9. Motion and its Description

Motion: A continuous change in the position of the object with respect to time is called motion.

Rectinear motion: If an object moving in a straight line changes its position with respect to time.

Circular motion: When an object moves at a constant distance from a fixed point, its motion is called circular motion.

Periodic motion: A motion which repeats itself after certain fixed interval of time is called periodic motion

Oscillatory motion: A motion which is repeated about its mean position periodically is called oscillatory motion e.g. motion of simple pendulum.

Distance: The length of the path fallowed by a body is called distance.

Displacement: The shortest distance between initial and final position of the object is called displacement. It is vector quantity.

Speed: Distance travelled by a body in unit time is called speed i.e.

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

Average speed: $\dfrac{\text{Total distance travelled}}{\text{Total time taken}}$

Velocity: Displacement of a body in unit time is called velocity i.e. $\dfrac{\text{Displacement}}{\text{Time taken}}$

The unit of velocity in SI system is m/s. Other commonly used unit is km/h. It is a vector quanity.

The SI unit of distance and displacement is metre (m), of speed, velocity, average speed and averge velocity is ms^{-1}.

Acceleration: The rate of change of velocity is called accelertion. i.e.

$$\text{Acceleration} = \frac{\text{Final velocity} - \text{initial velocity}}{\text{Time}}$$

$$a = \frac{v-u}{t}$$

The unit of acceleration in SI unit is ms^{-2}. It is a vector quantity.

Equations for uniformly accelerated motion:

$$v = u + at \tag{i}$$

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

$$v^2 = u^2 + 2as \tag{iii}$$

where $u =$ initial velocity
  $v =$ final velocity
  $a =$ acceleration
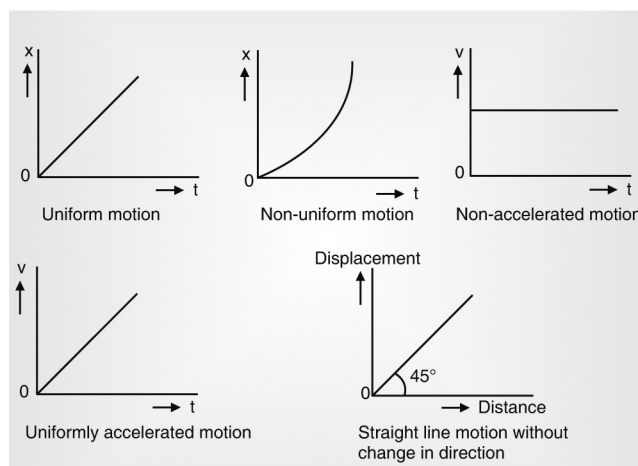 $s =$ distance
  $t =$ time

Distancwe travelled by a body in n^{th} second:

$$s = u + \frac{a}{2}(2n-1)$$

Here $n =$ n^{th} second

Graphical representation of motion

Uniform motion   Non-uniform motion   Non-accelerated motion

Uniformly accelerated motion   Straight line motion without change in direction

- A person starts from point A and moves following path (i) ABC (ii) AC (iii) ACDE and takes 12 min, 14 min and 20 min in all these cases respectively.

  Find (a) distance and displacement (b) speed and velocity in all these cases.
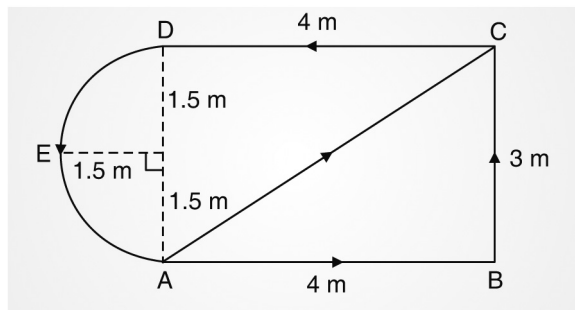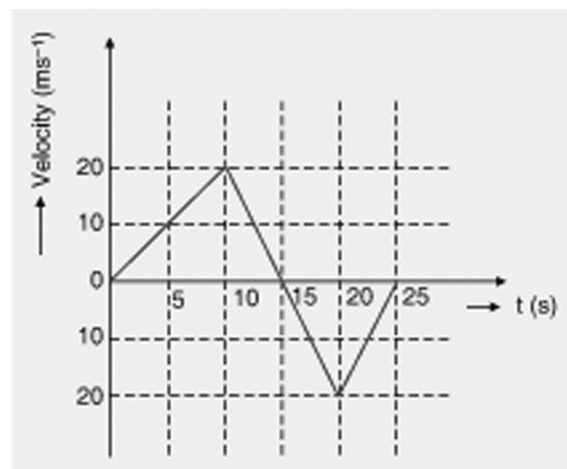

