NCERT solutions for class 11 physics Chapter 3 Motion in a Straight Line

Q 3.1 (a) In which of the following examples of motion, can the body be considered approximately a point object:

a railway carriage moving without jerks between two stations.

Answer:

Since the length of railway carriage is quite small as compared to the distance between two stations it could be considered as a point object.

Q 3.1 (b) In which of the following examples of motion, can the body be considered approximately a point object:

a monkey sitting on top of a man cycling smoothly on a circular track.

Answer:

The monkey can be considered a point object as its size is quite small as compared to the circumference of the circular track.

Q 3.1 (c) In which of the following examples of motion, can the body be considered approximately a point object :

a spinning cricket ball that turns sharply on hitting the ground.

Answer:

The ball cannot be considered as a point object because the distance covered around the instant when it hits the ground is comparable to its size.

Q 3.1 (d) In which of the following examples of motion, can the body be considered approximately a point object :

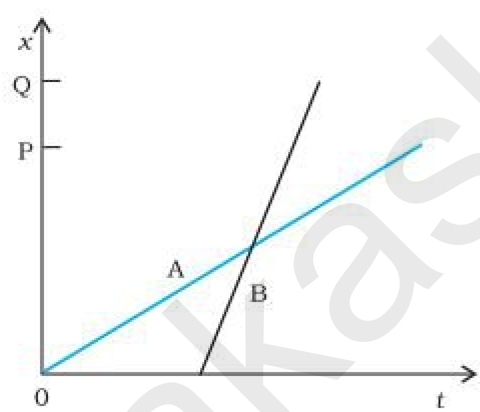
a tumbling beaker that has slipped off the edge of a table

Answer:

Since the size of the beaker is comparable to the distance it travels after slipping off the edge of the table it can not be considered to be a point object.

Q 3.2 (a) The position-time (x-t) graphs for two children A and B returning from their school O to their homes P and Q respectively are shown in figure. Choose the correct entries in the brackets below

(a) (A/B) lives closer to the school than (B/A)

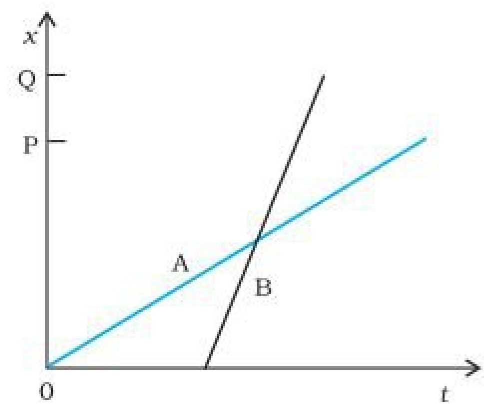


Answer:

It is clear from the graph that A Lives closer to the school than B.

Q 3.2 (b) The position-time (x-t) graphs for two children A and B returning from their school O to their homes P and Q respectively are shown in figure. Choose the correct entries in the brackets below

(b) (A/B) starts from the school earlier than (B/A)

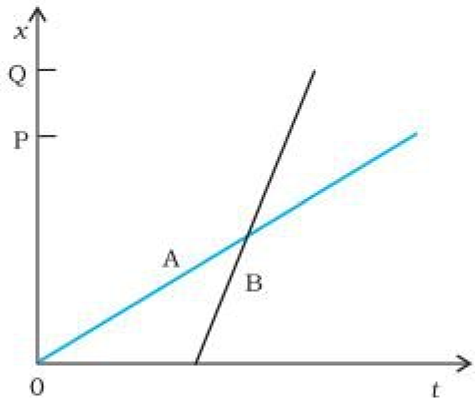


Answer:

From the graph, we can see that the position of A starts changing at time t=0 whereas in case of B starts changing at some finite time and therefore A starts from the school earlier than B.

Q 3.2 (c) The position-time (x-t) graphs for two children A and B returning from their school O to their homes P and Q respectively are shown in figure. Choose the correct entries in the brackets below

(c) (A/B) walks faster than (B/A)

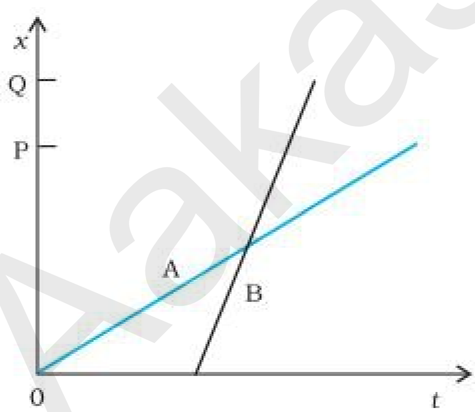


Answer:

The velocity of a particle is equal to the slope of its position-time (x-t) graph. Since the graph of B is steeper B walks faster than A

Q 3..2 (d) The position-time (x-t) graphs for two children A and B returning from their school O to their homes P and Q respectively are shown in Figure. Choose the correct entries in the brackets below ;

(d) A and B reach home at the (same/different) time

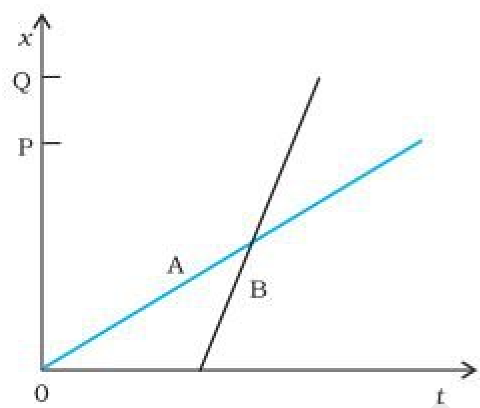


Answer:

The time(x-coordinate) is different for both A and B when their position(y-coordinate) is equal to that of their home. Therefore A and B reach home at a different time.

