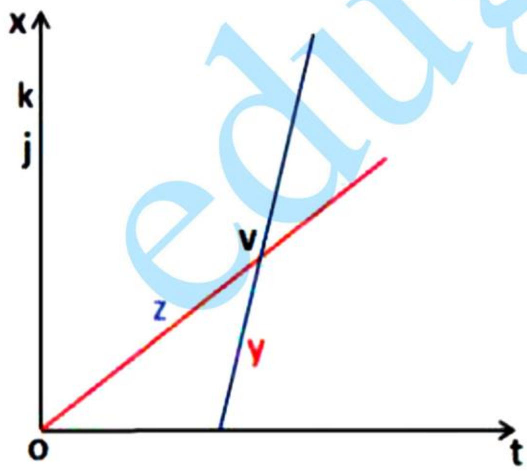
Q1 In which of the following examples of motion, can the body be considered approximately a point object:
(a) a railway carriage moving without jerks between two stations.
(b) a monkey sitting on top of a man cycling smoothly on a circular track.
(c) a spinning cricket ball that turns sharply on hitting the ground.
(d) a tumbling beaker that has slipped off the edge of a table.
Ans.
(a), (b) The size of the train carriage and the cap is very small as compared to the distance they've travelled, i.e. the distance between the two stations and the length of the race track, respectively. Therefore, the cap and the carriage can be considered as point objects.
The size of the basketball is comparable to the distance through which it bounces off after hitting the floor. Thus, basketball cannot be treated as a point object. Likewise, the size of the bottle is comparable to the height of the chair from which it drops. Thus, the bottle cannot be treated as a point object.

Q2 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 Fig. 3.19. Choose the correct entries in the brackets below ;
(a) (A/B) lives closer to the school than (B/A)
(b) (A/B) starts from the school earlier than (B/A)
(c) (A/B) walks faster than (B/A)
(d) A and B reach home at the (same/different) time
(e) (A/B) overtakes (B/A) on the road (once/twice).



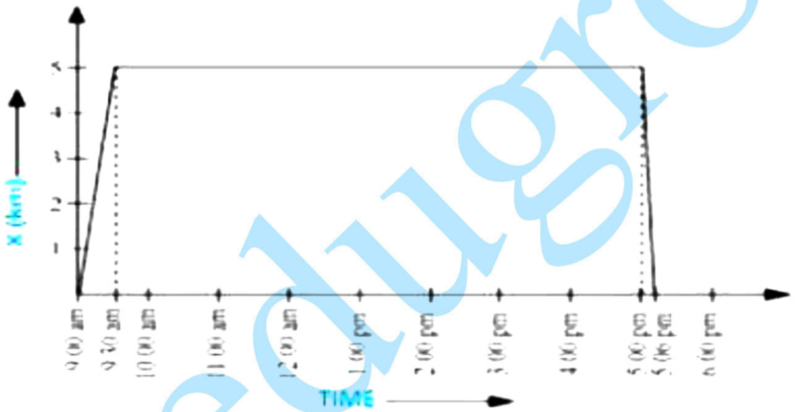
Ans.
(a) Y lives father from the office than Z, since OK> OJ
(b) Y starts from the office later than Z, since for x = 0 for both Z and Y, Z has t = 0

while Y has some finite value for t. Which means Y starts later than Z.
(c) Z walks slower than Y since the slope of Z is lesser.
(d) Z and Y get home at the same time.
(e) Y overtakes Z on the road once at the intersection V.

Q3 A woman starts from her home at 9.00 am, walks with a speed of 5 km h^{-1} on the 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

Ans.

Given,
Speed of the lady= 5 km/h
Distance from her home and to her office = 2.5 km
Time taken = Distance / speed
= 2.5/ 5 = 0.5 h = 30 min.
Also, we know that she covers the same distance in the evening on a bus as she returns home
Speed of the bus = 25 kmph
Time taken = distance/ speed
= 2.5/25 = 0.1 h = 6 min
Thus an appropriate graph is:

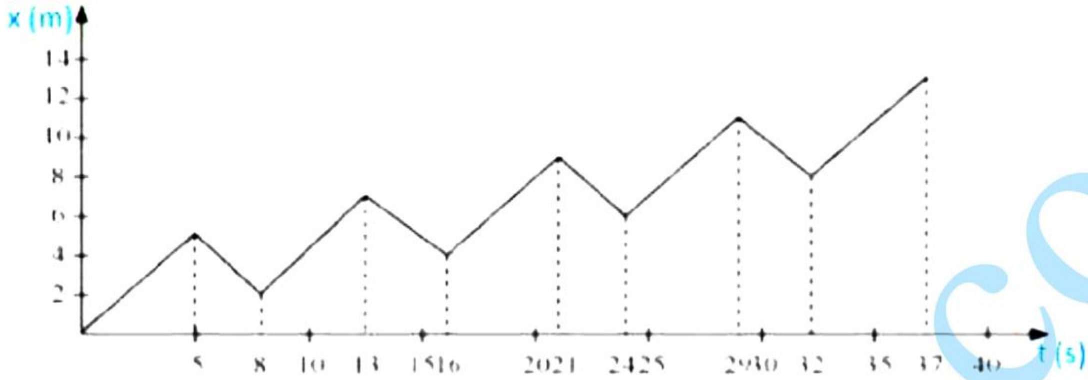


Q4 A drunkard walking in a narrow lane takes 5 steps forward and 3 steps backwards, followed again by 5 steps forward and 3 steps backwards, and so on. Each step is 1 m long and requires 1 s. Plot the x-t graph of his motion. Determine graphically and otherwise how long the drunkard takes to fall in a pit 13 m away from the start.

