Date: 13/10/2021

Q1. What does slope of velocity-time graph represent?

Q2. Read the statement below carefully and state with reasons and examples, if it is true or false: with positive value of acceleration must be speeding up.

Q3. Can Earth be regarded as a point object if only the orbital motion of Earth around the Sun is considered?

Q4. Why the speed of the object can never be negative?

Q5. Two balls of different masses (one lighter and other heavier) are thrown vertically upward with same initial speed. Which one will rise to the greater height?

Q6. Consider that the acceleration of a moving body varies with time. What does the area under acceleration-time graph for any time interval represent?

Q7. If the acceleration of particle is constant in magnitude but not in direction, what type of path the particle follow?

Q8. Give an example of a body possessing zero velocity and still accelerating.

Q9. A ball is thrown straight up. What is its velocity and acceleration at the top?

Q10. Why does the earth impart the same acceleration to all bodies?

Q11. Two particles *A* and *B* are moving with speeds of $2\ \text{km h}^{-1}$ and $3\ \text{km h}^{-1}$ respectively in the same direction. Find how far will *B* be from *A* after 1 hour?

Q12. A train moving with a velocity of $48\ \text{km h}^{-1}$ is brought to rest in 11 second to avoid collision. What is the retardation of the train in m s^{-2} and km h^{-2}?

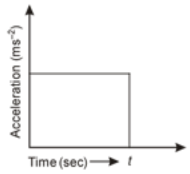
Q13. A car travelling at $40\ \text{km h}^{-1}$ overtakes another car travelling at $58\ \text{km h}^{-1}$. Assuming each car to be 5 metre long, calculate the time taken for overtaking.

Q14. A train which is 150 m long is moving due south at a speed of $10\ \text{m s}^{-1}$. A parrot flies at a speed of $5\ \text{m s}^{-1}$ towards north parallel to the rail track. In what time the parrot shall cross the train?

Q15. Ambala is at a distance of 200 km from Delhi. Ram sets out from Ambala at a speed of $60\ \text{km h}^{-1}$ and Sham sets out at the same time from Delhi at a speed of $40\ \text{km h}^{-1}$. When will they meet?

Q16. Two trains of lengths 109 m and 91 m are moving in opposite directions with velocities $34\ \text{km h}^{-1}$ and $38\ \text{km h}^{-1}$ respectively. In what time two trains will completely cross each other? Choose the most logical reference point for time measurement.

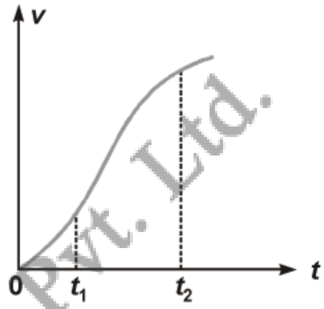
Q17. The acceleration-time graph for a body is shown in the adjoining. Plot the corresponding velocity-time graph.



Q18. Two balls are thrown simultaneously, A vertically upwards with a speed of $20\ m\,s^{-1}$ from the ground and B vertically downwards from a height of 40 m with the same speed and along the same line of motion. At what point do the two balls collide? Given: $g = 9.8\ m\,s^{-2}$.

Q19. A stone is dropped from the top of a tower 100 metre high. At the same time, another stone is thrown vertically upwards with a velocity of $50\ m\,s^{-1}$. When and where the two stone will meet?

Q20. The velocity-time graph of a particle in one-dimensional motion is shown in figure:



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

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

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

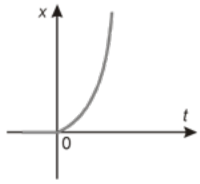
$$v_{Average} = (x(t_2) - x(t_1)) / (t_2 - t_1)$$

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

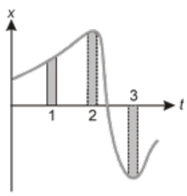
$$x(t_2) = x(t_1) + v_{Average}(t_2 - t_1) + \left(\frac{1}{2}\right) a_{Average}(t_2 - t_1)^2$$

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

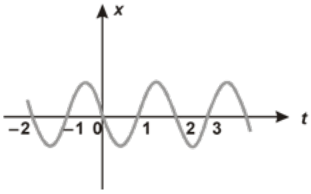
Q21. Figure shows the x-t plot of one-dimensional motion of a particle. Is it correct to say from the graph that the particle moves in a straight line for $t < 0$ and on a parabolic path for $t > 0$? If not, suggest a suitable physical context for this graph.