Sol:

(a) (i)   7 m, 5 m (ii) 5 m, 5m

   (iii) 11.93 m, $1.5\sqrt{2}$ m

(b) (i) $\dfrac{7}{720}$ ms^{-1}, $\dfrac{5}{720}$ ms^{-1}

   (ii) $\dfrac{5}{840}$ ms^{-1}, $\dfrac{5}{840}$ ms^{-1}

   (iii) $\dfrac{11.93}{1200}$ ms^{-1}, $\dfrac{1.5\sqrt{2}}{1200}$ ms^{-1}

- Find distance, displacement and maximum acceleration from the given graph.

Sol:

Distance $= \dfrac{1}{2} \times 20(15) + \dfrac{1}{2} \times 20(10) = 250$ m

Displacement $= 150 - 100 = 50$ m

Maximum acceleration $= \dfrac{20-0}{25-20} = 4$ ms^{-2}

Plan Your Jorney

If Nimish covers x_1 distance in time t_1 with speed v_1 and x_2 distance in time t_2 with speed v_2, then Average speed

$$= \dfrac{x_1 + x_2}{t_1 + t_2}$$

$$= \dfrac{v_1 t_1 + v_2 t_2}{t_1 + t_2}$$

$$= \dfrac{(x_1 + x_2) v_1 v_2}{x_1 v_2 + x_2 v_2}$$

✔ **Maximise Your Marks**

There is a smooth pole of height 18 m. A monkey climbs up 3m and slips down 2 m over the pole again and again. If time of each climb and slip is 6 min and 2 min respectively, then find (i) number of climbs to reach at the top of the pole (ii) average velocity, (iii) average speed (iv) distance travelled and (v) displacement of monkey.

Sol. (i) 16   (ii) $\dfrac{18}{126 \times 60}$ ms^{-1}

   (iii) $\dfrac{48+30}{126 \times 60}$ ms^{-1} (iv) 78 m

   (v) 18 m

Learner Guide

1. If a body does not move in the same direction its displacement is less than the distance.
2. Distance is path dependent while displacement is position dependent.
3. Displacement can be zero but distance can not be zero.
4. Instantaneous speed is the magnitude of instantaneous velocity but average speed is not the magnitude of average velocity.
5. Average velocity is less than or equal to the aveage speed.
6. Average velocity can be zero but not average speed.

? **Test Yourself**

1   An object is dropped from a height of 19.6 m. Find the time taken and the velocity of the object when it reaches the ground.

2. Krishna goes from her house to Kalpna's house with the speed of 40 kmh^{-1}. When she just reaches her house she came to know that the gift given to Kalpna is left at home and returns the home immediately with speed of 60 kmh^{-1}. Find the average speed of Krishna.

3. Find the acceleration and displacement of an object from the given velocity-time graph.
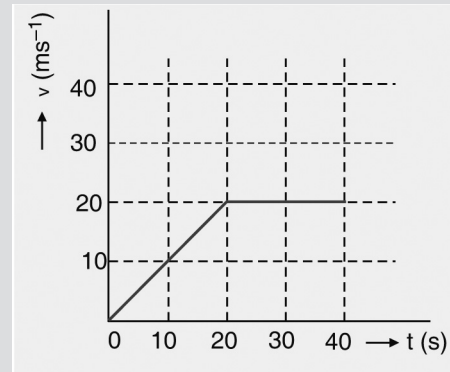
4. Find the distance and displacement for the entire motion of an object shown in graph.
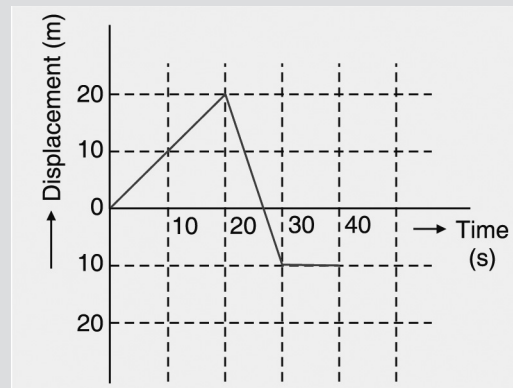
5. An object is dropped from the height of 78.4 m at the same time another object is thrown vertically up with the speed of 39.2 ms^{-1}. When and where will they meet?