Ans.

Given,
Distance covered in 1 step = 1 m

Time taken = 1 s Time taken to move first 5 m forward = 5 s Time taken to move 3 m backward = 3 s Net distance covered = 5 – 3 = 2 m Net time taken to cover 2 m = 8 s Drunkard covers 2 m in 8 s. Drunkard covered 4 m in 16 s. Drunkard covered 6 m in 24 s. Drunkard covered 8 m in 32 s. In the next 5 s, the drunkard will cover a distance of 5 m and a total distance of 13 m and falls into the pit. Net time taken by the drunkard to cover 13 m = 32 + 5 = 37 s The x-t graph of the drunkard's motion can be shown as:



Q5 A jet aeroplane 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?

Ans.

Given,

Speed of the car, V_C= 200 kmph

The relative speed of the exhaust with respect to the car, V_E = – 800 kmph

Let the relative speed of the exhaust with respect to the observer = V_{OE}

Thus, $V_C = V_{OE} - V_E$

$V_{OE} = 200 - 800$

$= -600$ Kmph

The negative sign indicates that the exhaust is moving in a direction opposite to the car.

Q6 A car moving along a straight highway with a 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?

Ans.

The initial velocity of the car = u

Final velocity of the car = v

Distance covered by the car before coming to rest = 200 m

Using the equation,

v = u + at

t = (v – u)/a = 11.44 sec.

Therefore, it takes 11.44 sec for the car to stop.

Q7. Two green anacondas X and Y of length 10 m are moving in the same direction with a uniform speed of 20 kmph, with X ahead of Y. Upon detecting prey, Y decides to overtake X. Thus it accelerates by 1 m/s2, after 50 s the tail of Y slithers past X's head. Calculate the original distance between the two?

Ans.

For anaconda X

Initial velocity, u =20kmph = 5.55 m/s

Time, t = 50 secs.

Acceleration , a = 0 (Since it is moving with a uniform speed)

Using the second equation of motion we get:

$S_X = ut + ½ a_X t^2$

$S_X = 5.55 \times 50 + 0 = 277.5$ m.

For anaconda Y

Initial velocity, u =20kmph = 5.55 m/s

Time, t = 50 secs.

Acceleration , a = 1 m/s^2

Using the second equation of motion we get:

$S_Y = ut + ½ a_Y t^2$

$S_Y = 5.55 \times 50 + (1/2) \times 1 \times 50^2 = 1527.5$m.

Therefore the original distance between the two = 1527.5 – 277.5

= 1250m.

Q8. A skater X is skating at a speed of 20 kmph. Two cars Y and Z approach X from the opposite directions at a speed of 40 kmph each. At a particular instant, when the distance XY is equal to XZ, both being 500 m, Y decides to overtake X before Z does. What is the minimum velocity with which Y must accelerate in order to avoid an accident?

Ans.

Velocity of X, v_X = 20 km/h = 5.55 m/s

Velocity of Y, v_Y = 40 km/h = 11.11 m/s

Velocity of Z, v_Z = 40 km/h = 11.11 m/s

Relative velocity of Y with respect to X, $v_{XY} = v_Y – v_X$ = 11.11 – 5.55 = 5.56 m/s

Relative velocity of Z with respect to X, $v_{XZ} = v_Z – (– v_X)$ = 11.11 + 5.55 (It is – v_X since X and Z = 16.66 m/s are in opposite direction)

At a particular instance, both cars Y and Z are at the same distance from the skater X i.e.,

S = 500 m
Time taken (t) by car Z to cover 500 m = 500/16.66 = 30.01s
Thus, to avoid an accident Y must cross X within 30.01 seconds.
Now, from the second equation of motion minimum acceleration "a" in car Y to avoid a collision is:
$s = ut + ½ at^2$
$a = 2(s – ut)/ t^2$
$= 2(500 – 5.56×30.01)/ 30.01^2 = 0.74\ ms^{-1}$

