CHAPTER: 02

Kinematics

Short Response Questions:

Q1. In a park, children are enjoying a ride on Ferris wheel as shown. What kind of motion the big wheel has and what kind of motion the riders have?

The big wheel rotates about its own fixed axis, therefore it has **rotatory motion**. The riders move along a circular path while the wheel rotates. Hence, the riders are said to be in **circular motion**, which is a type of translatory motion.

Q2. A boy moves for some time, give two situations in which his displacement is zero but covered distance is not zero.

When a boy moves from a point and returns back to the same point, his **displacement becomes zero** although the distance covered is not zero. Similarly, if the boy completes one full round of a circular track and reaches the starting point, his displacement remains zero while the distance covered is equal to the circumference of the track.

Q3. A stone tied to string is whirling in circle, what is direction of its velocity at any instant?

At any instant, the velocity of the stone is directed **along the tangent** to the circular path. This tangential direction is always **perpendicular to the radius** of the circle. The direction of velocity keeps changing continuously during circular motion.

Q4. Is it possible to accelerate an object without speeding it up or slowing it down?

Yes, it is possible to accelerate an object without changing its speed. When an object moves in a **circular path with constant speed**, its direction of velocity changes at every instant. This continuous change in direction produces acceleration.

Q5. Can a car moving towards right have direction of acceleration towards left?

Yes, a car moving towards the right can have acceleration towards the left. When brakes are applied, the velocity of the car decreases. In this case, acceleration acts **opposite to the direction of motion**, which is called retardation.

Q6. With the help of daily life examples, describe the situations in which:

(a) Acceleration is in the direction of motion

When a car speeds up while moving forward, its velocity increases in the same direction. In this case, acceleration acts in the direction of motion. As a result, the speed of the car increases with time.

(b) Acceleration is against the direction of motion

When brakes are applied to a moving car, its speed decreases. The acceleration acts opposite to the direction of motion. Such acceleration is called negative acceleration or retardation.

(c) Acceleration is zero and body is in motion

When a body moves with **constant speed in a straight line**, its velocity does not change. Since there is no change in velocity, acceleration becomes zero. The body continues its motion without speeding up or slowing down.

Q7. Examine distance–time graph of a motorcyclist (as shown), what does this graph tell us about the speed of motorcyclist? Also plot its velocity–time graph.

The distance–time graph is a **straight line**, which shows that the motorcyclist is moving with **uniform speed**. The slope of the distance–time graph remains constant, indicating that speed does not change with time.
The corresponding **velocity–time graph** will be a **horizontal straight line parallel to the time axis**, showing constant velocity.

Q8. Which controls in the car can produce acceleration or deceleration in it?

The **accelerator** of the car produces acceleration by increasing the speed of the car. The **brakes** produce deceleration by decreasing the speed of the car. Both controls change the velocity of the car and hence produce acceleration.

Q9. 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)

Both stones will hit the ground with the **same velocity** because acceleration due to gravity is independent of mass. They will also hit the ground **at the same time** since both experience the same gravitational acceleration. Neglecting air resistance, mass does not affect the motion.

Q10. A 100 g ball is just released (from rest) and another is thrown downward with velocity of 10 m/s, which will have greater acceleration? (Neglect the air resistance)

Both balls will have the **same acceleration**. The acceleration due to gravity is constant and independent of initial velocity. Therefore, both balls accelerate downward with acceleration **g = 9.8 m/s^2**.

Long Response Questions:

Q1. Differentiate between rest and motion. With the help of example, show that rest and motion are relative to observer.

An object is said to be **at rest** if it does not change its position with respect to its surroundings or an observer with the passage of time. On the other hand, an object is said to be **in motion** if it changes its position with respect to an observer with time. Rest and motion are described by comparing the position of an object relative to a reference point.

Rest and motion are **relative terms**, meaning that the same object can be at rest for one observer and in motion for another observer at the same time. For example, a passenger sitting inside a moving bus is at rest with respect to the bus because his position does not change relative to the bus. However, the same passenger is in motion with respect to a person standing on the roadside because his position is changing relative to that observer.

Similarly, a book lying on a table is at rest with respect to the table, but it is in motion with respect to the Sun because the Earth is rotating and revolving around the Sun. This shows that there is no absolute rest or absolute motion. Therefore, rest and motion always depend upon the observer and the frame of reference.

Q2. What are different types of motion? Define each type of motion with examples from daily life.

The motion of objects can be classified into different types on the basis of the way objects move. The main types of motion are **translatory motion, rotatory motion and vibratory motion**.

Translatory motion is the motion in which all points of a moving body move through the same distance in the same direction. In this type of motion, the orientation of the body does not change. Examples include the motion of a car on a road, a flying bird and a moving train. Translatory motion can further be divided into **rectilinear motion**, **curvilinear motion** and **random motion**.