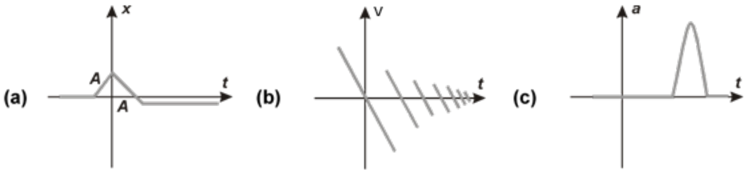
Q22. The figure gives the x-t plot of a particle in one-dimensional motion. Three different equal intervals of time are shown. In which interval is the average speed greatest, and in which is it the least? Give the sign of average velocity for each interval.



Q23. The 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.



Q24. Suggest a suitable physical situation for each of the following graphs:



Q25. (a) A stone is dropped from a balloon moving upwards with a velocity of 4.5 ms^{-1}. The stone reaches the ground in 5 second. Calculate the height of the balloon when the stone was dropped.

(b) A stone falls freely under gravity, starting from rest. Calculate the ratio of distance travelled by the stone during the first half of any interval of time to the distance travelled during the second half of the same interval.

Q26. A stone is thrown upwards from the top of tower 85 m high. It reaches the ground in 5 second. Calculate (a) the greatest height above the ground (b) the velocity with which it reaches the ground and (c) the time taken to reaches the maximum height. Given: $g = 10$ ms^{-2}.

Q27. Two ships are 10 km apart on a line running south to north. The one farther north is steaming west at 20 km h^{-1}. The other is steaming north at 20 km h^{-1}. What is their distance of closest approach? How long do they take to reach it?

Q28. A car starts from rest and accelerates uniformly for 10 s to a velocity of 8 m s^{-1}. It then runs at a constant velocity and is finally brought to rest in 64 m with a constant retardation. The total distance covered by the car is 584 m. Find the values of acceleration, retardation and total time taken.

Q29. Define the acceleration, it is vector quantity or scalar. 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. 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 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?

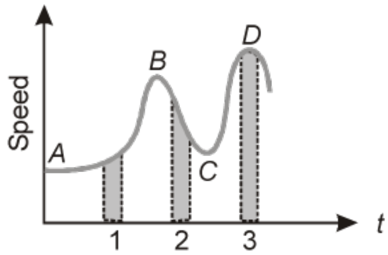
Q30. The figure gives a speed-time graph of a particle in motion along a constant direction. Three equal intervals of time are shown.

(a) In which interval is the average acceleration greatest in magnitude?

(b) In which interval is the average speed greatest?

(c) Choosing the positive direction as the constant direction of motion, give the signs of *v* and *a* in the three intervals.

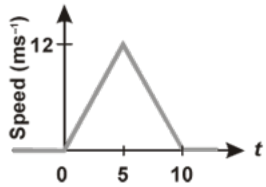
(d) What are the accelerations at the points *A*, *B*, *C* and *D*?



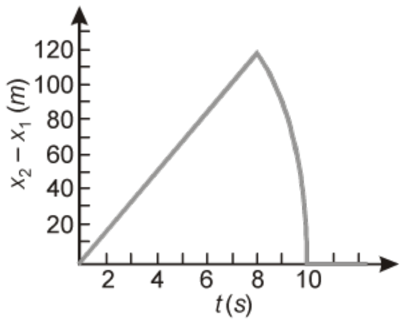
Q31. Define the instantaneous acceleration. Derive an equation for the distance covered by a uniformly accelerated body in n^{th} second of its motion. A body travels half its total path in the last second of its fall from rest. Calculate the time of its fall.

Q32. 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, (b) $t = 2$ s to 6 s.

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



Q33. Two stones are thrown up simultaneously from the edge of a cliff 200 m high with initial speeds of 15 m/s and 30 m/s. 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.



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S1. Acceleration.

S2. True.
Explanation: This statement is true when both velocity and acceleration are positive, at the instant time taken as origin. Such a case happens when a particle is moving with positive acceleration or falling vertically downwards from a height.

S3. Yes. This is because the size of the Earth is very small as compared to the size of the orbit of the Earth around the Sun.

S4. Speed is distance covered per unit time. Since distance cannot be negative therefore speed cannot be negative.

S5. Both the balls will rise to the same height. It is because, for a body moving with given initial velocity and acceleration, the distance covered by the body does not depend on the mass of the body.

S6. The area under acceleration-time graph for any time interval represents the change of speed of the body during that time interval.

S7. It will follow a non-linear path.

S8. A body thrown up vertically has zero velocity at the top-most point, but has acceleration of *g*.

S9. Velocity at the top = **0**.

and acceleration at the top = **9.8 ms^{-2} (downwards)**

S10. Acceleration is force on unit mass. So, Earth does exert same acceleration.

S11. Relative velocity of *B* w.r.t. *A*

$$V_{AB} = (3 - 2)\text{ km h}^{-1} = 1\text{ km h}^{-1}$$

B will be ahead of *A* by a distance of 1 km h^{-1} × 1 h = 1 km.