Q 3.2 (e) T he position-time (x-t) graphs for two children A and B returning from their school O to their homes P and Q respectively are shown in Figure. Choose the correct entries in the brackets below

(e) (A/B) overtakes (B/A) on the road (once/twice)



Answer:

B starts after A at a higher speed and B overtakes A on the road once.

Q 3.3 A woman starts from her home at 9.00 am, walks with a speed of 5 km h^{-1} on a straight road up to her office 2.5 km away, stays at the office up to 5.00 pm, and returns home by an auto with a speed of 25 km h^{-1} . Choose suitable scales and plot the x-t graph of her motion.

Answer:

Distance between the office and the home = 2.5 Km

the speed of the women=5 Kmh^{-1}

time taken by the women to reach the office is

$$\frac{2.5}{5} = 0.5h = 30min$$

at 9:30 am the women is at the office till 5 pm

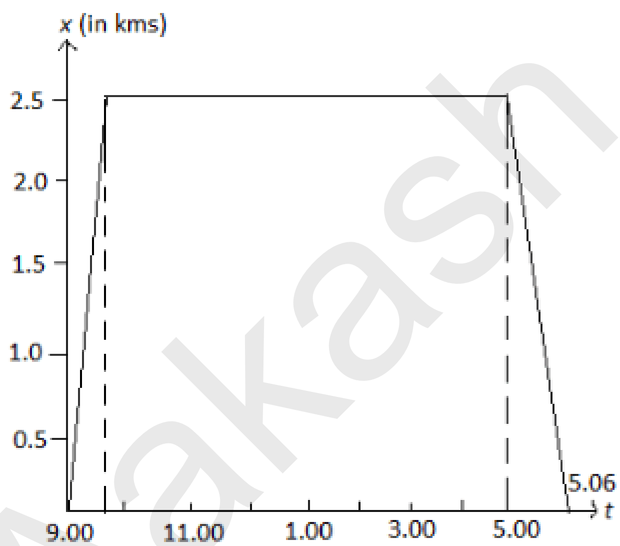
The speed of auto = 25 Kmh $^{-1}$

The time taken by the women to reach back to home is

$$\frac{2.5}{25} = 0.1h = 6min$$

at 5:06 pm women reach home.

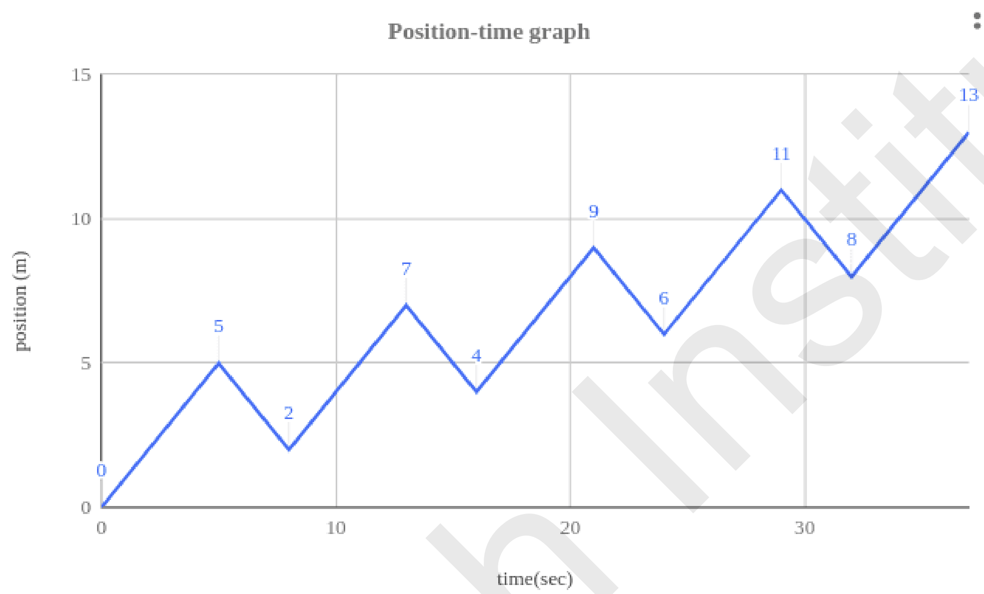
The position-time graph will be



Q 3.4 A drunkard walking in a narrow lane takes 5 steps forward and 3 steps backward, followed again by 5 steps forward and 3 steps backward, and so on. Each step is 1 m long and requires 1 s. Plot the x-t graph of his motion. Determine graphically and otherwise how long the drunkard takes to fall in a pit 13 m away from the start.

Answer:

time	0	5	8	13	16	21	24	29	32	37
distance covered	0	5	2	7	4	9	6	11	8	13



at time t= 37 dec the man falls in a pit at 13 meters from the start

Q 3.5 A jet airplane travelling at the speed of 500 km h^{-1} ejects its products of combustion at the speed of 1500 km h^{-1} relative to the jet plane. What is the speed of the latter with respect to an observer on the ground?

Answer:

$V_{airplane}$ =500 km h^{-1}

$V_{prod/airplane}$ =-1500 km h^{-1} (the negative sign signifies the Velocity of the plane and the velocity of the ejected combustion products relative to the plane are in opposite directions)

$V_{prod/airplane} = V_{prod} - V_{airplane}$

$V_{prod} = V_{prod/airplane} + V_{airplane}$

$V_{prod} = -1500+500 = -1000$ km h $^{-1}$

The speed of the ejected combustion products with respect to an observer on the ground is 1000 km h $^{-1}$

Q 3.6 A car moving along a straight highway with speed of 126 km h $^{-1}$ is brought to a stop within a distance of 200 m. What is the retardation of the car (assumed uniform), and how long does it take for the car to stop ?

Answer:

Initial velocity(u)=126 km h $^{-1}$ =35 m s $^{-1}$

Final velocity(v)=0

Distance travelled before coming to rest(s)=200m

Using the third equation of motion

$$v^2 - u^2 = 2as$$
$$a = \frac{v^2 - u^2}{2s}$$
$$a = \frac{-35^2}{200}$$
$$a = -3.0625\ m\ s^{-2}$$

Using the first equation of motion

$$v = u + at$$
$$t = \frac{v-u}{a}$$
$$t = \frac{0-35}{-3.0625}$$
$$t = 11.428\ s$$

The retardation of the car is 3.0625 m s^{-2} and it takes 11.428 seconds for the car to stop.