Q9. Two housing colonies X and Y are connected by a regular taxi service with a taxi leaving in either direction every T minutes. A man cycling with a speed of 25 kmph from X to Y observes that a taxi passes him every 20 min in the direction he is moving, and every 8 min in the direction opposite to him. Find the period T of the taxi service and the speed (assumed constant) at which the taxi moves.
Ans.
let V be the velocity of the taxi running between X and Y.
Speed of cyclist = 25 kmph
Relative speed of the taxi moving in the same direction as the cyclist = V – v
= (V – 25) kmph
The taxi passes the cyclist every 20 minutes = 20/60 hrs. (both moving in the same direction)
Thus, distance covered by the taxi = speed x time
= (V - 25) (20/60) km . . . . (i)
Since, one taxi leave every T minutes, the distance travelled by the bus will also be = V x T/60 . . . . . (ii)
Equating equations (i) and equation (ii) we get:
(V – 25)(20/60) = VT / 60 . . . . (iii)
Relative velocity of the taxi moving in the direction opposite to the cyclist = (V + 25) kmph
Time taken by the taxi to cross the cyclist = 8/60 hr.
Thus we have ,
(V + 25)(8/60) = VT / 60 . . . . (iv)
Using equation (iii) and equation (iv), we get
(V – 25)(20/60) = (V + 25)(8/60)
20V – 500 = 8V +200
12V = 700
There the velocity of the taxi, V =58.33 kmph
And , substituting the value of V in equation (iv), we get
(58.33 + 25)(8/60) = 58.33T/60

T = 11.42 min.

Q10. In a basketball match, the referee throws the ball up in the air with an initial speed of 10 m/s.
(a) In what direction is the ball accelerating when it is thrown upwards?
(b) At the highest point of its ascend what is its acceleration and velocity?
(c) Assuming x = 0 and t = 0 to be the location and the time of the basketball at its highest point and the vertically downward direction to be the positive direction of the x axis. What will the signs of velocity, acceleration and position of the basketball be during its downward and upward motion?
(d) To what height does the ball rise? And what is the total air time of the ball?
Ans.
(a) When the basketball moves upward its acceleration is vertically downwards.
(b) At the highest point of the ball's ascend the velocity of the ball is 0 and its acceleration ,a = g =9.8 m/s^2 (acceleration due to gravity) in the vertically downward direction.
(c) Taking the above assumption, we get:
(i) During downward motion, x = positive, velocity, v = positive and acceleration, a = g = +ve.
(ii) During upward motion, x = +ve, velocity = -ve and acceleration = g = positive.
(d) Given,
Initial velocity, u = 10 m/s
a = 9.8m/s^2
Final velocity, v = 0
Thus, using the third equation of motion, we get:
$v^2 - u^2 = 2gs$
$s = (v^2 - u^2) / 2g$
$s = (0 - 10^2) / 2 \times (- 9.8)$
$s = - 100 / -19.6 = 5.10$ m
Therefore the ball attains a maximum height of 5.10m.
Now to find the time of ascent, t
v = u + at
t = (v – u) / a
= -10/-9.8 = 1.02s
Thus, the total time taken by the ball to ascend and come down (air time) = 2 x 1.02 = 2.04 seconds

Q11. Explain with examples whether the following statements are true or false; An object in one – dimensional motion

(a) possessing a positive value of acceleration has to be speeding up.
(b) moving with a constant speed must have zero acceleration.
(c) with zero speed at an instant may have non-zero acceleration at that instant.
(d) possessing zero speed could have a non-zero velocity.

Ans.

(a) False. If the position direction is not along the direction of motion the object is not speeding up.

(b) True. Acceleration is the rate of change of velocity so if speed is constant then velocity is constant, thus the acceleration is 0.

(c) True. When a ball is thrown up its acceleration at the highest point of its ascent = g. However, at that point, the ball's speed is 0.

(d) False. Speed is the magnitude of velocity, so if speed is 0 then velocity is 0.

Q12. A rubber box is dropped from a 90 m high terrace. As it rebounds off the floor, the box loses one-tenth of its speed. Represent its speed with time on a graph, of its motion between t = 0 to 12 s.

Ans.

Given,

Height, s = 90 m

Initial velocity of the ball, u = 0

Acceleration, $a = g = 9.8\ m / s^2$

Final velocity of the ball = v

Using the second equation of motion, we get:

$s = u + (½)\ at^2$

$90 = 0 + ½\ (9.8t^2)$

Therefore , $t^2 = 180 / 9.8$

Or, t = 4.29 secs.

Where t is the time taken by the box to hit the floor.

Using the first equation of motion ,we get final velocity v = u + at

Thus, v = 0 + 9.8×4.29 = 42.04 m / s

Rebound velocity of the box, u_R = (9/10)v = (9 x 42.04)/ 10 = 37.84 m/s

Let t' be the time taken by the box to reach maximum height after bouncing off the floor

Using the first equation of motion we get:

$v = u_R + at'$

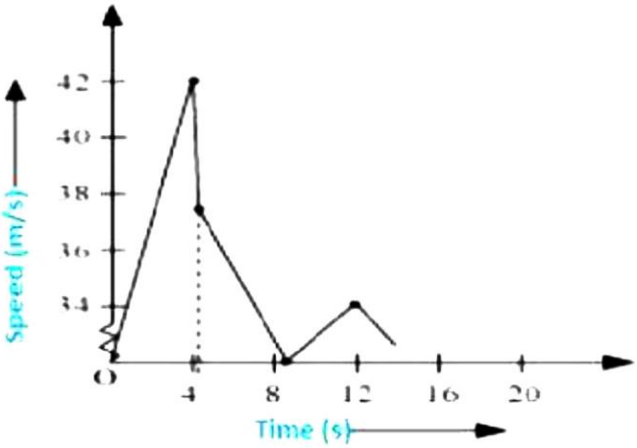
$0 = 37.84 + (-9.8)\ t'$

t' = -37.84 / -9.8 = 3.86s

Total time taken by the ball = t + t′ = 4.29 + 3.86 = 8.15 seconds.

