Question 3. 11. Read each statement below carefully and state with reasons and examples, if it is true or false; A particle in one-dimensional motion

(a) with zero speed at an instant may have non-zero acceleration at that instant.

(b) with, zero speed may have non-zero velocity.

(c) with constant speed must have zero acceleration,

(d) with positive value of acceleration must be speeding up.

Answer:

(a) True. Consider a ball thrown up. At the highest point, speed is zero but the acceleration is non-zero.

(b) False. If a particle has non-zero velocity, it must have speed.

(c) True. If the particle rebounds instantly with the same speed, it implies infinite acceleration which is physically impossible.

(d) False. True only when the chosen position direction is along the direction of motion.

Question 3. 12. A ball is dropped from a height of 90 m on a floor. At each collision with the floor, the ball loses one tenth of its speed. Plot the speed-time graph of its motion between t =0 to 12 s.

Answer:

$u = 0,\ a = 10\ \text{ms}^{-2},\ S = 90\ \text{m},\ t = ?,\ v = ?$

Using $v^2 - u^2 = 2as$, $v^2 - (0)^2 = 2 \times 10 \times 90$

$\Rightarrow \qquad v = 30\sqrt{2}\ \text{m/s}$

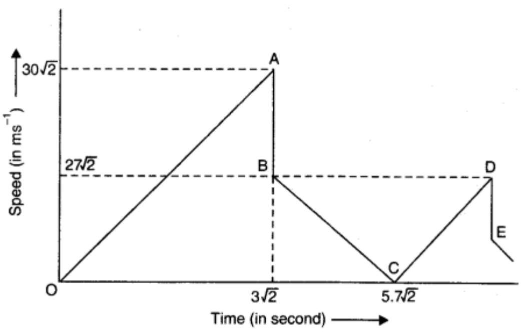
Again, using $\qquad S = ut + \frac{1}{2}at^2,\ 90 = 0 \times t + \frac{1}{2} \times 10t^2$

$\Rightarrow \qquad t = \sqrt{18}\ \text{s} = 3\sqrt{2}\ \text{s}$

Rebound velocity $= \frac{9}{10} \times 30\sqrt{2}\ \text{ms}^{-1} = \sqrt{2}\ \text{ms}^{-1}$

Time taken to reach highest point $= \frac{27\sqrt{2}}{10}\text{s} = 2.7\sqrt{2}\ \text{s}$

Total time $= (3\sqrt{2} + 2.7\sqrt{2})\ \text{s} = 5.7\sqrt{2}\ \text{s}$



OA represents the vertically downward motion after the ball has been dropped from a height of 90 m. The ball reaches the floor with a velocity of $30\sqrt{2}$ ms^{-1} after having been in motion for $3\sqrt{2}$ s. The vertical straight portion AB represents the loss of $\frac{1}{10}$ th of speed. BC represents the vertically upward motion after first rebound. The ball reaches? the highest point in $2.7\sqrt{2}$ s. The total time from the beginning is $3\sqrt{2} + 2.7\sqrt{2}$ *i.e.*, $5.7\sqrt{2}$ s. C represents the highest point reached after first rebound. CD represents the vertically downward motion. D represents the situation when the ball again reaches the floor. DE represents the loss of speed.

Question 3. 13. Explain clearly, with examples, the distinction between:

(a) Magnitude of displacement (sometimes called distance) over an interval of time, and the total length of path covered by a particle over the same interval;

(b) Magnitude of average velocity over an interval of time, and the average speed over the same interval. (Average speed of a particle over an interval of time is defined as the total path length divided by the time interval). Show in both (a) and (b) that the second quantity is either greater than or equal to the first. When is the equality sign true? [For simplicity, consider one dimensional motion only],

Answer:

(a) Suppose a particle goes from point A to B along a straight path and returns to A along the same path. The magnitude of the displacement of the particle is zero, because the particle has returned to its initial position. The total length of path covered by the particle is AB + BA = AB + AB = 2 AB. Thus, the second quantity is greater than the first,

(b) Suppose, in the above example, the particle takes time t to cover the whole journey. Then, the magnitude of the average velocity of the particle over time-interval t is = Magnitude of displacement /Time-interval =0/t =0

While the average speed of the particle over the same time-interval is = Total path length /Time-interval = 2AB /t

Again, the second quantity (average speed) is greater than the first (magnitude of average velocity).