Q 3.7 Two trains A and B of length 400 m each are moving on two parallel tracks with a uniform speed of 72 km h^{-1} in the same direction, with A ahead of B. The driver of B decides to overtake A and accelerates by 1 m s^{-2} . If after 50 s, the guard of B just brushes past the driver of A, what was the original distance between them?

Answer:

Since both the objects are in motion it will be easier for us to do this problem in the relative frame. We take the train A as an observer.

Let the distance between the guard of B and driver of A be s.

Since both the trains are travelling with the same velocity initially, the relative initial velocity of B with respect to A(u) is 0.

Since A is not accelerating the relative acceleration would be the same as the acceleration wrt the ground frame, a= 1ms^{-2}

The time taken to cover s distance by B wrt A = 50 s

Using the second equation of motion

$$s = ut + \frac{1}{2}at^2$$
$$s = \frac{1}{2} \times 1 \times 50^2$$
$$s = 1250\ m$$

The distance between the guard of A and driver of B initially is 1250 meter

Q 3.8 On a two-lane road, car A is travelling with a speed of 36 km h^{-1} . Two cars B and C approach car A in opposite directions with a speed of 54 km h^{-1} each. At a certain instant, when the distance AB is equal to AC, both being 1 km, B decides to overtake A before C does. What minimum acceleration of car B is required to avoid an accident?

Answer:

Velocity of car A=36 km h^{-1} = 10 m s^{-1}

Velocity of car B and car C = 54 km h^{-1} = 15 m s^{-1}

A and B are travelling in the same direction.

A and C are travelling in opposite directions.

The velocity of A w.r.t C is V_{AC} = 25 m s^{-1}.

Time in which A would reach C is t

$$t=\frac{AC}{v_{AC}}$$
$$=\frac{1000}{25}$$
$$=40s$$

The velocity of B w.r.t A is V_{BA} = 5 m s^{-1}

Distance between A and B is s= 1000 m

Maximum time in which B has to overtake A=40s

The required acceleration can be therefore calculated using the second equation of motion

$$s = ut + \frac{1}{2}at^2$$
$$1000 = 5 \times 40 + \frac{1}{2} \times a \times 40^2$$
$$1000 - 200 = 800a$$
$$a = 1\ m\ s^{-2}$$

B has to have a minimum acceleration of 1 m s^{-2} to avoid an accident.

Q 3.9 Two towns A and B are connected by a regular bus service with a bus leaving in either direction every T minutes. A man cycling with a speed of 20 km h^{-1} in the direction A to B notices that a bus goes past him every 18 min in the direction of his motion, and every 6 min in the opposite direction. What is the period T of the bus service and with what speed (assumed constant) do the buses ply on the road?

Answer:

Let the velocity of the bus be V km h^{-1}

Let the period of the bus be T minutes.

The speed of the bus travelling in the same direction as the cyclist relative to the cyclist is = (V-20) km h^{-1}

The speed of the bus travelling in the opposite direction as the cyclist relative to the cyclist is = (V+20) km h^{-1}

The distance between two consecutive buses travelling in the same direction is s

$$s = \frac{VT}{60}\ km$$

This distance s is in turn equal to the distance between the cyclist and the next bus at an instant when one bus goes past him.

$$\frac{VT}{60} = \frac{(V-20)\times 18}{60} \quad (i)$$

$$\frac{VT}{60} = \frac{(V+20)\times 6}{60} \quad (ii)$$

Solving the above equations (i) and (ii) we get V=40 km h^{-1} and T=9 min

The buses travel at a speed 40 km h^{-1} and the period of the bus service is 9 minutes.

Q 3.10 (a) A player throws a ball upwards with an initial speed of 29.4 ms^{-1} .

(a) What is the direction of acceleration during the upward motion of the ball?

Answer:

The acceleration of the ball will always be in the downward direction irrespective of its position and direction of motion since the gravitational force always acts in the downward direction.

Q 3.10 (b) A player throws a ball upwards with an initial speed of 29.4 ms^{-1} .

(b) What are the velocity and acceleration of the ball at the highest point of its motion?

Answer:

The velocity is 0 m s^{-1} and acceleration is 9.8 m s^{-2} in the downward direction at the highest point of the motion of the ball.

Q 3.10 (c) A player throws a ball upwards with an initial speed of 29.4 ms^{-1} .

(c) Choose the x = 0 m and t = 0 s to be the location and time of the ball at its highest point, vertically downward direction to be the positive direction of x-axis, and give the signs of position, velocity and acceleration of the ball during its upward, and downward motion.

Answer:

The sign of velocity is positive during the motion in downwards direction and negative during motion in upwards direction. The signs of position and acceleration are positive during motion in both directions.

Q 3.10 (d) A player throws a ball upwards with an initial speed of 29.4 ms^{-1}.

(d) To what height does the ball rise and after how long does the ball return to the player's hands? (Take g = 9.8 $m\ s^{-2}$ and neglect air resistance).

Answer:

Consider the motion from the instant the ball starts travelling in the upwards direction to the instant it reaches the highest point. Let the upwards direction be positive.

At the highest point, its velocity v is 0 $m\ s^{-1}$.

Initially the velocity u is 29.4 $m\ s^{-1}$.

Acceleration is -g = -9.8 $m\ s^{-2}$

Using the third equation of motion we have

$$v^2 - u^2 = 2as$$
$$s = \frac{v^2 - u^2}{2a}$$
$$s = \frac{0^2 - 29.4^2}{2 \times (-9.8)}$$
$$s = 44.1\ m$$

Consider the motion from the instant the ball starts travelling in the upwards direction to the instant it reaches back to the player's hand.