S12. Given, $u = 48\text{ km h}^{-1}$

$$= \cancel{48}^{8} \times \frac{5}{\cancel{18}_{3}} = \frac{40}{3}\text{ m s}^{-1}$$

$v = 0, \quad t = 11$ sec

$v = u - at$

$u = at$

$$a = \frac{u}{t} = \frac{40}{3 \times 11} = \mathbf{\frac{40}{33}\ m\ s^{-2}}$$

$$a = \frac{u}{t} = \frac{48 \times 3600}{11} = \mathbf{15709\ km\ h^{-2}}.$$

S13. Relative velocity = $(58 - 40)\ \text{km h}^{-1}$

$$= 18\ \text{km h}^{-1} = 18 \times \frac{5}{18}\ \text{m s}^{-1}$$

$$= 5\ \text{m s}^{-1}$$

Total distance to be travelled = 10 m;

$$\text{Time} = \frac{10}{5} = 2\text{s}.$$

S14. Relative velocity of parrot w.r.t. train

$$= (5 + 10)\ \text{m s}^{-1} = 15\ \text{m s}^{-1}$$

Displacement = 150 m

$$\text{Time taken} = \frac{150\ \text{m}}{15\ \text{m s}^{-1}} = 10\ \text{s}.$$

S15. Relative speed = $60 - (-40)\ \text{km h}^{-1} = 100\ \text{km h}^{-1}$;

$$\text{Time taken} = \frac{200\ \text{km}}{100\ \text{km h}^{-1}} = 2\ \text{h}.$$

Distance from Ambala at where they meet = 60 x 2 = 120 km and 80 Km from Delhi.

S16. Relative speed = $(34 + 38)\ \text{km h}^{-1} = 72\ \text{km h}^{-1}$

$$= 72 \times \frac{5}{18} = 20\ \text{m s}^{-1}$$

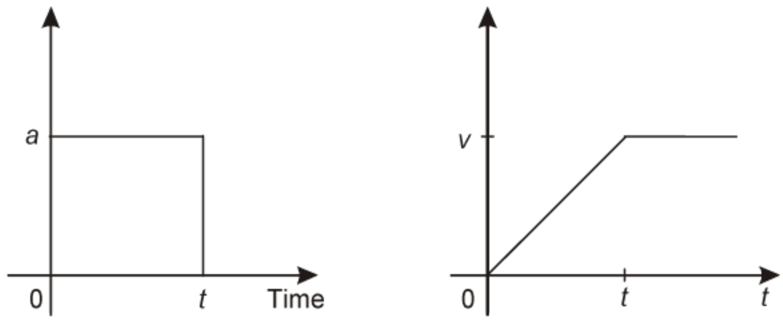
Total distance = (109 + 91) m = 200 m

$$\text{Time} = \frac{200\ \text{m}}{20\ \text{m s}^{-1}} = 10\ \text{s}.$$

S17. For time t, there is an acceleration a.

$\therefore$ Velocity increases after time 't' acceleration is zero.

Thus $v - t$ graph will be shown as



S18. For A, $u = 20\,\text{m s}^{-1}$, $a = -9.8\,\text{m s}^{-2}$,

$$x = 20t - \frac{1}{2} \times 9.8t^2 \qquad \text{... (i)}$$

For B, $u = -20\,\text{m s}^{-1}$, 'S' $= -(40 - x)$,

'a' $= -9.8\,\text{m s}^{-2}$,

Using $S = ut + \frac{1}{2}at^2$,

We get $$-(40 - x) = -20t - \frac{1}{2} \times 9.8t^2$$

or $$40 - x = 20t + 4.9t^2 \qquad \text{... (ii)}$$

Adding (i) and (ii),

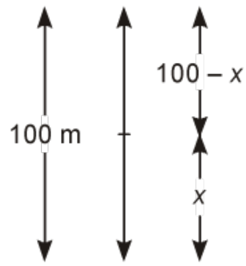
$$40t = 40$$

or $$t = 1\,\text{s};$$

From equation (i),

$$x = 20 \times 1 - 4.9 \times 1 \times 1 = \mathbf{15.1\,m}.$$

S19. When the stone is thrown vertically upward



$$x = ut - \frac{1}{2}gt^2$$

$$x = 50t - \frac{1}{2}gt^2 \qquad \text{... (i)}$$

When the stone droped from top of tower

$$100 - x = ut - \frac{1}{2}gt^2$$

$$x = 100 - \frac{1}{2}gt^2 \qquad \text{... (ii)}$$

Put the value x in Eq. (i), we get

$$100 - \frac{1}{2}gt^2 = 50t - \frac{1}{2}gt^2 \quad \Rightarrow \quad t = 2\text{ sec}$$

From Eq. (i), we get

$$x = 4.9 \times 2 \times 2 \text{ m} = \mathbf{19.6\ m}$$

$$\text{Height} = (100 - 19.6) \text{ m} = \mathbf{80.4\ m}.$$

S20. The correct formulae describing the motion of the particle are (c), (d) and, (f)

The given graph has a non-uniform slope. Hence, the formulae given in (a), (b), and (e) cannot describe the motion of the particle. Only relations given in (c), (d), and (f) are correct equations of motion.