Note: In both the above cases, the two quantities are equal if the particle moves from one point to another along a straight path in the same direction only.

Question 3.14. A man walks on a straight road from his home to a market 2.5 km away with a speed of 5 km h^{-1} .Finding the market closed, he instantly turns and walks back home with a speed of 7.5 km h^{-1} What is the (a) Magnitude of average velocity, and (b) Average speed of the man over the interval of time (i) 0 to 30 min. (ii) 0 to 50 min. (iii) 0 to 40 min? [Note: You will appreciate from this exercise why it is better to define average speed as total path length divided by time, and not as magnitude of average velocity. You would not like to tell the tired man on his return home that his average speed was zero!]

Answer:

Since $$v = \frac{S}{t} \Rightarrow t = \frac{S}{v}$$

Time taken by the man to reach market,

$$t = \frac{S}{v} = \frac{2.5}{5} = 0.5 \text{ h}$$

Time taken by the man to come back,

$$t_1 = \frac{S}{v_1} = \frac{2.5}{7.5} = 0.333 \text{ h}$$

(*i*) Average velocity (0 – 30 min) = $\frac{\Delta x}{\Delta t} = \frac{2.5}{0.5} = 5 \text{ kmh}^{-1}$

[$\because$ In 0.5 h, distance covered by man = 2.5 km]

(*ii*) Average velocity (0 – 50 min)

$$= \frac{(2.5+2.5)\text{ km}}{(0.5+0.333)\text{ h}} = \frac{5}{0.833}\text{ kmh}^{-1} = 8 \text{ kmh}^{-1}$$

(*iii*) Average velocity (0 – 4 min) = $\frac{\Delta x}{\Delta t} = \frac{\left(2.5 - \frac{2.5}{2}\right)\text{km}}{\frac{40}{60}h} = 1.875 \text{ kmh}^{-1}$

[$\because$ during 1st 30 min, distance covered = 2.5 km, in next 10 min, distance covered = $\frac{2.5}{2}$ km in return journey]

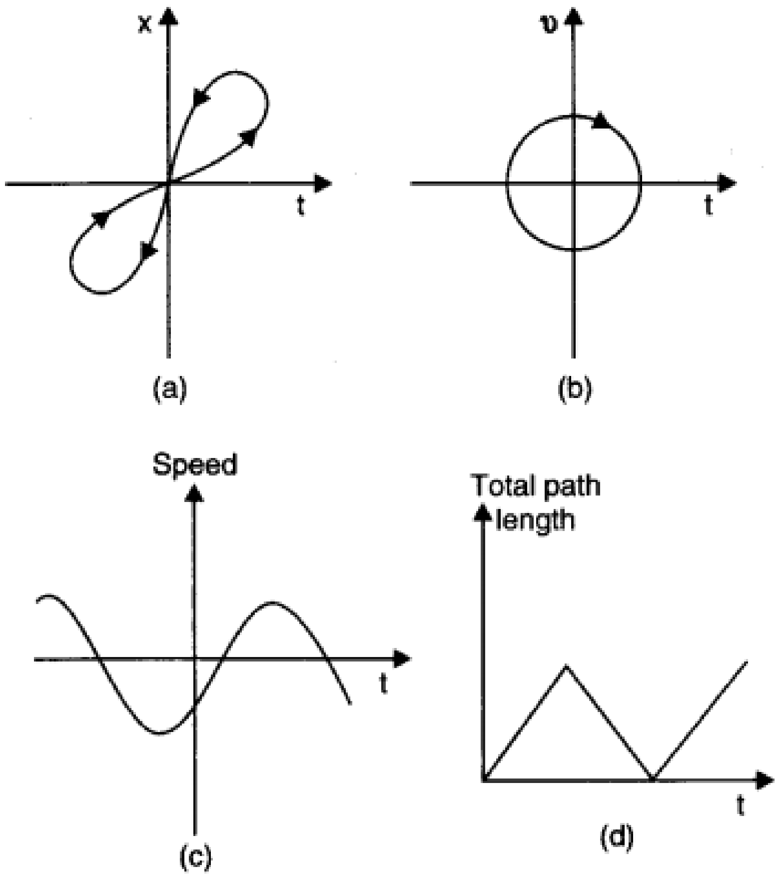
(*iv*) Average speed (0 – 40 min) = $\frac{\text{Total distance}}{\text{Total time}}$

$$= \frac{2.5 + \frac{2.5}{2}}{\frac{40}{60}} = 5.625 \text{ km h}^{-1}$$

Question 3. 15. In Exercises 3.13 and 3.14, we have carefully distinguished between average speed and magnitude of average

