PHYSICS

CLASS NOTES FOR CBSE

Chapter 04. Motion in a Straight Line

01. Introduction

Statics and dynamics are the two main branches of mechanics. Whereas statics is the study of the objects at rest, dynamics is the study of objects in motion. An object can have uniform motion, even when a number of forces are acting on it. Such forces are said to be in equilibrium.

Thus, statics is the study of the motion of an object under the effect of forces in equilibrium.

The motion of objects is studied under two separate headings:

Kinematics. *The study of the motion of the objects without talking into account the cause of their motion is called kinematics.*

Dynamics. *The study of the motion of the objects by taking into account the cause (or cause) opf their change of state (rest or of uniform motion) is called dynamics.*

02. Rest and Motion

Rest and motion are relative terms.

An object is said to be in motion, if it changes its position w.r.t its surroundings with the passage of time.

One *the other hand, if an object does not change its position w.r.t. its surroundings with passage of time, it is said to be at rest.*

03. The Concept of a Point Object

While studying the motion of an object; sometimes, its dimensions are of no importance. For example, if one travels from one place to another distant place by a bus, the length of the bus may be ignored as compared to the distance travelled. In other words, although the bus has a finite size, yet for the study of the motion of the bus along the road; its motion may be considered as the motion of a point or a particle.

In mechanics, *a particle is a geometrical mass point or a material body of negligible dimensions.*

04. Motion Along a Straight Line – Path Length and Displacement

In the present chapter, we shall confine our study to the motion of an object along a straight line, also known as ***rectilinear motion.***

Path length. *The distance covered by the object in a given time is called* ***path length.***

Displacement. *The distance covered by the object in a particular direction is called displacement.*

The displacement has both magnitude and direction and hence it is a vector* quantity.

(i) *The displacement has units of length.*

(ii) *The displacement of an object in a given time interval can be positive, zero or negative.*

(iii) *The actual distance travelled by an object in a given time interval is either equal to or greater than the magnitude of the displacement.*

(iv) *The displacement of an object between two points does not tell exactly how the object actually moved between those two points.*

05. Speed and Velocity

Speed. *The time rate of covering the distance by an object is called its speed.*

The speed of an object is a *scalar* quantity. Its unit in cgs system is **cm s^{-1}** and in SI, the unit of speed is **m s^{-1}**. The dimensional formula of speed is **$[M^0LT^{-1}]$**.

Velocity. *The time rate of change of displacement of an object is called the velocity of the object.*

In general, *the velocity of an object may also be defined as its speed in a particular direction.*

The following points may be noted about the speed and velocity of an object moving along a straight line:

(i) *Speed is a scalar quantity.* The magnitude of the velocity of the object is called its speed.

(ii) *The speed of an object in particular direction is called velocity of the object.*

(iii) *Whereas the velocity of an object can be positive* (moving towards right of the origin of position-axis), *zero* (at rest) *or negative* (moving towards left of the origin of position-axis), *the speed of an object can only be positive or zero. In other wards, speed of an object can never be negative.*

(iv) *The speed of an object gives only quantitative knowledge of 'how fast the object is moving'. It tells nothing about the direction of motion of the object.*

(v) *The speed of an object has the same units as that of velocity.*

06. Uniformly Accelerated Motion in a Straight Line

Uniformly accelerated motion. *The motion of an object is said to be uniformly accelerated, if the same change in its velocity takes place in each unit of time.*

To describe uniformly accelerated motion, let us first define quantities, such as ***average speed, average velocity, instantaneous velocity*** *and* ***acceleration***.

Average Speed. *It is defined as the ratio of the path length to the time taken by the object to cover that path.*

Mathematically, average speed of the uniform motion $= \frac{path\ length}{time\ interval}$

It may be noted that *the average speed is that uniform speed with which the object will cover the same path length in same interval of time as it does with its actual varying speed during that time interval.*

Average velocity. *It is defined as the ration of the displacement to the time taken by the object to cover that displacement.*

Mathematically, average velocity of the uniform motion $= \frac{displacement}{time\ interval}$

07. Non-Uniform Motion

Variable velocity. An object is said to be moving with variable velocity, if it undergoes unequal displacements in equal intervals of time.

The following points are true for variable motion:

(i) *When an object moves with variable velocity, either its speed or direction of motion or both change with time.*
Accordingly, the object may move along a straight line or a curved path i.e. in one, two or three dimension.

(ii) *The instantaneous velocity of the object at different instants of time during a time interval is not equal to the average velocity in that time interval.*

(iii) *The velocity-time graph may or may not be a straight line, but it will bot be parallel to the time-axis.*

(iv) *The position-time graph is never a straight line.*

08. Instantaneous Velocity and Acceleration

Instantaneous velocity. *The velocity of an object at a particular instant or at a particular point of its path is called instantaneous velocity.*

Mathematically, the instantaneous velocity,

$$v = \lim_{\Delta t \to} \left(\frac{\Delta x}{\Delta t} \right) \qquad \text{(i)}$$

Instantaneous acceleration. The instantaneous acceleration of an object is defined as the limiting value of the average acceleration of the object in a small time interval around that instant, when the time interval approaches zero.

Let v and $v + \Delta v$ be the velocities of the object at times t and $t + \Delta t$, where Δt is a very small time interval.