S21. No.

The *x*-*t* graph of a particle moving in a straight line for $t < 0$ and on a parabolic path for $t > 0$ cannot be shown as the given graph. This is because, the given particle does not follow the trajectory of path followed by the particle as $t = 0$, $x = 0$. A physical situation that resembles the above graph is of a freely falling body held for sometime at a height.

S22. Interval 3 (Greatest), Interval 2 (Least)

Positive (Intervals 1 & 2), Negative (Interval 3)

The average speed of a particle shown in the *x*-*t* graph is obtained from the slope of the graph in a particular interval of time.

It is clear from the graph that the slope is maximum and minimum restively in intervals 3 and 2 respectively. Therefore, the average speed of the particle is the greatest in interval 3 and is the least in interval 2. The sign of average velocity is positive in both intervals 1 and 2 as the slope is positive in these intervals. However, it is negative in interval 3 because the slope is negative in this interval.

S23. Negative, Negative, Positive (at $t = 0.3$ s)

Positive, Positive, Negative (at $t = 1.2$ s)

Negative, Positive, Positive (at $t = -1.2$ s)

For simple harmonic motion (SHM) of a particle, acceleration (a) is given by the relation:

$$a = -\omega^2 x \quad \omega \rightarrow \text{angular frequency} \qquad \dots \text{(i)}$$

$$t = 0.3 \text{ s}.$$

In this time interval, x is negative. Thus, the slope of the *x*-*t* plot will also be negative. Therefore, both position and velocity are negative. However, using equation (i), acceleration of the particle will be positive.

$$t = 1.2 \text{ s}.$$

In this time interval, x is positive. Thus, the slope of the *x*-*t* plot will also be positive. Therefore, both position and velocity are positive. However, using equation (i), acceleration of the particle comes to be negative.

$$t = -1.2 \text{ s}.$$

In this time interval, x is negative. Thus, the slope of the x-t plot will also be negative. Since both x and t are negative, the velocity comes to be positive. From equation (i), it can be inferred that the acceleration of the particle will be positive.

S24. (a) The given x-t graph shows that initially a body was at rest. Then, its velocity increases with time and attains an instantaneous constant value. The velocity then reduces to zero with an increase in time. Then, its velocity increases with time in the opposite direction and acquires a constant value.

A similar physical situation arises when a football (initially kept at rest) is kicked and gets rebound from a rigid wall so that its speed gets reduced. Then, it passes from the player who has kicked it and ultimately gets stopped after sometime.

(b) In the given v-t graph, the sign of velocity changes and its magnitude decreases with a passage of time. A similar situation arises when a ball is dropped on the hard floor from a height.

It strikes the floor with some velocity and upon rebound, its velocity decreases by a factor. This continues till the velocity of the ball eventually becomes zero.

(c) The given a-t graph reveals that initially the body is moving with a certain uniform velocity. Its acceleration increases for a short interval of time, which again drops to zero.

This indicates that the body again starts moving with the same constant velocity. A similar physical situation arises when a hammer moving with a uniform velocity strikes a nail.

S25. (a) $u = -4.5 \text{ ms}^{-1}$; $t = 5$ s; $a = +9.8 \text{ ms}^{-2}$; $S = ?$

[Dawnward direction is taken along +ve Y axis]

$$S = -4.5 \times 5 + \frac{1}{2} \times 9.8 \times 5 \times 5$$

$$= -22.5 + 122.5 = 100 \text{ m}.$$

(b)
$$S_1 = 0 \times t\,\frac{t}{2} + \frac{1}{2} g \left(\frac{t}{2}\right)^2$$

or
$$S_1 = \frac{gt^2}{8}$$

$$S = 0 \times t + \frac{1}{2} gt^2 = \frac{gt^2}{2}$$

$$= \frac{gt^2}{2} - \frac{gt^2}{8} = \frac{3gt^2}{8}.$$

$$\frac{S_1}{S_2} = \frac{\frac{gt^2}{8}}{\frac{3gt^2}{8}} = \frac{1}{3}$$

S26. Let us first calculate the velocity with which the ball was thrown.