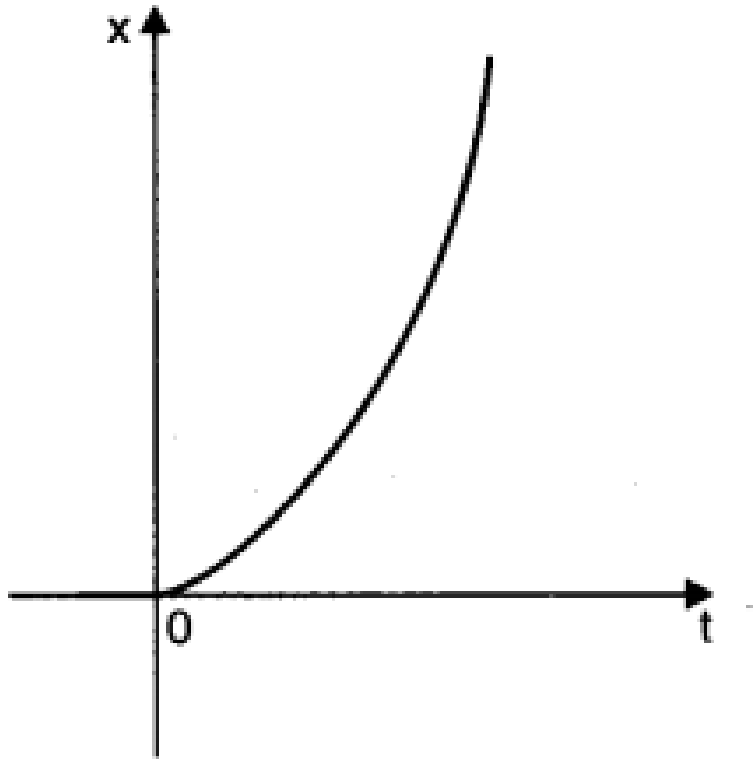
velocity. No such distinction is necessary when we consider instantaneous speed and magnitude of velocity. The instantaneous speed is always equal to the magnitude of instantaneous velocity. Why?
Answer: Instantaneous velocity is the velocity of a particle at a particular instant of time. In this case of small interval of time, the magnitude of the displacement is effectively equal to the distance travelled by the particle in the same interval of time. Therefore, there is no distinction between instantaneous velocity and speed.

Question 3. 16. Look at the graphs (a) to (d) Fig. carefully and state, with reasons, which of these cannot possibly represent one-dimensional motion of a particle.



Answer: None of the four graph represent a possible one-dimensional motion. In graphs (a) and (b) motions are definitely two dimensional.
Graph (a) represents two positions at the same time which is not possible.
In graph (b) opposite motion is visible at the same time.
The graph (c) is not correct since it shows that the particle has negative speed at a certain instant. Speed is always positive.
In graph (d) path length is shown as increasing as well as decreasing. Path length never decreases.

Question 3. 17. Figure shows the x-t plot of one-dimensional motion of a particle.
Is it correct to say from the graph that the particle moves in a straight line for t < 0 and on a parabolic path for t > 0? If not, suggest a suitable physical context for this graph.



Answer: It is not correct to say that the particle moves in a straight line for t < 0 (i.e., -ve) and on a parabolic path for t > 0 (i.e., + ve) because the x-t graph can not show the path of the particle.
For the graph, a suitable physical context can be the particle thrown from the top of a tower at the instant t =0.

