform and non-uniform velocity with examples.

Ans:

- **Uniform Velocity:** The object moves with constant speed and direction.
Example: A car on a straight highway at 50 km/h.
 - **Non-uniform Velocity:** The object's speed or direction changes.
Example: A car turning a corner.
-

- **Displacement:** The shortest straight-line distance between the initial and final positions of an object.

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Example: A car turning a corner.
-

Q3: A car travels 50 km in 2 hours and then 30 km in 1 hour. Calculate average speed.

Ans:

Total distance = $50 + 30 = 80$ km, Total time = $2 + 1 = 3$ hours.

Average speed = Total distance / Total time = $80 / 3 = 26.67$ km/h.

Q4: Explain instantaneous speed and velocity.

Ans:

- **Instantaneous Speed:** The speed of an object at a particular instant.
Example: A car's speedometer shows its instantaneous speed.
 - **Instantaneous Velocity:** Velocity at a specific moment, including direction.
Example: A car moving 20 m/s east at a particular second.
-

2.4 Acceleration

Q1: Define acceleration and its formula.

Ans:

Acceleration is the rate of change of velocity with time. It is a vector quantity.

Formula: $a = (v - u) / t$, where v is final velocity, u is initial velocity, and t is time.

Q2: Explain positive and negative acceleration with examples.

Ans:

- **Positive Acceleration:** Velocity increases over time.
Example: A car speeding up from 20 m/s to 40 m/s.
 - **Negative Acceleration (Deceleration):** Velocity decreases over time.
Example: A car slowing down from 40 m/s to 20 m/s.
-

Q3: A car accelerates from 10 m/s to 20 m/s in 5 seconds. Find its acceleration.

Ans:

Using $a = (v - u) / t$

$$a = (20 - 10) / 5 = 10 / 5 = 2 \text{ m/s}^2$$

Q4: Differentiate between uniform and non-uniform acceleration.

Ans:

- **Uniform Acceleration:** Velocity changes at a constant rate.
Example: Free fall.
 - **Non-uniform Acceleration:** Velocity changes irregularly.
Example: A car in stop-and-go traffic.
-

2.5 Motion Due to Gravity

Q1: Define free fall and its characteristics.

Ans:

Free fall is the motion of an object under the influence of gravity alone.

Characteristics:

1. Acceleration is constant ($g = 9.8 \text{ m/s}^2$).
2. Objects fall at the same rate irrespective of mass.

Q2: A ball is dropped from a height of 20 m. How long will it take to hit the ground?

Ans:

Using $s = \frac{1}{2}gt^2$:

$$20 = 0.5 \times 9.8 \times t^2 \Rightarrow 0.5 \times 9.8 \times t^2 = 20$$

$$t^2 = 20 / 4.9 = 4.08 \Rightarrow t = \sqrt{4.08} = 2.02 \text{ s}$$

$$t = 2.02 \text{ s}$$

Q3: What is terminal velocity?

Ans:

Terminal velocity is the constant speed an object reaches when the downward gravitational force equals the upward air resistance.

Example: A skydiver reaches terminal velocity during free fall.

Q4: Explain why heavier objects don't fall faster in a vacuum.

Ans:

In a vacuum, there is no air resistance, so all objects experience the same gravitational acceleration regardless of mass.

2.6 Graphical Analysis of Motion

Q1: Describe a distance-time graph for different types of motion.

Ans:

- **Horizontal Line:** Object is at rest.
- **Straight Inclined Line:** Uniform motion.
- **Curved Line:** Non-uniform motion.

Q2: How is acceleration represented on a velocity-time graph?

Ans:

- **Positive Slope:** Positive acceleration.
- **Negative Slope:** Negative acceleration.
- **Horizontal Line:** Zero acceleration.

Q3: Calculate the distance covered from a velocity-time graph.

Ans: The distance is the area under the graph.

Example: A rectangle-shaped graph with $v=10 \text{ m/s}$ and $t=5 \text{ s}$ has:

Distance = $10 \times 5 = 50 \text{ m}$ $10 \times 5 = 50 \text{ m}$.

Q4: Differentiate between displacement-time and velocity-time graphs.

Ans:

- **Displacement-Time Graph:** Shows position changes over time. Slope gives velocity.
- **Velocity-Time Graph:** Shows velocity changes over time. Slope gives acceleration.

Exera Long Questions (Topic Wise)

Q1: Define rest and motion. Explain how they are relative concepts with examples.

Rest and Its Explanation

Rest is a state where an object does not change its position relative to a chosen reference point over time. It is a subjective state dependent on the observer.

Example: A book on a table remains stationary concerning the table, so it is considered at rest relative to the table.

Motion and Its Explanation

Motion occurs when an object changes its position concerning a reference point over time.

Example: A moving car changes its position concerning a stationary observer on the roadside, so it is in motion relative to the observer.

Why Rest and Motion Are Relative

The state of rest or motion depends entirely on the frame of reference chosen by the observer.

