Chapter 7: Motion

Introduction to Motion

Motion is Everywhere

In everyday life, we see objects at rest and in motion. Birds fly, cars move, and blood flows. Even atoms, planets, and stars are in motion.

Perception of Motion

We often perceive an object to be in motion when its position changes with time. Sometimes motion is inferred indirectly, like observing dust movement to know the wind is blowing.

Relative Motion

An object may appear moving to one person and stationary to another. For example, roadside trees appear to move backwards to passengers in a moving bus, but are stationary to a person on the road.

Describing Motion

Reference Point

To describe the location of an object, we specify a reference point called the origin. For example, if a school is 2 km north of the railway station, the station is the reference point.

Motion Along a Straight Line

Distance

The total path length covered by an object is the distance. It has only magnitude (numerical value) and no direction.

Displacement

The shortest distance measured from the initial to the final position of an object is known as displacement. It has both magnitude and direction.

Difference

The magnitude of displacement can be zero (if the object returns to the start), but the distance covered will not be zero.

Uniform and Non-Uniform Motion

Uniform Motion

If an object covers equal distances in equal intervals of time, it is said to be in uniform motion.

Non-Uniform Motion

If an object covers unequal distances in equal intervals of time, it is in non-uniform motion. Example: A car moving on a

crowded street.

Measuring the Rate of Motion

Speed

The distance travelled by an object in unit time is called speed. The SI unit is metre per second (m/s).

Average Speed

Since speed is often not constant, we use average speed. Average speed = Total distance travelled / Total time taken.

Speed with Direction: Velocity

Definition

Velocity is the speed of an object moving in a definite direction. It specifies both magnitude and direction.

Changing Velocity

Velocity can change by changing the object's speed, direction of motion, or both.

Average Velocity

If velocity changes at a uniform rate, Average velocity = (Initial velocity + Final velocity) / 2.

Rate of Change of Velocity: Acceleration

Definition

Acceleration is the measure of the change in the velocity of an object per unit time. Acceleration = (Change in velocity) / (Time taken).

Formula

If velocity changes from u (initial) to v (final) in time t, then acceleration a = (v - u) / t. The SI unit is m/s^2.

Uniform Acceleration

If velocity changes by equal amounts in equal time intervals, acceleration is uniform (e.g., a freely falling body).

Graphical Representation: Distance-Time Graphs

Uniform Speed

For an object moving with uniform speed, the distance-time graph is a straight line. The slope of the line indicates the speed.

Non-Uniform Speed

For non-uniform speed, the graph is a curved line, showing non-linear variation of distance with time.

Velocity-Time Graphs

Uniform Motion

If an object moves at uniform velocity, the graph is a straight line parallel to the time axis. The area under the graph gives the displacement.

Uniform Acceleration

For uniformly accelerated motion, the velocity-time graph is a straight line. The area under the graph gives the distance travelled.

Equations of Motion

The Three Equations

For an object moving along a straight line with uniform acceleration: 1) $v = u + at$ (Velocity-time relation), 2) $s = ut + \frac{1}{2}at^2$ (Position-time relation), 3) $2as = v^2 - u^2$ (Position-velocity relation).

Symbols

u = initial velocity, v = final velocity, a = acceleration, t = time, s = distance.

Uniform Circular Motion

Accelerated Motion

When an object moves in a circular path with uniform speed, its direction changes continuously. Therefore, the velocity changes, making it an accelerated motion.

Examples

Examples include the motion of the moon around the earth, a satellite in orbit, or a stone tied to a thread and whirled in a circle.

Formula

Speed $v = (2\pi r) / t$, where r is the radius of the circular path and t is the time taken for one round.