Question 3. 18. A police van moving on a highway with a speed of 30 km h^{-1} fires a bullet at a thief s car speeding away in the same direction with a speed of 192 km h^{-1} . If the muzzle speed of the bullet is 150 ms^{-1} , with what speed does the bullet hit the thief s car? (Note: Obtain that speed which is relevant for damaging the thief s car).
Answer:

$$\text{Speed of police van} = v_p = 30 \text{ kmh}^{-1} = 30 \times \frac{1000}{3600} \text{ ms}^{-1} = \frac{25}{3} \text{ ms}^{-1}$$

$$\text{Speed of thief's car} = v_t = 192 \text{ km h}^{-1}$$

$$= 192 \times \frac{5}{18} \text{ms}^{-1} = \frac{160}{3} \text{ ms}^{-1}$$

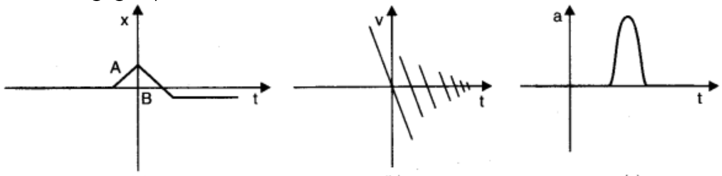
$$\text{Speed of bullet, } v_b = \text{Speed of police van + speed with which bullet is actually fired}$$

$$\therefore \quad v_b = \left(\frac{25}{3} + 150\right) \text{ms}^{-1} = \frac{475}{3} \text{ ms}^{-1}$$

Relative velocity of bullet w.r.t thief's car,

$$v_{bt} = v_b - v_t = \left(\frac{475}{3} - \frac{160}{3}\right) \text{ ms}^{-1} = 105 \text{ ms}^{-1}.$$

Question 3. 19. Suggest a suitable physical situation for each of the following graphs:

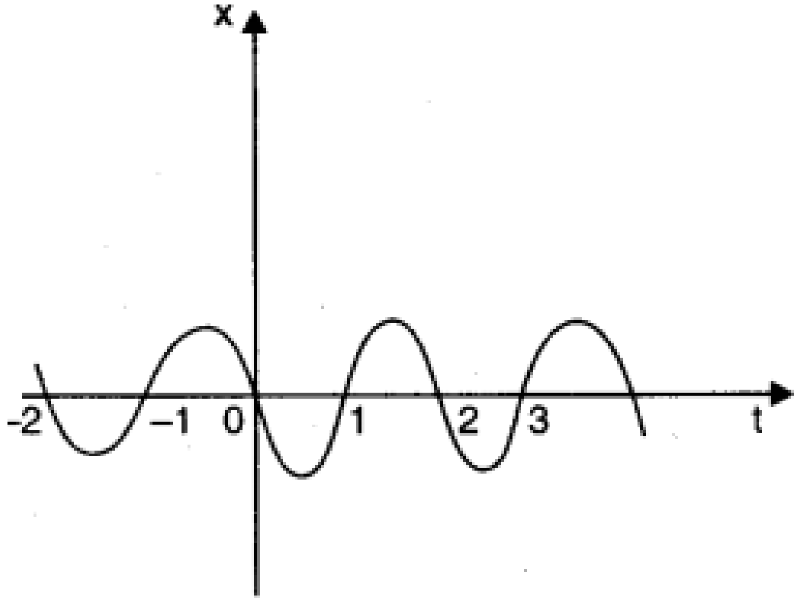


(a) (b) (c)

Answer:
(a) A ball at rest on a smooth floor is kicked. It rebounds from a wall with reduced speed and moves to the opposite wall which stops it.
(b) The graph shows that velocity changes again and again with the passage of time and every time losing some speed. Therefore, it may represent a physical situation such as a ball falling freely (after thrown up), on striking the ground rebounds with reduced

speed after each hit against the ground.
(c) A uniformly moving cricket ball turned back by hitting it with a bat for a very short time-interval.

Question 3. 20. Figure gives the x-t plot of a particle executing one¬dimensional simple harmonic motion. (You will learn about this motion in more detail in Chapter 14). Give the signs of position, velocity and acceleration variables of the particle at t = 0.3 s, 1.2 s, -1.2 s.
Answer: In x-t graph of Fig. showing simple harmonic motion of a particle, the signs of position, velocity and acceleration are as given below.



In S.H.M., acceleration, a - x or a = - kx.
(i) At t = 0.3 s, x < 0 i.e., x is in -ve direction. Moreover, as x is becoming more negative with time, it shows that v is also - ve (i.e., v < 0). However, a = -kx will be +ve (a > 0).
(ii) At t = 1.2 s, x > 0, v > 0 and a < 0.
(iii) At t = -1.2 s, x < 0, but here on increasing the time t, value of x becomes less negative.
It means that v is +ve (i.e., v > 0). Again a = - kx will be positive (i.e., a > 0).

*********** END **********