1. **Example 1:** A person seated on a moving train is at rest relative to another passenger but in motion relative to someone standing on the platform.
2. **Example 2:** Earth appears stationary to us, but it is in motion relative to the Sun, as it rotates and revolves.

Conclusion

Rest and motion are not absolute states. They depend on the observer's frame of reference, which makes them relative concepts.

Q2: Differentiate between distance and displacement. Provide examples and explain when displacement can be zero while distance is not.

Distance

Distance is the total path length traveled by an object. It is scalar and does not include direction.

Example: If a person walks 5 km in a circular track, the total distance is 5 km.

Displacement

Displacement is the shortest straight-line distance between an object's initial and final positions, including direction. It is a vector quantity.

Example: If the person ends at the starting point after walking 5 km in the circular track, the displacement is 0 km.

When Displacement is Zero but Distance is Not

If an object returns to its starting point, the displacement is zero because there is no net change in position, but the distance is the total path traveled.

Example: A car traveling 2 km east and then 2 km west covers a distance of $2+2=4$ km, but its displacement is $2-2=0$ km.

Key Differences Between Distance and Displacement

1. Distance is always positive, while displacement can be positive, negative, or zero.

- Distance depends on the actual path taken, whereas displacement depends only on the initial and final positions.

Q3: Define speed and velocity. Explain their differences with examples.

Speed

Speed is the rate at which an object covers distance. It is a scalar quantity.

Formula: $\text{Speed} = \frac{\text{Distance}}{\text{Time}}$ $\text{Speed} = \frac{\text{Distance}}{\text{Time}}$

Example: A car traveling 100 km in 2 hours has a speed of $\frac{100}{2} = 50 \text{ km/h}$.

Velocity

Velocity is the rate at which an object changes its displacement. It is a vector quantity.

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

Example: A car traveling 100 km east in 2 hours has a velocity of $\frac{100}{2} = 50 \text{ km/h east}$.

Key Differences Between Speed and Velocity

- Speed has no direction, while velocity includes direction.
- Speed can never be negative, while velocity can be positive, negative, or zero.
- Speed is based on distance, whereas velocity is based on displacement.

Example Showing the Difference

If a car moves 50 km east and then 50 km west in 2 hours:

- Distance = $50 + 50 = 100 \text{ km}$, so speed = $\frac{100}{2} = 50 \text{ km/h}$.
- Displacement = $50 - 50 = 0 \text{ km}$, so velocity = $\frac{0}{2} = 0 \text{ km/h}$.

Q4: Define acceleration. Explain its types with formulas and examples.

Definition of Acceleration

Acceleration is the rate of change of velocity with time. It is a vector quantity.

Formula: $a = \frac{v - u}{t}$ $a = \frac{v - u}{t}$, where v is final velocity, u is initial velocity, and t is time.

Types of Acceleration

- Positive Acceleration:** Velocity increases over time.

Example: A car accelerates from 10 m/s to 20 m/s in 5 seconds. $a = \frac{20 - 10}{5} = 2 \text{ m/s}^2$.

- Negative Acceleration (Deceleration):** Velocity decreases over time.

Example: A car slows from 20 m/s to 10 m/s in 5 seconds. $a = \frac{10 - 20}{5} = -2 \text{ m/s}^2$.

3. **Uniform Acceleration:** Velocity changes at a constant rate.

Example: An object in free fall under gravity.

4. **Non-Uniform Acceleration:** Velocity changes irregularly.

Example: A car moving through heavy traffic.

Real-Life Application

Acceleration is used in designing vehicles to ensure optimal performance during speeding up, braking, and turning.

Q5: Explain free fall under gravity. Derive the equations of motion for a freely falling object.

Free Fall Definition

Free fall is the motion of an object under the influence of gravity alone, with no air resistance. The acceleration due to gravity (g) is 9.8 m/s^2 .

Equations of Motion for Free Fall

For a freely falling object, the standard equations of motion are modified by replacing a with g :

- $v = u + gt$
- $s = ut + \frac{1}{2}gt^2$
- $v^2 = u^2 + 2gs$

Where:

- u = Initial velocity (0 for an object dropped from rest).
- v = Final velocity.
- s = Distance fallen.
- t = Time taken.

Example Problem

If a ball is dropped from rest, calculate its velocity after 3 seconds.

Using $v = u + gt$:

$$v = 0 + 9.8 \times 3 = 29.4 \text{ m/s}$$

Q6: Explain the importance of distance-time and velocity-time graphs with examples.

Distance-Time Graph

A distance-time graph shows how an object's position changes with time.

- Horizontal Line:** Object is at rest.
- Straight Inclined Line:** Uniform motion.
- Curved Line:** Non-uniform motion.

Example: A straight inclined line with a slope of 5 represents an object moving at 5 m/s.

Velocity-Time Graph

A velocity-time graph shows how an object's velocity changes with time.

1. **Horizontal Line:** Constant velocity.
2. **Inclined Line (Upwards):** Positive acceleration.
3. **Inclined Line (Downwards):** Negative acceleration.

Example: A straight line with a slope of 2 represents uniform acceleration of 2 m/s^2 .