The displacement during this period is s = 0 m.

Initial velocity is u=29.4 m s^{-1}

Acceleration is a=-g=-9.8 m s^{-2}

Using the second equation of motion we have

$$
\begin{aligned}
&s = ut + \frac{1}{2}at^2 \\
&0 = 29.t - 4.9t^2 \\
&t = 0\ s \\
&or \\
&t = 6\ s
\end{aligned}
$$

The ball, therefore, reaches back to the player's hand in 6 seconds.

Note: The second solution of the above quadratic equation, t = 0 signifies that at the instant the ball starts travelling its displacement is 0 m.

Q 3.11 (a) Read each statement below carefully and state with reasons and examples, if it is true or false ;

(a) A particle in one-dimensional motion with zero speed at an instant may have non-zero acceleration at that instant

Answer:

True since non zero velocity is not at all a necessary condition for non zero acceleration. A ball thrown upwards at its highest point in motion has zero velocity but non zero acceleration due to gravity.

Q 3.11 (b) Read each statement below carefully and state with reasons and examples, if it is true or false ;

(b) A particle in one-dimensional motion with zero speed may have non-zero velocity

Answer:

False as speed is the magnitude of velocity, therefore, a non zero velocity would imply a non zero speed.

Q 3.11 (c) Read each statement below carefully and state with reasons and examples, if it is true or false;

(c) A particle in one-dimensional motion with constant speed must have zero acceleration

Answer:

True. A particle moving in a straight line with constant speed will have constant velocity since its direction of motion is constant and as acceleration is defined as the rate of change of velocity its acceleration will be zero.

Q 3.11 (d) Read each statement below carefully and state with reasons and examples, if it is true or false;

(d) A particle in one-dimensional motion with positive value of acceleration must be speeding up

Answer:

False. The answer to this question depends on the choice of a positive direction. If a ball is thrown upwards and the downwards direction is chosen to be positive then its acceleration will be positive but its speed will still be decreasing.

Q 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:

At time t = 0 velocity is 0

Initial velocity , u = 0

Acceleration = 10 ms $^{-2}$

Height, s = 90 m

$$s = ut + \frac{1}{2}at^2$$
$$90 = 0 \times t + \frac{1}{2} \times 10t^2$$
$$t = 3\sqrt{2}s$$
$$t = 4.242s$$

$$v = u + at$$
$$v = 10 \times 3\sqrt{2}$$
$$v = 30\sqrt{2}ms^{-1}$$

The above is the speed with which the ball will collide with the ground. After colliding the upwards velocity becomes

$$u = 30\sqrt{2} \times \frac{9}{10}$$
$$u = 27\sqrt{2}ms^{-1}$$

Acceleration a = -10ms $^{-2}$

While the ball will again reach the ground its velocity would have the same magnitude $v = -27\sqrt{2}ms^{-1}$

Let the time between the successive collisions be t

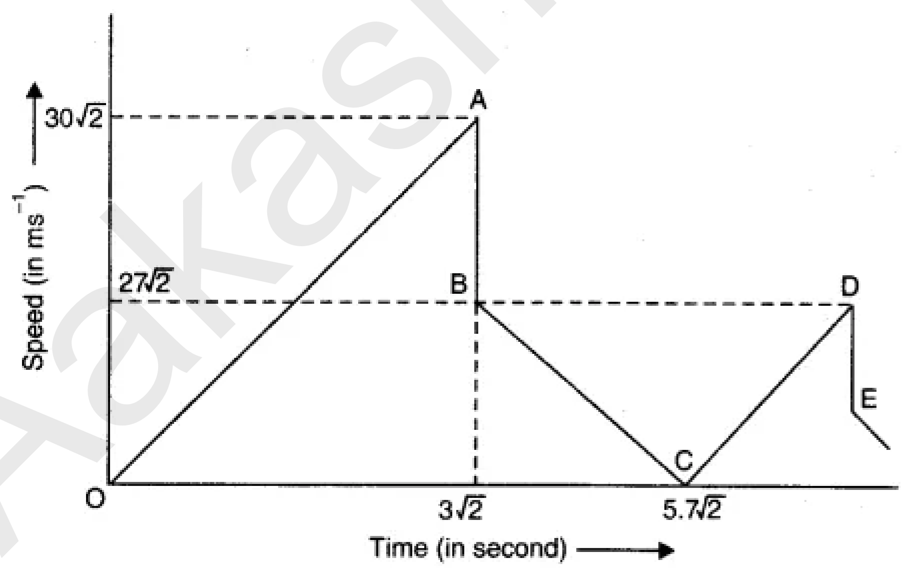
$$v = u + at$$
$$t = \frac{v - u}{a}$$
$$t = \frac{-27\sqrt{2} - 27\sqrt{2}}{-10}$$
$$t = 5.4\sqrt{2}s$$
$$t = 7.635$$

After the first collision, its speed will become 0 in time $2.7\sqrt{2}s$

Total time = 4.242 + 7.635 = 11.87s

After this much time, it will again bounce back with a velocity v given by

$$v = 27\sqrt{2} \times \frac{9}{10}$$
$$v = 24.3\sqrt{2}ms^{-1}$$



$$v_E = 24.3\sqrt{2}ms^{-1}$$

Q 3.13 (a) Explain clearly, with examples, the distinction between :

(a) the 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

Answer:

The magnitude of displacement is defined as the shortest distance between the initial and final position of a particle whereas the total length of path covered by a particle is the actual distance it has travelled. e.g a ball thrown upwards which goes to a height h and comes down to its starting position has its magnitude of displacement to be zero but the total length of the path covered by the ball is 2h. In the case of 1-D motion, the two will be equal if the particle moves only in one direction.

Q 3.13 (b) Explain clearly, with examples, the distinction between :

(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:

The magnitude of average velocity over an interval of time is defined as total displacement upon the time taken whereas the average speed over the same interval is defined as the actual distance travelled by the particle divided by the total time taken. e.g a ball thrown upwards which goes to a height h in time t and comes down to its starting position in the same time has the magnitude of average velocity zero whereas the average speed of the ball is h/t. In the case of 1-D motion, the two will be equal if the particle moves only in one direction.

