

Motion

Introduction

Motion is one of the most common phenomena observed in our daily lives. Anything that changes its position with respect to time is said to be in **motion**. In this chapter, we study different types of motion, concepts of distance, displacement, speed, velocity, acceleration, and the equations of motion.

What is Motion?

Definition

Motion is the change in the position of an object with time with respect to a reference point.

Examples:

- A moving car
- A flying bird
- A rotating fan
- A person walking

If an object does not change its position with time, it is said to be **at rest**.

Distance and Displacement

Difference Between Distance and Displacement

Distance is the total length of the path travelled by an object.

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

Key Difference:

- Distance is a **scalar quantity**.
- Displacement is a **vector quantity** because it has both magnitude and direction.

Speed and Velocity

Meaning

Speed is the distance travelled by an object in unit time.

Formula:

$$\text{Speed} = \text{Distance} / \text{Time}$$

Velocity is the displacement covered per unit time in a particular direction.

Formula:

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

$$\text{Average Speed} = \text{Total Distance} \div \text{Total Time}$$

$$\text{Average Velocity} = \text{Total Displacement} \div \text{Total Time}$$

Acceleration

Definition

Acceleration is the **rate of change of velocity with time**.

Formula:

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

Acceleration may be:

- **Positive** (speed increases)
- **Negative (Retardation)** (speed decreases)
- **Zero** (velocity remains constant)

Uniform and Non-Uniform Motion

Types of Motion

Uniform Motion:

An object covers **equal distances in equal intervals of time**.

Non-Uniform Motion:

An object covers **unequal distances in equal intervals of time** or changes its direction.

Equations of Motion

Three Equations

For an object moving with **uniform acceleration**, the equations of motion are:

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

Where:

- u = Initial velocity
- v = Final velocity
- a = Acceleration
- t = Time
- s = Displacement

Graphical Representation of Motion

Distance-Time and Velocity-Time Graphs

- A **Distance-Time Graph** shows how distance changes with time.
- A **Velocity-Time Graph** shows how velocity changes with time.
- A straight line indicates **uniform motion**, while a curved line indicates **non-uniform motion**.

Graphs help us understand the nature of motion easily.

Uniform Circular Motion

Definition

When an object moves along a **circular path with constant speed**, it is said to be in **uniform circular motion**.

Although the speed remains constant, the **direction of motion changes continuously**, so the object is considered to be accelerating.

Examples:

- A satellite revolving around the Earth
- The hands of a clock
- A stone tied to a string and rotated in a circle

Key Points

- Motion is the change in position with time.
- Distance is a scalar quantity, while displacement is a vector quantity.
- Speed depends on distance, whereas velocity depends on displacement.
- Acceleration is the rate of change of velocity.
- Uniform motion covers equal distances in equal intervals of time.
- The three equations of motion apply only to **uniformly accelerated motion**.
- Uniform circular motion has constant speed but changing direction.

Chapter Summary

Motion describes the movement of objects from one place to another. In this chapter, we learned about distance, displacement, speed, velocity, acceleration, equations of motion, and graphical representation of motion. These concepts help us understand and describe the movement of objects in everyday life and form the basis of mechanics in physics.