$$85 = 5u + \frac{1}{2} \times 10 \times 5 \times 5 \qquad \textbf{[upward direction is taken +ve]}$$

or $$u = -8\,\text{ms}^{-1}.$$

(a) Let us now calculate the height, from the top of tower, which the ball has attained.

$$u = -8\,\text{ms}^{-1}, \quad v = 0, \quad a = +10\,\text{ms}^{-2}$$

$$0^2 - (-8)^2 = 2 \times 10 \times h$$

or $$h = -3.2\,\text{m}.$$

Greatest height above the ground

$$= (85 + 3.2)\,\text{m} = 88.2\,\text{m}.$$

(b) Given $$u = -8\,\text{ms}^{-1}; \quad a = 10\,\text{ms}^{-2}$$

$$4t = 5\,\text{sec}$$

$$v = u + at$$

$$= -8 + 10 \times 5$$

$$= 42\,\text{ms}^{-1}.$$

(c) Given $$u = -8\,\text{ms}^{-1}; \quad v = 0; \quad a = +10\,\text{ms}^{-2}$$

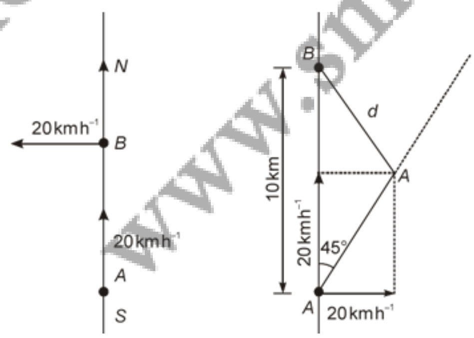
$$t = ?;$$

$$0 = -8 + 10t \quad \text{or} \quad t = 0.8\,\text{s}.$$

S27. $v_A = 20\,\text{km}\,\text{h}^{-1}$ due north, $v_B = 20\,\text{km}\,\text{h}^{-1}$ due west. Impress velocity $(-v_B)$ on both *B* and *A*. While *B* would come to rest, A would possess two velocities; $20\,\text{km}\,\text{h}^{-1}$ due north and $20\,\text{km}\,\text{h}^{-1}$ due east.

$$v_{AB} = 20\sqrt{2}\ \text{km}\,\text{h}^{-1}.$$

Note that the length *d* of the perpendicular will give the distance of closest approach.



Now, $\sin 45° = \dfrac{d}{10}$

or $d = 10 \sin 45°$

$= \dfrac{10}{\sqrt{2}} = 7.07\text{ km}$

Also, $\cos 45° = \dfrac{AA'}{10}$

or $AA' = \dfrac{10}{\sqrt{2}}\text{ km}$

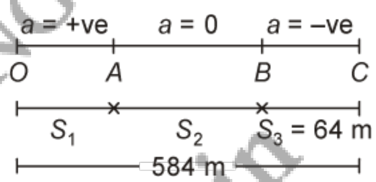
Now, $20\sqrt{2} = \dfrac{10}{\sqrt{2}\,t}$

or $t = \dfrac{1}{4}\text{ h} = \mathbf{0.25\text{ h.}}$

S28. First part

Given, $u = 0,\quad t_1 = 10\text{ sec},\quad v = 8\text{ m/s}$

Acceleration (a) $= \dfrac{8}{10} = 0.8\text{ m/s}^2$



$S_1 = ut_1 + \dfrac{1}{2}at_1^2$

$= \dfrac{1}{2}\left(\dfrac{8}{10}\right)(10)^2 = \mathbf{40\text{ m}}$

Second part $S_1 + S_2 + S_3 = 584$

and $S_2 = 584 - (S_1 + S_3)$

$= 584 - (40 + 64) = 480\text{ m}$

$S_2 = ut_2 + \dfrac{1}{2}at_2^2$

$\because$ $a = 0$

$S_2 = ut_2$

$t_2 = \dfrac{S_2}{u} = \dfrac{480}{8} = 60\text{ sec.}$

Third part $v = u - at_3$

$u = at_3$

$a = 8/t_3$

$$S_3 = ut_3 - \frac{1}{2}at_3^2$$

$$= 8t_3 - \frac{1}{2}\left(\frac{8}{t_3}\right)(t_3)^2$$

$$= 8t_3 - 4t_3$$

$$= 4t_3$$

$$t_3 = \frac{64}{4} = \mathbf{16\ sec}$$

$$a = \frac{8}{16} = -0.5 \text{ m/s}^2$$

Total time = $t_1 + t_2 + t_3$ = 10 + 60 + 16 = 86 sec.

S29. The rate of change of the velocity w.r.t. time it called the acceleration. It is vector quantity.

Initial velocity of the ball, u = 49 m/s

Acceleration, $a = -g = -9.8$ m/s

Case I: When the lift was stationary, the boy throws the ball.