Q 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:

(a).(i) Time taken by the man to reach the market is t_1

$$t_1 = \frac{2.5}{5}$$
$$t_1 = 0.5\ h$$
$$t_1 = 30\ min$$

Displacement in 30 minutes is d_1 =2.5 km

Magnitude of average velocity=d_1/t_1 = 5 km h^{-1}

(b).(i) Distance travelled in 30 minutes is s_1 =2.5 km

Average speed=s_1/t_1 = 5 km h^{-1}

The first 30 minutes the man travels from his home to the market.

During the next 10 minutes, he travels with a speed of 7.5 km h^{-1} towards his home covering a distance s_3

$$s_3 = 7.5 \times \frac{10}{60}$$
$$= 1.25\ km$$

t_3 =40 min

Magnitude of average velocity =(2.5-1.25)/t_3 =1.875 km h^{-1}

Average speed=(2.5+1.25)/t_3 =5.625 km h^{-1}

Q 3.15 The instantaneous speed is always equal to the magnitude of instantaneous velocity. Why?

Answer:

Instantaneous speed is defined as the first derivative of distance travelled with respect to time and magnitude of instantaneous velocity is the first derivative of the magnitude of displacement with respect to time. The time interval considered is so small that it is safe to assume that the particle won't change its direction of motion during it and therefore the magnitude of displacement during this interval will be the same as the distance travelled and therefore instantaneous speed is always equal to the magnitude of instantaneous velocity.

Q 3.16 Look at the graphs (a) to (d) carefully and state, with reasons, which of these cannot possibly represent one-dimensional motion of a particle.

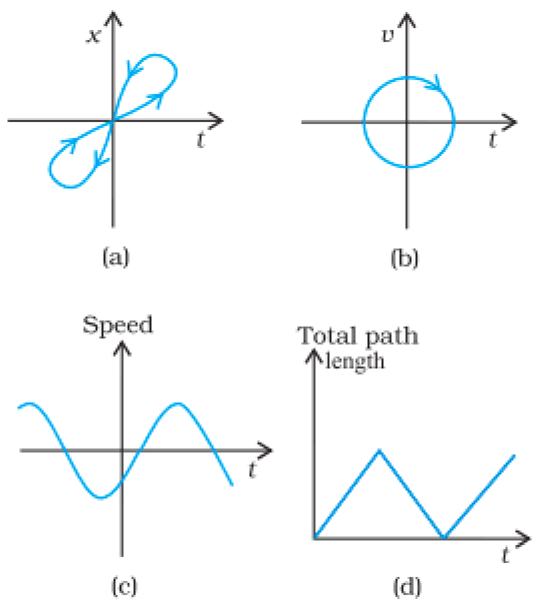


Fig. 3.20

Answer:

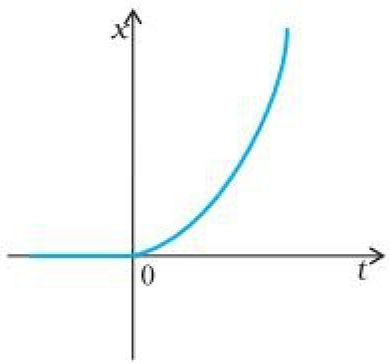
(a) The given x-t graph cannot represent the one-dimensional motion of a particle as the particle cannot be at two positions at the same instant.

(b) The given v-t graph cannot represent the one-dimensional motion of a particle as the particle cannot be travelling at two velocities at the same instant.

(c) The given speed-time graph cannot represent the one-dimensional motion of a particle as the particle cannot have negative speed.

(d) The given path length-time graph cannot represent the one-dimensional motion of a particle as the total path length cannot decrease.

Q 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 cannot be said from the above-given graph whether the particle is moving along a straight line or along a parabolic path as the x-t graph does not tell us about the trajectory taken by the particle. From the given graph we can only say that the position of the particle along the x-axis does not change till time t=0 and after that it starts increasing in non-linear manner.

Q 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 m s^{-1}, with what speed does the bullet hit the thief's car?

Answer:

Muzzle speed of the bullet is V_B=150 m s^{-1} =540 km h^{-1}

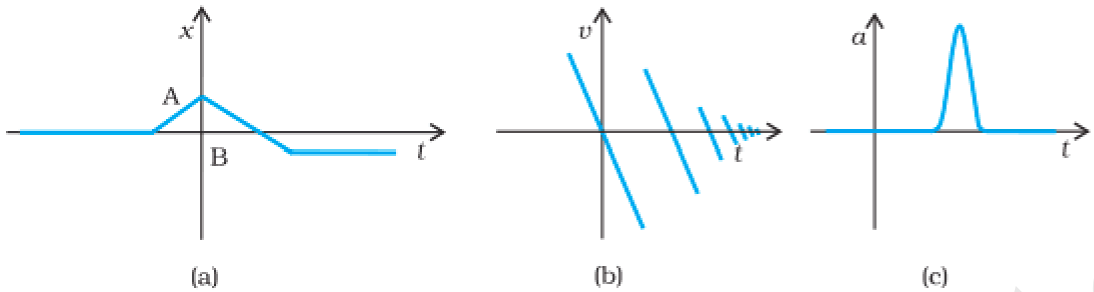
Speed of the Police van is V_V=30 km h^{-1}

Resultant Speed of the bullet is V=540+30=570 km h^{-1}

Speed of the thief's car= V_T=192 km h^{-1}

The speed with which the bullet hits the thief's car=V-V_T=570-192=378 km h^{-1} =105 m s^{-1}

Q 3.19 Suggest a suitable physical situation for each of the following graphs.



Answer:

(a)The particle is initially at rest. Then it starts moving with a constant velocity for some time and then its velocity changes instantaneously and it starts moving in the opposite direction, crosses the point where it was at rest initially and then comes to a halt.

