

# CLASS 9 SCIENCE NOTES CHAPTER 8 MOTION

## Facts that Matter

An object is said to be in motion when its position changes with time.

We describe the location of an object by specifying a reference point. Motion is relative. The total path covered by an object is said to be the distance travelled by it.

The shortest path/distance measured from the initial to the final position of an object is known as the displacement.

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

Non-uniform motion: Motions where objects cover unequal distances in equal intervals of time.

Speed: The distance travelled by an object in unit time is referred to as speed. Its unit is m/s.

Average speed: For non-uniform motion, the average speed of an object is obtained by dividing the total distance travelled by an object by the total time taken.

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

**Velocity:** Velocity is the speed of an object moving indefinite direction. S.I. unit is m/s.

$$\text{Average velocity} = \frac{\text{initial velocity} + \text{final velocity}}{2}$$

$$\therefore V_{av} = \frac{u + v}{2} \quad \begin{array}{l} u = \text{initial velocity} \\ v = \text{final velocity} \end{array}$$

**Acceleration:** Change in the velocity of an object per unit time.

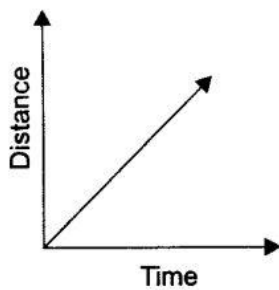
$$\text{Acceleration } a = \frac{v - u}{t} \quad \text{S.I. unit is } m/s^2$$

### Graphical representation of motions

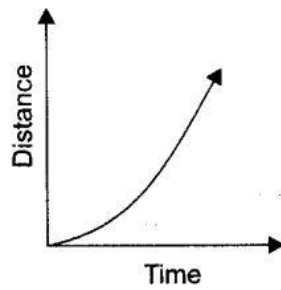
#### (i) Distance-time graph

For a distance-time graph, time is taken on x-axis and distance is taken on the y-axis.

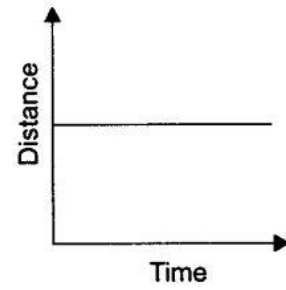
[**Note:** All independent quantities are taken along the x-axis and dependent quantities are taken along the y-axis.]



Uniform speed



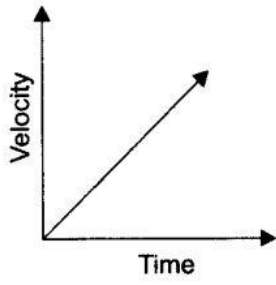
Non-uniform speed



Stationary

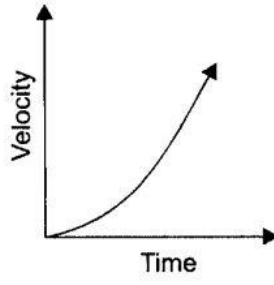
$$\left( \text{speed} = \frac{\text{distance}}{\text{time}} \right)$$