Taking upward motion of the ball,

Final velocity, v of the ball becomes zero at the highest point.

From first equation of motion, time of ascent (t) is given as:

$$v = u + at$$

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

$$= \frac{-49}{-9.8} = 5\text{ s}$$

But, the time of ascent is equal to the time of descent.

Hence, the total time taken by the ball to return to the boy's hand = 5 + 5 = 10 s.

Case II: The lift was moving up with a uniform velocity of 5 m/s. In this case, the relative velocity of the ball with respect to the boy remains the same *i.e.*, 49 m/s. Therefore, in this case also, the ball will return back to the boy's hand after 10 s.

S30. (a) Average acceleration is greatest in interval 2

Explanation:

Acceleration is given by the slope of the speed-time graph. In the given case, it is given by the slope of the speed-time graph within the given interval of time.

Since the slope of the given speed-time graph is maximum in interval 2, average acceleration will be the greatest in this interval.

(b) Average speed is greatest in interval 3

Explanation:

Height of the curve from the time-axis gives the average speed of the particle. It is clear that the height is the greatest in interval 3. Hence, average speed of the particle is the greatest in interval 3.

(c) *v* is positive in intervals 1, 2, and 3

a is positive in intervals 1, zero in interval 3 and negative in interval 2

Explanation:

In interval 1: The slope of the speed-time graph is positive. Hence, acceleration is positive. Similarly, the speed of the particle is positive in this interval.

In interval 2: The slope of the speed-time graph is negative. Hence, acceleration is negative in this interval. However, speed is positive because it is a scalar quantity.

In interval 3: The slope of the speed-time graph is zero. Hence, acceleration is zero in this interval. However, here the particle acquires some uniform speed. It is positive in this interval.

(d) $a = 0$ at *A*, *B*, *C*, *D*

Explanation:

Points *A*, *B*, *C*, and *D* are all parallel to the time points. Therefore, at points *A*, *B*, *C*, and *D*, acceleration of the particle is zero.

S31. The instantaneous acceleration of an object is different as the limiting value of average acceleration of the object in a small time interval around that instant when the time interval approaches zero.

For a body having a uniform acceleration '*a*' in a straight line, starting with an initial velocity *u*, the displacement in '*n*' seconds is given by,

$$S_n = nu + \frac{1}{2}an^2$$

In $(n-1)$ seconds,

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

$\therefore$ Displacement in n^{th} second $= S_n - S_{n-1}$

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

Let *S* be the complete length of fall and *t* be the time taken for it. Then,

$$S = \frac{1}{2}gt^2 \qquad (\because \; u = 0) \quad \ldots \text{(i)}$$

Also, $\frac{S}{2}$ is covered in the last second.

$$\therefore \qquad \frac{S}{2} = 0 + \frac{g}{2}(2t - 1) \quad \ldots \text{(ii)}$$

Using Eq. (i) and (ii), solve for t to be,

$$g(2t - 1) = \frac{1}{2}gt^2,$$

i.e., $4tg - 2g = gt^2$

$$gt^2 - 4tg + 2g = 0$$

$\Rightarrow$ $t^2 - 4t + 2 = 0$

i.e., $$t = \frac{4 \pm \sqrt{16-8}}{2} = \frac{4 \pm 2\sqrt{2}}{2}$$

$$t = 2 \pm \sqrt{2}.$$

S32. (a) Distance travelled by the particle = Area under the given graph

$$= \frac{1}{2} \times (10 - 0) \times (12 - 0) = 60 \text{ m}$$

$$\text{Average speed} = \frac{\text{Distance}}{\text{Time}} = \frac{60}{10} = 6 \text{ m/s}$$

(b) Let s_1 and s_2 be the distances covered by the particle between time $t = 2$ s to 5 s and $t = 5$ s to 6 s respectively.

Total distance (s) covered by the particle in time $t = 2$ s to 6 s

$$s = s_1 + s_2 \quad \ldots \text{(i)}$$

For distance s_1 :

Let u' be the velocity of the particle after 2 s and a' be the acceleration of the particle in $t = 0$ to $t = 5$ s.

Since the particle undergoes uniform acceleration in the interval $t = 0$ to $t = 5$ s, from first equation of motion, acceleration can be obtained as:

$$v = u + at$$

Where, v = Final velocity of the particle

$$12 = 0 + a' \times 5$$

$$a' = \frac{12}{5} = 2.4 \text{ m/s}^2$$

Again, from first equation of motion, we have

$$v = u + at$$

$$= 0 + 2.4 \times 2 = 4.8 \text{ m/s}$$

Distance travelled by the particle between time 2 s and 5 s *i.e.*, in 3 s

$$s_1 = u't + \frac{1}{2}a't^2$$

$$= 4.8 \times 3 + \frac{1}{2} \times 2.4 \times (3)^2$$

$$= 25.2 \text{ m} \qquad \dots \text{(ii)}$$

For distance s_2:

Let a'' be the acceleration of the particle between time $t = 5$ s and $t = 10$ s.