A similar physical situation arises when a bowler throws a ball towards the batsman, the ball travels towards the batsman with some constant speed and after the batsman hits it the ball goes past the bowler and gets caught by a fielder and its velocity comes down to zero within an instant.

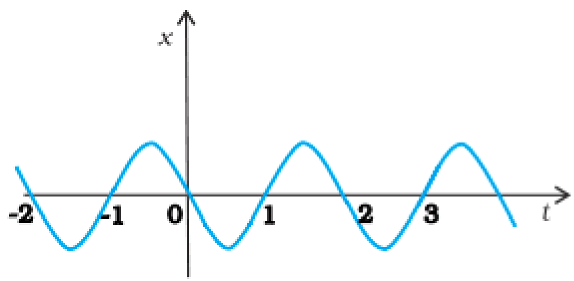
(b)The velocity of a particle starts coming down to zero from some velocity with some constant acceleration, goes to zero and changes its direction. Then suddenly the direction of velocity changes and magnitude decreases.

This is the case when a ball is thrown in the air. It starts moving with some velocity and gets retarded by g, its velocity becomes zero at the highest point and its velocity then changes direction and as it hits the ground it loses some of its speed and gets rebound and this keeps on happening till it comes to rest.

(c) The acceleration of a body is zero. It increases to some value for a very small period of time and again comes to zero.

This is the case when a football travelling horizontally hits a wall or gets kicked by a player.

Q 3.20 Figure gives the x-t plot of a particle executing one-dimensional simple harmonic motion. Give the signs of position, velocity and acceleration variables of the particle at t = 0.3 s, 1.2 s, – 1.2 s.



Answer:

At t=0.3 s signs of position, velocity and acceleration are negative, negative and positive.

At t=1.2 s signs of position, velocity and acceleration are positive, positive and negative.

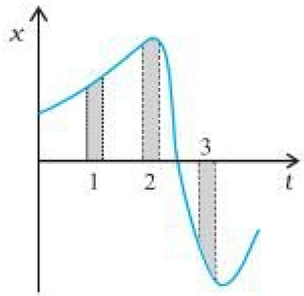
At t=-1.2 s signs of position, velocity and acceleration are negative, positive and positive.

Note: The displacement of the particle as a function of time can be thought of as

$$x = f(t) = -Asin\pi t$$

where A is some positive real number equal to the amplitude of oscillation.

Q 3.21 Figure gives the x-t plot of a particle in one-dimensional motion. Three different equal intervals of time are shown. In which interval is the average speed greatest, and in which is it the least? Give the sign of average velocity for each interval.

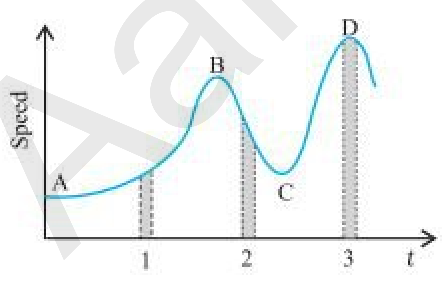


Answer:

The average speed is greatest in interval 3 and least in interval 2 as the average of the magnitude of the slope is maximum in 3 and minimum in 2.

Average velocity is positive in interval 1 and interval 2 as the slope is positive over these intervals and average velocity is negative in interval 3 as the slope is negative over this interval.

Q 3.22 Figure gives a speed-time graph of a particle in motion along a constant direction. Three equal intervals of time are shown. In which interval is the average acceleration greatest in magnitude? In which interval is the average speed greatest ? Choosing the positive direction as the constant direction of motion, give the signs of v and a in the three intervals. What are the accelerations at the points A, B, C and D?



Answer:

The average acceleration greatest in magnitude in interval 2 as in this interval the magnitude of change in speed is the greatest.

The average speed is greatest in interval 3.

	v	a
Interval 1	Positive	Positive
Interval 2	Positive	Negative
Interval 3	Positive	Zero

In interval 1 speed increases, in interval 2 it decreases and in interval 3 it remains constant.

At points, A, B, C and D acceleration is zero as at these points the curve is parallel to the time axis .

NCERT solutions for class 11 physics chapter 3 motion in a straight line additional exercises

Q 3.23 A three-wheeler starts from rest, accelerates uniformly with 1 m s^{-2} on a straight road for 10 s, and then moves with uniform velocity. Plot the distance covered by the vehicle during the nth second (n = 1,2,3….) versus n. What do you expect this plot to be during accelerated motion: a straight line or a parabola?

Answer:

Initial velocity u = 0

Acceleration, a = 1 ms $^{-2}$

t = n seconds

Let the total distance travelled in n seconds be S_n

$$S_n = ut + \frac{1}{2}at^2$$
$$S_n = 0 \times n + \frac{1}{2} \times 1 \times n^2$$
$$S_n = \frac{n^2}{2}$$

Similarly, total distance travelled in n - 1 second would be S_{n-1}

$$S_{n-1} = \frac{(n-1)^2}{2}$$

Distance travelled in n th second would be given as

$x_n = S_n - S_{n-1}$

$$x_n = \frac{n^2}{2} - \frac{(n-1)^2}{2}$$
$$x_n = n - \frac{1}{2}$$

As we can see the dependency of x_n on n is linear we conclude the plot of the distance covered by the vehicle during the nth second versus n would be a straight line.

Q 3.24 A boy standing on a stationary lift (open from above) throws a ball upwards with the maximum initial speed he can, equal to 49 m s $^{-1}$. How much time does the ball take to return to his hands? If the lift starts moving up with a uniform speed of 5 m s $^{-1}$ and the boy again throws the ball up with the maximum speed he can, how long does the ball take to return to his hands?