Since the time of ascent = the time of descent, the box takes 3.86 s to hit the ground for the second time.

The box rebounds off the floor with a velocity = (9/10)37.84 = 34.05 m/s
Time taken by the box for the second rebound = 8.15 + 3.86 = 12.01 s .
The speed-time graph of the ball is as follows:



Q13. Provide clear explanations and examples to distinguish between:
(a) The total length of a path covered by a particle and the magnitude of displacement over the same interval of time.
(b) The 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].
In (a) and (b) compare and find which among the two quantity is greater.
When can the given quantities be equal? [For simplicity, consider one-dimensional motion only].
Ans.
(a) Let us consider an example of a football, it is passed to player B by player A and then instantly kicked back to player A along the same path. Now, the magnitude of displacement of the ball is 0 because it has returned to its initial position. However, the total length of the path covered by the ball = AB +BA = 2AB. Hence, it is clear that the first quantity is greater than the second.
(b) Taking the above example, let us assume that football takes t seconds to cover the total distance. Then,
The magnitude of the average velocity of the ball over time interval t = Magnitude of displacement/time interval
= 0 / t = 0.
The average speed of the ball over the same interval = total length of the path/time interval
= 2AB/t

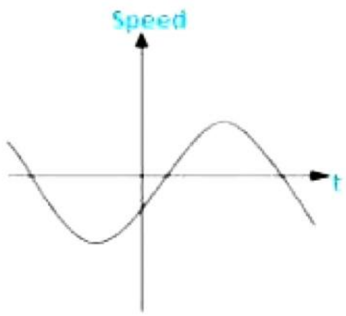
Thus, the second quantity is greater than the first.
The above quantities are equal if the ball moves only in one direction from one player to another (considering one-dimensional motion).

Q14. A man skateboards on a straight road from his hostel to a mall 2 km away at a speed of 4 kmph. Finding the mall closed, he instantly returns back to his hostel at a speed of 6 kmph.
Ans.
a) Calculate the magnitude of average velocity and the average speed of the man over the time interval of:
(i) 0 to 30 min (ii) 0 to 50 min
(iii) 0 to 40 min
(a) Time taken to reach the mall,t_1 = 2/4 = 1/2 hrs = 30 min
Time taken to return from the mall,t_2 = 2/6 hrs = 1/3 hours = 19.8 min
Total time taken for the whole journey = 1/3 + 1/2
= 5/6hrs = 0.833 hrs = 50 minutes.
Total displacement = 0
Total distance = 2 + 2 = 4km.
(i) Average velocity (0 – 30 min) = 2/0.5 = 4 kmph = Average speed
. . . . (Since in 30 minutes the mall was reached)
(ii) Average velocity = displacement/time = 0 . . . .(Since the net displacement is 0)
Average speed (0 – 50 min) = (2 + 2) / 0.833 = 4.801 kmph
(iii) Average velocity (0 – 40 min);
Distance travelled in the first 30 minute = 2 km
Distance travelled in the next 10 minute = 6 x10/60 = 1km
Net displacement = 2- 1= 1km
Total displacement = 2 + 1 = 3km
Average velocity = 1/ 40min = (1 x 60)/ 40 = 1.5 kmph
Average speed = 3/ 40 min = (3 x 60)/ 40 = 4.5kmph

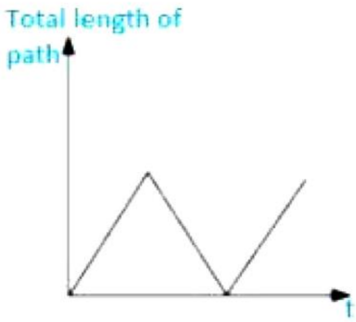
Q15. Why is there no distinction required between instantaneous speed and magnitude of velocity?
Ans.
Instantaneous velocity is the first derivative of distance with respect to time (dx / dt). However, dt is so small it is assumed that the moving particle does not change direction. As a result, the total distance and the magnitude of displacement become equal in this time interval. Thus, instantaneous speed and magnitude of velocity are equal.

Q16. Study the following graphs (a) to (d) and explain which of these can or cannot represent the one-dimensional motion of a particle.