From first equation of motion,

$$v = u + at \qquad \text{(where } v = 0 \text{ as the particle finally comes to rest)}$$

$$0 = 12 + a'' \times 5$$

$$a'' = \frac{-12}{5} = -2.4 \text{ m/s}^2$$

Distance travelled by the particle in 1 s (*i.e.*, between $t = 5$ s and $t = 6$ s)

$$s_2 = u''t + \frac{1}{2}at^2$$

$$= 12 \times 1 + \frac{1}{2}(-2.4) \times (1)^2$$

$$= 12 - 1.2 = 10.8 \text{ m} \qquad \dots \text{(iii)}$$

From equations (i), (ii), and (iii), we get

$$s = 25.2 + 10.8 = 36 \text{ m}$$

$$\therefore \qquad \text{Average speed} = \frac{36}{4} = 9 \text{ m/s}.$$

S33. ***For first stone:***

Initial velocity, $u_I = 15$ m/s

Acceleration, $a = -g = -10 \text{ m/s}^2$

Using the relation, $x_1 = x_0 + u_I t + \frac{1}{2}at^2$

Where, height of the cliff, $x_0 = 200$ m

$$x_1 = 200 + 15t - 5t^2 \qquad \dots \text{(i)}$$

When this stone hits the ground, $x_1 = 0$

$$\therefore \qquad -5t^2 + 15t + 200 = 0$$

$$t^2 - 3t - 40 = 0$$

$$t^2 - 8t + 5t - 40 = 0$$

$$t(t-8) + 5(t-8) = 0$$

$$t = 8 \text{ s} \quad \text{or} \quad t = -5 \text{ s}$$

Since the stone was projected at time $t = 0$, the negative sign before time is meaningless.

$\therefore$ $t = 8$ s

For second stone:

Initial velocity, $u_{II} = 30$ m/s

Acceleration, $a = -g = -10 \text{ m/s}^2$

Using the relation, $x_2 = x_0 + u_{II}\,t + \frac{1}{2}at^2$

$$= 200 + 30t - 5t^2 \quad \text{... (ii)}$$

At the moment when this stone hits the ground; $x_2 = 0$

$$5t^2 - 30t - 200 = 0$$

$$t^2 - 6t - 40 = 0$$

$$t^2 - 10t + 4t - 40 = 0$$

$$t(t-10) + 4(t-10) = 0$$

$$t(t-10)(t+4) = 0$$

$$t = 10 \text{ s} \quad \text{or} \quad t = -4 \text{ s}$$

Here again, the negative sign is meaningless.

$\therefore$ $t = 10$ s

Subtracting equations (i) and (ii), we get

$$x_2 - x_1 = (200 + 30t - 5t^2) - (200 + 15t - 5t^2)$$

$$x_2 - x_1 = 15t \quad \text{... (iii)}$$

Equation (iii) represents the linear path of both stones. Due to this linear relation between $(x_2 - x_1)$ and t, the path remains a straight line till 8 s.

Maximum separation between the two stones is at $t = 8$ s.

$$(x_2 - x_1)_{max} = 15 \times 8 = 120 \text{ m}$$

This is in accordance with the given graph.

After 8 s, only second stone is in motion whose variation with time is given by the quadratic equation:

$$x_2 - x_1 = 15 \text{ t}$$

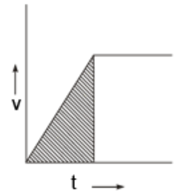
Hence, the equation of linear and curved path is given by

$$x_2 - x_1 = 15t \quad \text{(Linear path)}$$

$$x_2 = 200 + 30\,t - 5\,t^2 \quad \text{(Curved path).}$$

Date: 13/10/2021

Q1. The graph shows the velocity of a body at different times during motion. What does the area of the shaded portion of the graph represent?



Q2. Is it possible that your cycle has a northward velocity but southward acceleration? If yes, give an example?

Q3. Mention one consequence of the fact that instantaneous acceleration does not depend upon instantaneous velocity.

Q4. Even when rain is falling vertically downwards, the front screen of a moving car gets wet. On the other hand, the back screen remains dry. Why?

Q5. What is the velocity-time graph for a body moving with uniform velocity?

Q6. If the acceleration of the particle is constant in magnitude but not in direction, what type of path does the body follow?

Q7. Is it possible to have the rate of change of velocity constant while the velocity itself changes both in magnitude and direction?