Answer:

Let us consider the upward direction to be positive

Initial velocity of the ball (u) = 49 m s^{-1}

The speed of the ball will be the same when it reaches the boy's hand's but will be moving in a downward direction. Therefore final velocity (v) = -49 m s^{-1}

Acceleration (a) = -9.8 m s^{-2}

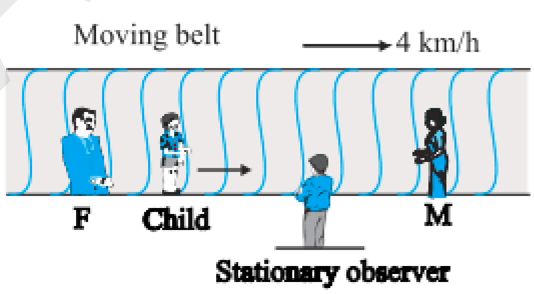
Using the first equation of motion we have

$$v = u + at$$
$$t = \frac{v-u}{a}$$
$$t = \frac{-49-49}{-9.8}$$
$$t = 10\ s$$

In the second case, as the ball has been thrown after the lift has started moving upwards with a constant velocity, the relative velocity of the ball with respect to the boy remains the same and therefore the ball will again take 10 seconds to reach the boy's hands.

Q 3.25 (a) On a long horizontally moving belt (Fig.), a child runs to and fro with a speed 9 km h^{-1} (with respect to the belt) between his father and mother located 50 m apart on the moving belt. The belt moves with a speed of 4 km h^{-1}. For an observer on a stationary platform outside, what is the

(a) speed of the child running in the direction of motion of the belt?

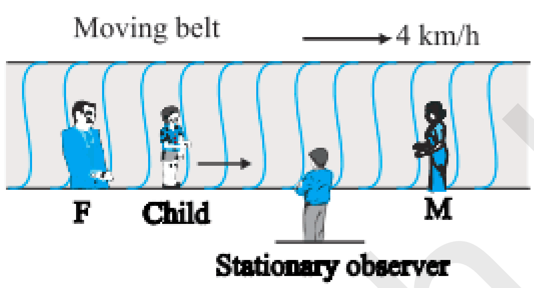


Answer:

(a) Speed of the child when the boy is running in the direction of the motion of the belt = 9 + 4 = 13 km h^{-1}

Q 3.25 (b) On a long horizontally moving belt (Fig.), a child runs to and fro with a speed 9 km h^{-1} (with respect to the belt) between his father and mother located 50 m apart on the moving belt. The belt moves with a speed of 4 km h^{-1}. For an observer on a stationary platform outside, what is the

(b) speed of the child running opposite to the direction of motion of the belt?



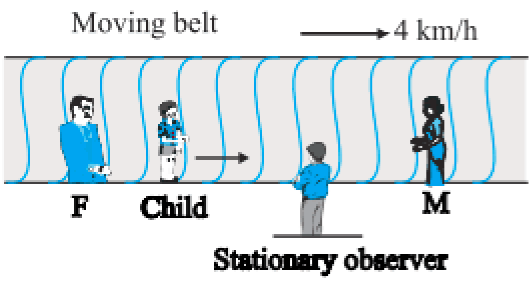
Answer:

(b) Speed of the child with respect to the stationary observer when the boy is running in the direction opposite to the motion of the belt = 9 - 4 = 5 km h^{-1}

Q 3.25 (c) On a long horizontally moving belt (Fig.), a child runs to and fro with a speed 9 km h^{-1}(with respect to the belt) between his father and mother located 50 m apart on the moving belt. The belt moves with a speed of 4 km h^{-1}. For an observer on a stationary platform outside, what is the

(c) time taken by the child in (a) and (b)?

Which of the answers alter if motion is viewed by one of the parents?



Answer:

The distance between the parents is s = 50 m

The relative velocity of the child with respect to both his parents remains the same as the parents are also standing on the moving belt.

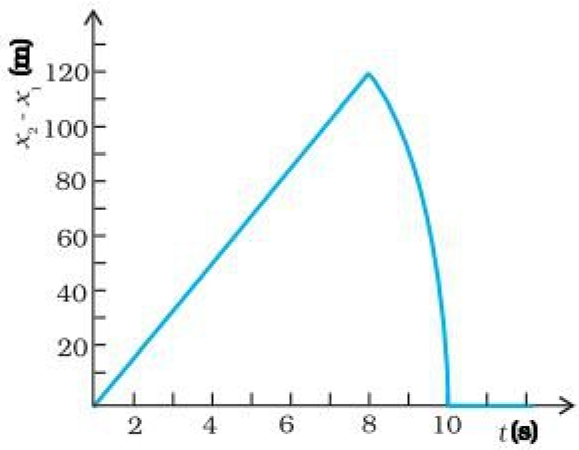
$v = 9\ km\ h^{-1} = 2.5\ m\ s^{-1}$

Time taken by the child in (a) and (b) is t = s/v = 20 s.

As both, the parents are also standing on the belt as well the speed of the child would appear to be 9 km h^{-1} to both the parents irrespective of the direction in which the child is moving. Therefore answer (a) and (b) would change.

The time taken by an object to travel from one point to another is independent of the observer and therefore answer to question (c) would not change.

Q 3.26 Two stones are thrown up simultaneously from the edge of a cliff 200 m high with initial speeds of 15 m s^{-1} and 30 m s^{-1}. Verify that the graph shown in Figure correctly represents the time variation of the relative position of the second stone with respect to the first. Neglect air resistance and assume that the stones do not rebound after hitting the ground. Take g = 10 m s^{-2}. Give the equations for the linear and curved parts of the plot.



Answer:

As both the stones are being accelerated due to gravity its effect will come on the relative motion only when one of them reaches the ground. Till that point of time, the relative velocity of the second stone would remain the same with respect to the first stone.

Let us consider the upward direction to be positive.

$v_1 = 15 \text{ m s}^{-1}$

$V_2 = 30 \text{ m s}^{-1}$

$V_{rel} = V_2 - V_1 = 30 - 15 = 15 \text{ m s}^{-1}$

Initial velocity of the first stone(u) = 15 m s^{-1}

Displacement from the point it has been thrown to the final point in its motion(s) = 200 m

Acceleration(a) = $-g = -10 \text{ m s}^{-2}$

Using the second equation of motion we have

As time cannot be negative the correct value of t is 8 seconds

For this much time the relative distance changes with the relative velocity.