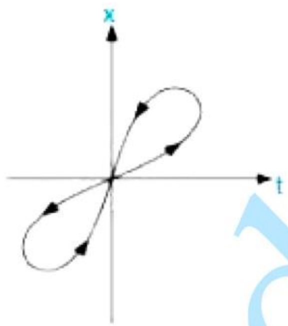
(a)



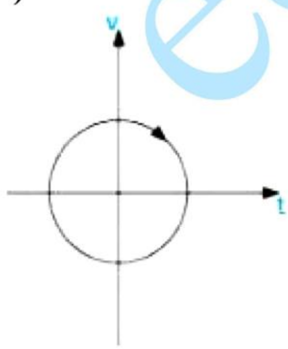
(b)



(c)



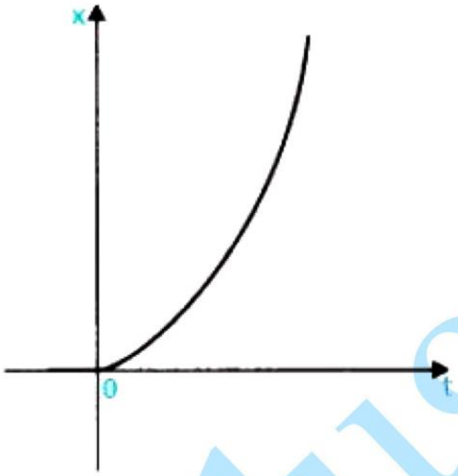
(d)



Ans.

(a) The graph is given in "a" does not represent one-dimensional motion because the point is moving along two axes i.e. axis x and y, and since each axis represents a dimension, moving along two axes means moving in two dimensions. Also, speed being a scalar quantity it cannot be negative.
(b) The graph given in "b" does not represent one-dimensional motion because the total path travelled by a particle cannot decrease with time in one-dimensional motion.
(c) The graph given in "c" does not represent one-dimensional motion because the point is moving along two axes i.e. axis x and y, and since each axis represents a dimension, moving along two axes means moving in two dimensions. Moreover, a particle cannot occupy two positions at the same time, this is only possible in multiple dimensions.
(d) The graph given in "d" does not represent one-dimensional motion because the once again a particle cannot have two values of velocity in one-dimensional motion.

Q17. The following figure shows the x-t plot of one-dimensional motion of an object. Can we say from the graph that the object moves on a parabolic path for t > 0 and on a straight line for t < 0? If not, present a suitable situation with characteristics resembling this graph.



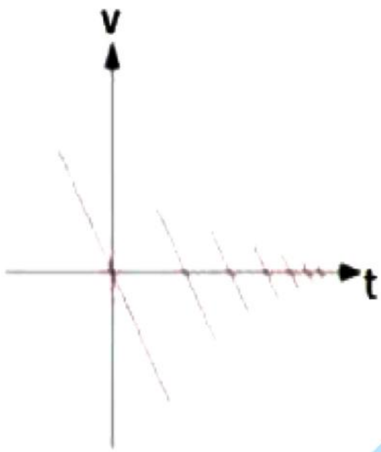
Ans.
No, from the graph we cannot say that the object moves on a parabolic path from t > 0 and on a straight line for t < 0, because the graph does not show the object's path. A suitable situation with characteristics resembling the above graph is a ball thrown from a tall building at instant t =0.

Q18. In a high-speed police chase, a police van is racing after an assassin at a speed of 90 kmph. The assassin, however, is speeding off in a powerful sports car at 220 kmph in the same direction. The officer in desperation fires a bullet with a muzzle speed of 150 m/s at the assassin's car. Calculate the speed when it hits the assassin's car (assuming the officer does not miss)?

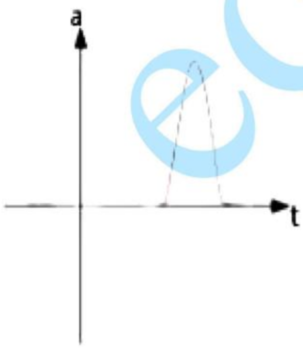
Ans.
Given,
Speed of the police van, Vp = 90 km/h = 25 m/s
Muzzle speed of the bullet, Vb = 150 m/s
Speed of the thief's car, Vt = 220 km/h = 61.11 m/s
Since the bullet is fired from a moving van, its resultant speed = 150 + 25 = 175 m/s
Since both the vehicles are moving in the same direction, the final velocity of the bullet, Vbf = Vb – Vt = 175 – 61.11 = 113.89 m/s.