#### (ii) Velocity-time graph

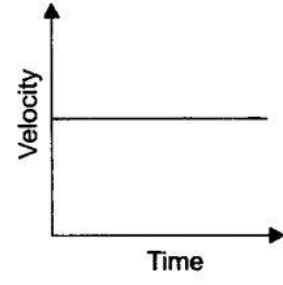


Uniform acceleration

$$\left( a = \frac{v}{t} \right)$$



Non-uniform acceleration

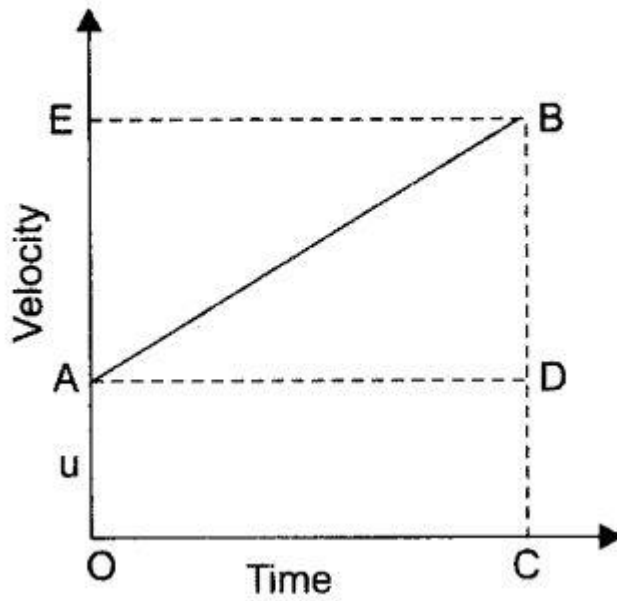


Uniform motion or no acceleration

### Equation of motion by graphical methods

(i) velocity-time relation:

$$v = u + at$$



$$OA = CD = u$$

$$OE = CB = v$$

$$OC = AD = t$$

$$BD = BC - DC \text{ (Change in velocity)}$$

$AD$  is parallel to  $OC$ .

$$\therefore BC = BD + DC = BD + OA$$

$$\therefore BC = v \text{ and } OA = u$$

We get

$$v = BD + u$$

$$\therefore BD = v - u \quad \dots(1)$$

In velocity-time graph, slope gives acceleration.

$$\therefore a = \frac{BD}{AD} = \frac{BD}{OC}$$

$$\therefore OC = t \text{ we get } a = \frac{BD}{t}$$

$$\therefore BD = at \quad \dots(2)$$

Substituting (2) in (1) we get

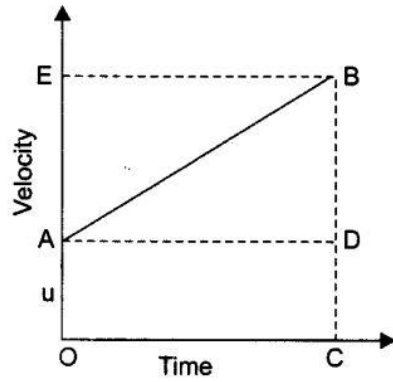
$$BD = v - u$$

$$at = v - u$$

$\therefore$

$$\boxed{v = u + at}$$

(ii) The equation for position-time relation:



Let us assume,

$s$  = distance travelled by the object

$t$  = in time  $t$

$a$  = with uniform acceleration.

$\therefore$  Distance travelled by the object is given by area enclosed with  $OABC$  in the graph.

$$\begin{aligned} \therefore s &= OABC \\ &= (\text{area of rectangle } OADC) + (\text{area of } \triangle ABD) \end{aligned}$$

$$= (OA \times OC) + \frac{1}{2} (AD \times BD)$$

Substituting

$$OA = u, \quad OC = AD = t \quad \text{and} \quad BD = at$$

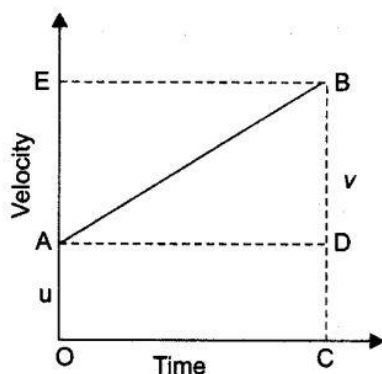
We get

$$s = ut + \frac{1}{2} (t \times at)$$

$\therefore$

$$\boxed{s = ut + \frac{1}{2} at^2}$$

**(iii) Equation for position-velocity relation:**



$s$  = distance travelled by the object

$t$  = in time  $t$

$a$  = moving with uniform acceleration

$\therefore$   $s$  = area enclosed by trapezium  $OABC$

$$\therefore s = \frac{(OA + BC) \times OC}{2}$$

$\therefore$   $OA = u, BC = v$  and  $OC = t.$

$$\therefore s = \frac{(u + v) t}{2} \quad \dots(1)$$

Slope  $t = \frac{v - u}{a}$  from the graph ... (2)

Substitute value of ' $t$ ' in (1)

$$\therefore s = \frac{u + v}{2} \times \frac{(v - u)}{a}$$

$$s = \frac{v^2 - u^2}{2a}$$

$$\therefore \boxed{v^2 - u^2 = 2as}$$

**Uniform circular motion:** When a body moves in a circular path with uniform speed, its motion is called uniform circular motion.