Maximum relative distance is

$$d = V_{rel} \times t$$
$$d = 15 \times 8$$
$$d = 120\ m$$

The graph is, therefore, correct till 8 seconds.

After that, the second stone will be moving towards the first stone with acceleration g towards it and their relative distance will keep on decreasing from 120 m till it becomes zero.

The velocity of the second stone 8 seconds after it has been thrown can be calculated as follows using the first equation of motion

$$v = u + at$$
$$v = 30 - 8 \times 10$$
$$v = -50ms^{-1}$$

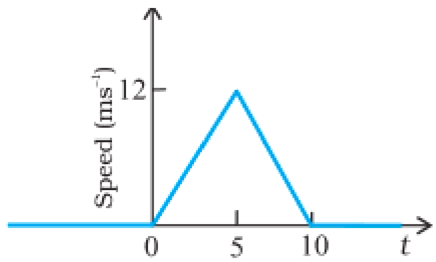
The time taken by it to travel 120 m in the downwards direction can be calculated as follows using the second equation of motion

as t has to be positive the correct answer is 2 seconds.

The relative distance will become zero after a total time of 10 seconds which is the case as shown in the graph and therefore the graph shown in Figure correctly represents the time variation of the relative position of the second stone with respect to the first.

Q 3.27 The speed-time graph of a particle moving along a fixed direction is shown in Figure. Obtain the distance traversed by the particle between

(a) t = 0 s to 10 s



What is the average speed of the particle over the intervals in (a) and (b)?

Answer:

The distance traversed by the particle equals the area under the speed time graph

The area under the curve is

$$A = \frac{1}{2} \times 10 \times 12$$
$$A = 60\ m$$

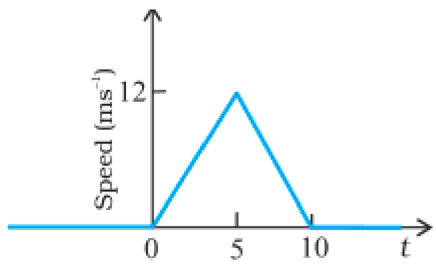
The particle has travelled a distance of 60 m from t=0 s to t=10 s.

The average speed over this interval is

$$v_{avg} = \frac{60}{10}$$
$$v_{avg} = 6\ ms^{-1}$$

Q 3.27 The speed-time graph of a particle moving along a fixed direction is shown in Figure. Obtain the distance traversed by the particle between

(b) t = 2 s to 6 s.



What is the average speed of the particle over the intervals in (a) and (b)?

Answer:

As the speed is increasing in the time interval t = 0 s to t = 5 s the acceleration is positive and can be given by

$$a_1 = \frac{12}{5}$$
$$a_1 = 2.4ms^{-2}$$

Speed at t = 2 s is

$$u_1 = 0 + 2.4 \times 2$$
$$u_1 = 4.8ms^{-1}$$

Speed at t = 5 s is $v_1 = 15$ m s^{-1}

$t_1 = 5 - 2 = 3$ s

Distance travelled in interval t = 2 s to t = 5 s is s_1

$$s_1 = u_1t_1 + \frac{1}{2}a_1t_1^2$$
$$s_1 = 4.8 \times 3 + 1.2 \times 3^2$$
$$s_1 = 25.2m$$

Acceleration is negative after t = 5 s but has the same magnitude

$a_2 = -2.4$ m s^{-2}

Speed at t = 5 s is $u_2 = 12\ m\ s^{-1}$

$t_2 = 6 - 5 = 1$ s

Distance travelled in this interval can be calculated as follows

$$s_2 = u_2 t_2 + \frac{1}{2} a_2 t_2^2$$
$$s_2 = 12 \times 1 - 1.2 \times 1^2$$
$$s_2 = 10.8m$$

Total distance travelled from t = 2 s to t = 6 s is $s = s_1 + s_2$

s=25.2+10.8

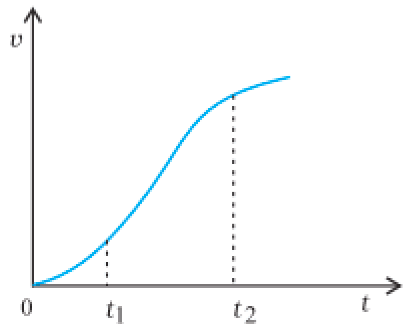
s=36 m

The average speed over this interval is

$$v_{avg} = \frac{s}{t_1 + t_2}$$
$$v_{avg} = \frac{36}{3+1}$$
$$v_{avg} = 9\ ms^{-1}$$

Q 3.28 The velocity-time graph of a particle in one-dimensional motion is shown in the figure:

Which of the following formulae are correct for describing the motion of the particle over the time-interval t_1 to t_2 :



(a) $x(t_2) = x(t_1) + v(t_2)(t_2 - t_1) + \frac{1}{2}a(t_2 - t_1)^2$

(b) $v(t_2) = v(t_1) + a(t_2 - t_1)$

(c) $v_{average} = \frac{[x(t_2) - v(t_2)]}{(t_2 - t_1)}$

(d) $a_{average} = \frac{[v(t_2) - v(t_2)]}{(t_2 - t_1)}$

(e) $x(t_2) = x(t_1) + v_{average}(t_2 - t_1) + \left(\frac{1}{2}\right) a_{average}(t_2 - t_1)^2$

(f) $x(t_2) - x(t_1)$ =area under the v-t curve bounded by the time axis and the dotted line shown.

Answer:

Only the formulae given in (c), (d) and (f) are correct for describing the motion of the particle over the time-interval t_1 to t_2.

The formulae given in (a), (b) and (e) are incorrect as from the slope of the graph we can see that the particle is not moving with constant acceleration.