Rotatory motion is the motion in which a body rotates about a fixed axis. Each particle of the body moves in a circular path around the axis of rotation. Examples of rotatory motion include the motion of a ceiling fan, blades of a windmill and a spinning wheel.

Vibratory motion is the motion in which a body moves to and fro about a fixed mean position. This motion repeats itself after equal intervals of time. Examples include the motion of a pendulum, the strings of a guitar and the prongs of a tuning fork.

Q3. What are scalars and vectors? Give examples. How are vectors represented symbolically and graphically?

Physical quantities are classified into **scalars and vectors** on the basis of direction.

A **scalar quantity** is a physical quantity that has magnitude only and no direction. Scalars are completely described by a numerical value and a unit. Examples of scalar quantities include mass, time, temperature, distance, speed and energy.

A **vector quantity** is a physical quantity that has both magnitude and direction. A vector quantity is not completely described unless its direction is specified along with its magnitude. Examples of vector quantities include displacement, velocity, acceleration, force and momentum.

Symbolically, vectors are represented by bold letters such as **v** or by placing an arrow over the symbol, for example →**v**. Graphically, vectors are represented by a straight line with an arrow head. The length of the line represents the magnitude of the vector, while the arrow head shows its direction.

Q4. Define the term position. Differentiate between distance and displacement.

The **position** of an object is its location relative to a chosen reference point or origin. Position helps us describe where an object is located in space at a particular time.

Distance is the total length of the actual path traveled by an object during its motion. It is a scalar quantity because it has magnitude only and no direction. Distance is always positive and depends on the path followed by the object.

Displacement is the shortest straight-line distance from the initial position to the final position of an object, along with direction. It is a vector quantity because it has both magnitude and direction. Displacement can be zero even when distance is not zero, such as when an object returns to its starting point.

Thus, distance depends on the path length, while displacement depends only on initial and final positions.

Q5. Differentiate between speed and velocity. Also define average speed, uniform and variable speeds, average velocity, uniform and variable velocities.

Speed is defined as the distance covered by an object per unit time. It is a scalar quantity and does not require direction for its description. Speed only tells how fast an object is moving.

Velocity is defined as the displacement covered by an object per unit time. It is a vector quantity and requires both magnitude and direction. Velocity tells both how fast and in which direction an object is moving.

Average speed is the total distance covered divided by the total time taken.
Uniform speed is when an object covers equal distances in equal intervals of time.
Variable speed is when an object covers unequal distances in equal intervals of time.

Average velocity is the total displacement divided by the total time taken.
Uniform velocity is when an object covers equal displacements in equal intervals of time in the same direction.
Variable velocity occurs when either the magnitude or direction of velocity changes with time.

Q6. What are freely falling bodies? What is gravitational acceleration? Write down sign conventions for gravitational acceleration. Write three equations of motion of a freely falling body.

A **freely falling body** is an object that falls under the influence of gravity alone, without any air resistance. Examples include a stone dropped from a height or a ball falling freely towards the Earth.

Gravitational acceleration is the acceleration produced in a freely falling body due to the gravitational force of the Earth. It is denoted by **g** and its value near the Earth's surface is approximately **9.8 m/s^2**, directed downward.

According to sign convention, when an object moves downward under gravity, acceleration due to gravity is taken as **positive (+g)**. When an object moves upward against gravity, acceleration due to gravity is taken as **negative (−g)**.

The three equations of motion for a freely falling body are:

$$v = u + at$$
$$s = ut + \frac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$

Q7. Draw distance–time graphs for rest, uniform speed, increasing speed and decreasing speed.

A **distance–time graph** shows the relationship between distance traveled and time.

When a body is **at rest**, the distance remains constant with time. The distance–time graph is a straight line parallel to the time axis.

When a body moves with **uniform speed**, it covers equal distances in equal intervals of time. The distance–time graph is a straight line with constant slope.

When a body moves with **increasing speed**, it covers greater distances in equal intervals of time. The distance–time graph is a curved line with increasing slope.

When a body moves with **decreasing speed**, it covers smaller distances in equal intervals of time. The distance–time graph is a curved line with decreasing slope.

Q8. Draw speed–time graphs for zero acceleration, uniform acceleration and uniform deceleration. Also show that area under speed–time graph represents distance covered by the body.

A **speed–time graph** represents the variation of speed with time.

For **zero acceleration**, speed remains constant with time. The speed–time graph is a straight line parallel to the time axis.

For **uniform acceleration**, speed increases uniformly with time. The speed–time graph is a straight line with positive slope.

For **uniform deceleration**, speed decreases uniformly with time. The speed–time graph is a straight line with negative slope.

The **area under a speed–time graph** gives the distance covered by the body. This is because distance equals speed multiplied by time. In a speed–time graph, the area between the graph and the time axis represents this product, hence giving the distance traveled..