Area Under Velocity-Time Graph

The area under the graph represents the distance traveled.

Example: A graph with a rectangle-shaped area of $10 \text{ m/s} \times 5 \text{ s}$ gives a distance of 50 m .

Multiple Choice Questions

1. What is the state of an object that does not change its position relative to a reference point?

- a) Motion b) Rest c) Acceleration d) Displacement

Answer: b) Rest

2. Which of the following describes motion?

- a) Change in speed b) Change in position relative to a reference point c) Constant position d) No movement

Answer: b) Change in position relative to a reference point

3. Rest and motion are:

- a) Absolute concepts b) Relative concepts c) The same for all observers d) Not related

Answer: b) Relative concepts

4. A person sitting in a moving train is:

- a) At rest relative to the platform b) In motion relative to another passenger c) At rest relative to the train d) In motion relative to the train

Answer: c) At rest relative to the train

5. Which type of motion involves movement around a fixed axis?

- a) Translatory motion b) Oscillatory motion c) Rotatory motion d) Random motion

Answer: c) Rotatory motion

6. What is the shortest distance between the initial and final positions of an object?

- a) Distance b) Displacement c) Path length d) Direction

Answer: b) Displacement

7. Displacement is a:

- a) Scalar quantity b) Vector quantity c) Constant quantity d) None of these

Answer: b) Vector quantity

8. Distance traveled by an object can never be:

- a) Positive b) Negative c) Zero d) Equal to displacement

Answer: b) Negative

9. Which of the following is always greater than or equal to displacement?

- a) Distance b) Time c) Velocity d) Speed

Answer: a) Distance

10. If an object returns to its starting point, its displacement is:

- a) Positive b) Negative c) Zero d) Equal to the distance traveled

Answer: c) Zero

11. Speed is:

- a) A vector quantity b) A scalar quantity c) Equal to velocity d) Always constant

Answer: b) A scalar quantity

12. Which of the following includes direction?

- a) Speed b) Distance c) Velocity d) Time

Answer: c) Velocity

13. If a car travels 100 km east in 2 hours, its velocity is:

- a) 50 km/h b) 50 km/h east c) 100 km/h east d) 200 km/h

Answer: b) 50 km/h east

14. The magnitude of velocity is the same as:

- a) Acceleration b) Displacement c) Speed d) Time

Answer: c) Speed

15. Uniform velocity means:

- a) Constant speed b) Constant speed in a straight line c) Constant acceleration d) Constant displacement

Answer: b) Constant speed in a straight line

16. Acceleration is the:

- a) Change in velocity over time b) Change in displacement over time c) Change in distance over time d) Rate of velocity change

Answer: a) Change in velocity over time

17. If velocity increases, acceleration is:

- a) Negative b) Positive c) Zero d) Constant

Answer: b) Positive

18. What type of acceleration occurs when a car slows down?

- a) Uniform acceleration b) Deceleration c) Non-uniform acceleration d) Constant acceleration

Answer: b) Deceleration

19. The unit of acceleration is:

- a) m/s b) m/s^2 c) km/h d) km/h^2

Answer: b) m/s^2

20. Acceleration is zero when:

- a) An object is at rest b) Velocity is constant c) An object is accelerating d) None of these

Answer: b) Velocity is constant

21. The acceleration due to gravity on Earth is approximately:

- a) 8.9 m/s^2 b) 9.8 m/s^2 c) 10.8 m/s^2 d) 11.8 m/s^2

Answer: b) 9.8 m/s^2

22. Free fall occurs when:

- a) Only air resistance acts on the object b) Gravity is the only force acting on the object c) An object moves upward d) An object moves horizontally

Answer: b) Gravity is the only force acting on the object

23. If a ball is dropped from rest, its velocity after 2 seconds is:

- a) 4.9 m/s b) 9.8 m/s c) 19.6 m/s d) 29.4 m/s

Answer: c) 19.6 m/s

24. Which of the following factors affects free fall in a vacuum?

- a) Mass b) Shape c) Gravity d) Air resistance

Answer: c) Gravity

25. An object thrown upward has a final velocity of:

- a) Zero at the topmost point b) Equal to the initial velocity at the topmost point c) Constant throughout d) None of these

Answer: a) Zero at the topmost point

26. A horizontal line on a distance-time graph represents:

- a) Motion with acceleration b) An object at rest c) Uniform motion d) Non-uniform motion

Answer: b) An object at rest

27. The slope of a distance-time graph gives:

- a) Velocity b) Acceleration c) Displacement d) Time

Answer: a) Velocity

28. The area under a velocity-time graph gives:

- a) Acceleration b) Displacement c) Speed d) Time

Answer: b) Displacement

29. A straight inclined line on a velocity-time graph represents:

- a) Uniform acceleration b) Zero acceleration c) Constant velocity d) Deceleration

Answer: a) Uniform acceleration

30. Which type of motion is shown by a curved line on a distance-time graph?

- a) Uniform motion b) Non-uniform motion c) Rest d) Constant velocity

Answer: b) Non-uniform motion

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