Q19. Suggest a suitable physical situation for each of the following graphs (Fig 3.22):

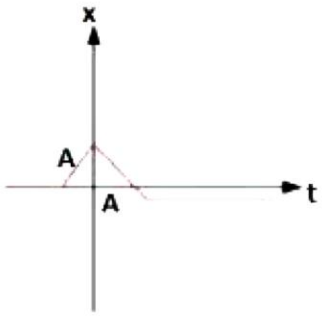
(a)



(b)

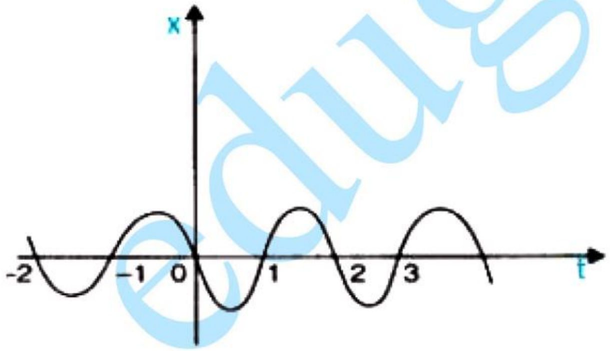


(c)



Ans.
(a) Here we can see that the velocity of the object decreases uniformly over time. An example of this situation would be a stone dropping in a pool of water.
(b) Here we can see that initially, an object is moving with a uniform velocity, it then accelerates for a short interval of time after which its acceleration drops to zero. An example of this would be a uniformly moving hockey ball being hit by a hockey stick for a very short interval of time.
(c) Here we see that the velocity increases initially, then it goes to 0. Again the velocity starts increasing but in the opposite direction and it attains a constant after some time. An example of this would be kicking a ball on a smooth floor. It gains velocity initially, then it stops momentarily when it hits the wall and from the wall, it rebounds and starts moving in the opposite direction with a constant speed.

Q20. The graph below plots the simple one-dimensional harmonic motion of an object. What are the signs of velocity, acceleration and position variables of the object at:
t = 0.3 s, 1.2 s, – 1.2 s.



Ans.
In Simple Harmonic motion a = -kx
(i) At t = 0.3s, x (position) is –ve, and on increasing time x becomes more negative so velocity is –ve. And acceleration, a is +ve (Since a = -k(-x))
(ii) At t = 1.2s, x is positive, velocity is +ve and acceleration is –ve
(iii) At t = -1.2s, x is –ve and on increasing time x becomes less negative. Thus, velocity is +ve and acceleration is positive (Since a = -k(-x))

Q21.The figure given below is an x-t plot of an object's motion in one dimensional. On the figure, three different equal time intervals are marked. Find the intervals in which the average speed is the least and the greatest. Also, write the sign of average velocity at each interval.

Ans.

The slope of the graph is minimum at 2 and maximum at 3. Thus, the least average speed is at time interval 2 and the greatest average speed is at time interval 3. Average velocity is positive in interval 1 and 2 and negative in 3.

Q22.The figure given below is a speed-time graph of an object moving in a constant direction. On figure three equal intervals of time have been marked. Find the intervals in which the average acceleration and the average speed are the greatest. Taking the positive direction to be the constant direction of motion, what are the signs of a and v in all the given intervals. Also find the value of acceleration at A, B, C and D?

Ans.

The average acceleration is the greatest in interval 2 as the change in speed with time (slope) is the greatest in this interval.

The average speed is the greatest in interval 3 as point D is the highest point on the speed axis.

The sign of v and a in all the intervals are:

V is positive in all the intervals. A is positive in interval 1, negative in interval 2 and equal to 0 in D.

Acceleration is 0 at A, B, C and D because at these points there are negligible slopes in the graph.

Q23. 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?

Ans.

For a straight line, the distance covered by a body in nth *second* is :

$S_N = u + a\,(2n - 1)/2$ . . . . (1)

Where,

a = Acceleration

u = Initial velocity

n = Time = 1, 2, 3, ... , *n*

In the above case,

a = 1 m/s^2 and u = 0.

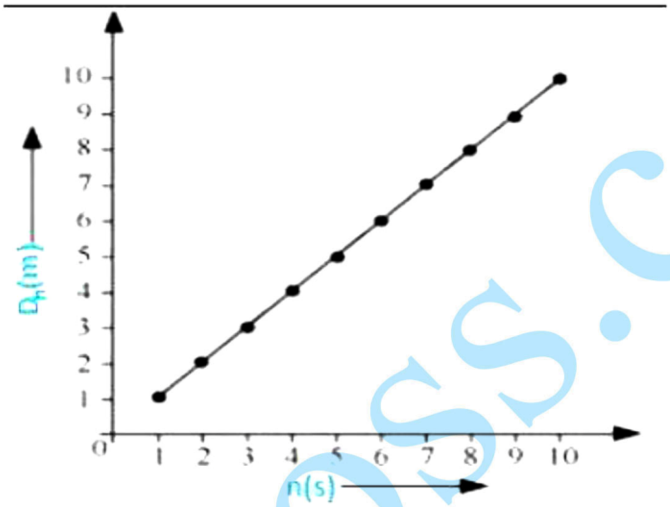
∴ $S_N = (2n - 1) / 2$ . . . .(2)

This relation shows that:

$S_N \propto n$ . . . . (3)

Now substituting different values of n in equation (2) we get:

n	1	2	3	4	5	6	7	8	9
S_N	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5



This plot is expected to be a straight line.

Q24. **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?**

Ans.

