MOTION

Motion

- Motion means movement.
- The motion of an object is perceived when its position changes continuously with respect to some stationary object.
- In certain situations, motion is inferred through indirect evidence.
- **The states of rest and motion are relative.** An object may appear to be moving with respect to one person, and the same object may appear to be at rest with respect to another person.
- To locate the position of an object, we have to choose some suitable reference point, called the origin.

Distance and Displacement

- The distance travelled by an object is the length of the actual path traversed by the object during motion.
- The displacement of an object in motion is the shortest distance between the initial position and final position of the object.
- Distance is a scalar quantity having magnitude only. Displacement is a vector quantity having both the magnitude as well as direction.
- The distance travelled by an object in motion can never be zero or negative. The displacement can be positive, zero or negative.
- When final position of an object in motion coincides with its initial position, the displacement is zero, but the distance travelled is not zero.
- Between two given positions, **distance travelled can never be less than the displacement.**

Speed and Velocity

Speed of a body is a measure of rate of motion of the body. It is equal to distance travelled by the body in unit time.

$$\text{speed}(v) = \frac{\text{distance travelled}(s)}{\text{time taken}(t)}$$

It is measured in m/s or cm/s or km/h.

Velocity of a body is defined as the distance travelled by the body in a given direction in unit time. Thus,

$$\text{velocity} = \frac{\text{distance travelled in a given direction}}{\text{time taken}}$$

$$\vec{v} = \frac{\text{displacement}(\vec{s})}{\text{time}(t)}$$

Acceleration

Acceleration of a body is defined as the rate of change of velocity of the body with time.

$$\text{Acceleration}(a) = \frac{\text{change in velocity}}{\text{time taken}} = \frac{v-u}{t}$$

Unit of acceleration = $m/s^2, cm/s^2, km/h^2$

Three equations of motion

When a body is moving along a straight line with uniform acceleration, the equations, which govern this motion, are:

(i) $v = u + at$ (velocity-time relation).

(ii) $s = ut + \frac{1}{2}at^2$ (position-time relation).

(iii) $v^2 - u^2 = 2as$ (position-velocity relation).

In all the three equations, u represents initial velocity of the body, a is uniform acceleration of the body; v is final velocity of the body after t seconds and s is the distance travelled by the body in this time.

Circular Motion

In uniform circular motion, speed of the body along a circular path is constant. But the direction of motion is changing continuously, being along the tangent to the circular path at every instant. Therefore, velocity of the body changes in uniform circular motion. Hence **uniform circular motion is an accelerated motion.**

An external force is required to move a body uniformly in a circle. This force is called **centripetal force.**

If a body takes t seconds to go once round a circle of radius r, then uniform speed of the body, $v = \frac{2\pi r}{t}$.