Case 1 when the elevator is still:

We know,

v = u + at

0 = 40 + (- 9.8)t (Since final velocity = 0 and a = -g as gravity acts downwards)

-40/-9.8 = t

t = 4.081 s.

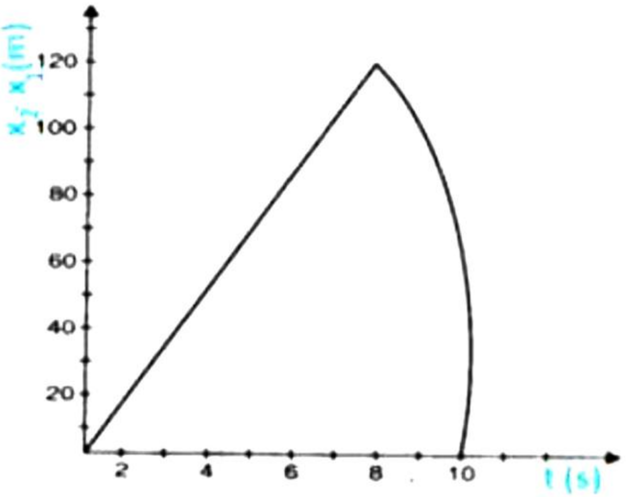
Thus, the total time taken by the ball to go up and return back is 4.081 x 2 = 8.16 s

Case 2 when the elevator is moving upwards:

The elevator moves up at a constant speed thus the relative velocity of the ball with respect to the lady remains the same. Thus it takes 8.16 s for the ball to go up and down.

Q25. On a long horizontally moving belt (Fig. 3.26), 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 ?.
(b) speed of the child running opposite to the direction of motion of the belt?
(c) time is taken by the child in (a) and (b)?
Which of the answers alter if motion is viewed by one of the parents?
Ans.
Given,
Speed of the child with respect to the walk way = 10 kmph
Speed of the belt (walk way) = 5 kmph
(a) When the child runs against the belt, then his speed with respect to the stationary observer = 10 – 5 = 5 kmph
(b) When the child runs on the belt in the same direction as the belt, then his speed to the stationary observer = 10+ 5 = 15 kmph
(c) Distance between the parents = 40 m
As both the parents are on the walk way the speed of child remains the same for both the parents = 10 kmph = 2.77 m/s
Hence the time taken by the child to move to any one of his parent from another one = 40 / 2.77 = 14.44 s
(d) For any of the parent as the observer, the answer to (a) and (b) changes while the answer to (c) is the same.

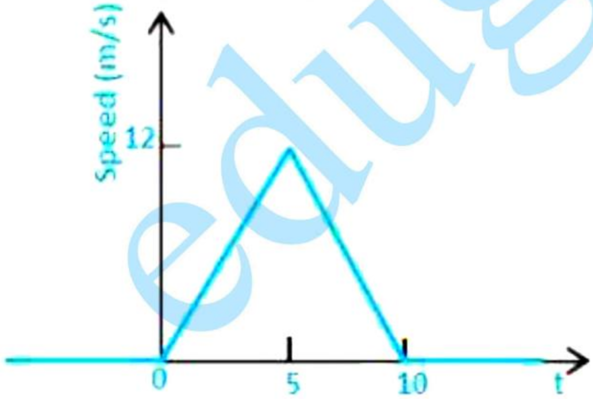
Q26. Two stones are thrown up simultaneously from the edge of a cliff 200 m high with initial speeds of 15 m s–1 and 30 m s–1. Verify that the graph shown in Fig. 3.27 correctly represents the time variation of the relative position of the second stone with respect to the first. Neglect air resistance 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.



Ans.
For the first stone:
Given,
Acceleration, $a = -g = -10\ m/s^2$
Initial velocity, $u_I = 15$ m/s
Now, we know
$s_1 = s_0 + u_I t + (1/2)at^2$
Given, height of the tree, $s_0 = 200$ m
$s_1 = 200 + 15t - 5t^2$ . . . . (1)
When this stone hits the jungle floor, $s_1 = 0$
$\therefore -5t^2 + 15t + 200 = 0$
$t^2 - 3t - 40 = 0$
$t^2 - 8t + 5t - 40 = 0$
$t(t - 8) + 5(t - 8) = 0$
$t = 8$ s or $t = -5$ s
Since, the stone was thrown at time t = 0, the negative sign is not possible
$\therefore t = 8$ s
For second stone:
Given,
Acceleration, $a = -g = -10\ m/s^2$
Initial velocity, $u_{II} = 30$ m/s
We know,
$s_2 = s_0 + u_{II}t + (1/2)at^2$
$= 200 + 30t - 5t^2$ . . . . (2)
when this stone hits the jungle floor; $s_2 = 0$
$-5t^2 + 30t + 200 = 0$
$t^2 - 6t - 40 = 0$

$t^2 - 10t + 4t + 40 = 0$
$t(t - 10) + 4(t - 10) = 0$
$t(t - 10)(t + 4) = 0$
$t = 10$ s or $t = -4$ s
Here again, the negative sign is not possible
$\therefore t = 10$ s
Subtracting equations (1) from equation (2), we get
$s_2 - s_1 = (200 + 30t - 5t^2) - (200 + 15t - 5t^2)$
$s_2 - s_1 = 15t$ . . . . (3)
Equation (3) represents the linear trajectory of the two stone, because to this linear relation between $(s_2 - s_1)$ and t,, the projection is a straight line till 8 s.
The maximum distance between the two stones is at t = 8 s.
$(s_2 - s_1)_{max} = 15 \times 8 = 120$ m
This value has been depicted correctly in the above graph.
After 8 s, only the second stone is in motion whose variation with time is given by the quadratic equation:
$s_2 - s_1 = 200 + 30t - 5t^2$
Therefore, the equation of linear and curved path is given by :
$s_2 - s_1 = 15t$ (Linear path)
$s_2 - s_1 = 200 + 30t - 5t^2$ (Curved path)

Q27. The given speed- time graph represents the motion of a particle in a fixed direction. Calculate the distance covered by the particle in the time intervals; (a) t = 0 s to 10 s, (b) t = 1 s to 8 s. Find the average speed of the particle over the intervals in (a) and (b).



Ans.
(a) Distance covered by the particle = Area of the given graph
= (1/2)base x height
= (1/2) x (10) x (12) = 60m
Average speed of the particle = 60/10 = 6 m/s

(b) The distance traversed by the particle between
t = 1s to 8s
let distance travelled in 1 to 5s be S1 and distance travelled from 6 to 8s be S2.
Thus, total distance travelled, S (in t = 1 to 8 s) = S1 + S2 . . . . . . (1)

Now, For S1.
Let u' be the velocity of the particle after 1 second and a' be the acceleration in the particle from t = 0 to 5s
We know that the particle is under uniform acceleration from t = 0 to 5s thus, we can obtain acceleration using the first equation of motion.
v = u + at
where, v = final velocity
12 = 0 + a' (5)
$a' = 2.4\ m/s^2$
Now to find the velocity of the particle at 1s
v = 0 + 2.4 (1)
v = 2.4 m/s = u' at t = 1s
Thus, the distance covered by the particle in 4 seconds i.e., from t = 1 to 5 s.
$S1 = u't + \frac{1}{2} a't^2$
$= 2.4 \times 4 + \frac{1}{2} \times 2.4 \times 4^2$
= 9.6 + 19.2 =28.8 m

Now, for S2
Let a" be the uniform acceleration in the particle from 5s to 10s
Using the first law of motion
v = u + at . . . . (v= 0 as the particle comes to rest)
0 = 12 + a" x 5
a" = -2.4 m/s
Thus, distance travelled by the particle in 3 seconds i.e., between 5s to 8s
S2 = u"t + ½ a"t
$S2 = 12 \times 3 + \frac{1}{2} \times (-2.4) \times 3^2$
= 36 + (-1.2)x9
S2 = 25.2m
Thus, putting the values of S1 and S2 in equation (1), we get:
S = 28.8 + 25.2 = 54m
Therefore, average speed = 54 / 7 = 7.71 m/s.

Q28. The graph below is a velocity-time graph of a particle in one-dimensional motion. Which of the following formulae correctly describe the motion of the

particle in the time interval t_1 to t_2.

(a) $a_{average} = (v(t_2) - v(t_1))/(t_2 - t_1)$

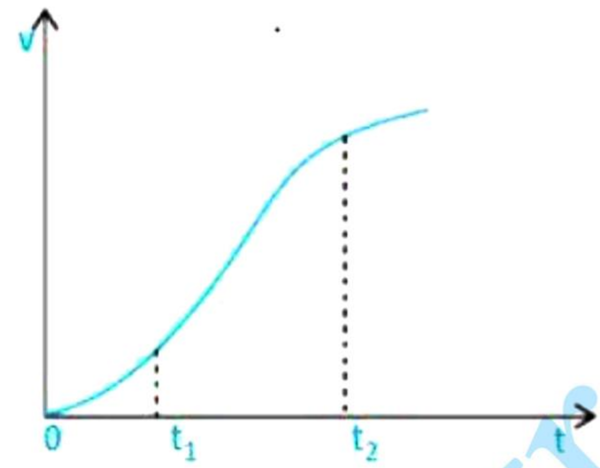
(b) $x(t_2) = x(t_1) + v_{average}(t_2 - t_1) + (½)\, a_{average}(t_2 - t_1)^2$

(c) $v_{average} = (x(t_2) - x(t_1))/(t_2 - t_1)$

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

(e) $x(t_2) = x(t_1) + v(t_1)(t_2 - t_1) + (½)\, a(t_2 - t_1)^2$

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



Ans.

The formulae in (a), (c) and (f) correctly describe the motion of the particle in one dimension.

Since the given graph has a non-uniform slope, the formulae are given in (b), (d) and (e) do not describe the motion of the particle in one motion.