Q8. A uniformly moving cricket ball is turned back by hitting it with a bat for a very short time-interval. Suggest acceleration-time graph for this situation.

Q9. Two masses in the ratio 1 : 2 are thrown vertically up with the same speed. What is the effect on the time by the mass?

Q10. The position coordinate of a moving particle is given by $x = 6 + 18t + 9t^2$ (x in metres and t in seconds). What is its velocity at $t = 2$ sec?

Q11. A body thrown up vertically reaches a maximum height of 100 m. Another body with double the mass thrown up with double the initial velocity reaches a maximum height h. What is the value of h?

Q12. A truck and a car with the same kinetic energy are brought to rest by the application of brakes which provide equal retarding forces. Which of them will come to rest in a shorter distance?

Q13. Which of the two decides the direction of motion of a particle: velocity or acceleration? Give one example in support of your answer.

Q14. What is the effect of operation of time reversal (changing t by $-t$) on the kinematic equations?

Q15. How long will see a boy sitting near the window of a train travelling at 54 km h^{-1} see a train passing by in the opposite direction with a speed of 36 km h^{-1}. The length of the slow-moving train is 100 m.

Q16. A swimmer's speed in the direction of flow of river is 16 km h^{-1}. Against the direction of flow of river, the swimmer's speed is 8 km h^{-1}. Calculate the swimmer's speed in still water and the velocity of flow of the river.

Q17. A highway motorist travels at a constant velocity of 45 km h^{-1} zone. A motorcyclist police officer has been watching from behind a bill board and at the same moment, the speeding motorist passes the bill board, the police officer accelerates uniformly from rest to overtake her. If the acceleration of the police officer is 10 km h^{-2}, how long does he take to reach the motorcyclist?

Q18. The engine of an electric train 72 m long passes a stationary car with a velocity of 6 ms^{-1}. When the tail end of the train passes the same car, its velocity is 9 ms^{-1}. Calculate the acceleration of the car and the time taken by the train to pass the car.

Q19. Derive an expression for stopping distance of vehicle in terms of initial velocity v_0 and deceleration a.

Q20. The position of an object moving along x-axis is given by $x = a + bt^2$ where a = 8.5 m, b = 2.5 m s^{-2} and t is measured in second. What is its velocity at t = 0 s and t = 2s? What is the average velocity between t = 2 s and t = 4 s?

Q21. An electron travelling with a speed of 5×10^3 m s^{-1} passes through an electric field with an acceleration of 10^{12} m s^{-2}. How long will it take for the electron to double its speed?

Q22. A stone is thrown downwards with a speed v from the top of a tower. It reaches the ground with a velocity $3v$. What is the height of the tower?

Q23. Is it possible for a body to be accelerated if its speed is constant?

Q24. A particle moves along x-axis in such a way that its co-ordinate x varies with time t according to the equation $x = 2 - 5t + 6t^2$. What is the initial velocity of the particle?

Q25. Discuss the motion of an object under free fall. Neglect air resistance.

Q26. What is the position at any time, for a body starting from rest, with acceleration $a = \alpha t^2$?

Q27. A ball is thrown vertically up with a velocity of 20 m/s. Construct acceleration-time and displacement-time graph.

Q28. The velocity of a particle is $v = 5 + 2\,(a_1 + a_2\,t)$ where a_1 and a_2 are constants and t is the time. What is the acceleration of the particle?

Q29. The race car accelerates on a straight road from rest to a speed of 180 km h^{-1} in 25 s. Assuming uniform acceleration of the car throughout, find the distance covered in this time. Use only the graphical method.

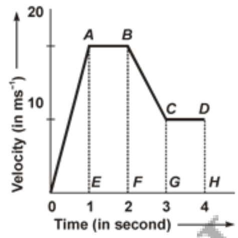
Q30. Is it possible that the brakes of a car are so perfect that the car stops instantaneously? If not, why not?

Q31. A woman standing on the edge of a cliff throws a ball straight up with a speed of 8 km h^{-1} and then throws another ball straight down with a speed of 8 km h^{-1} from the same position. What is the ratio of the speeds with which the balls hit the ground?

Q32. A mass A is released from the top of a frictionless inclined plane 18 m long and reaches the bottom 3 sec later. At the instant when A is released, a second mass B is projected upward along the plane from the bottom with a certain initial velocity u. The mass B travels a distance up the plane, stops and returns to the bottom so that it arrives simultaneously with A. The two masses do not collide with each other at any stage. Find the acceleration and initial velocity of B.

Q33. On a foggy day two drivers spot each other when they are just 80 metres apart. They were travelling at 72 km h^{-1} and 60 km h^{-1} respectively. Both of them applied brakes retarding their cars at the rate of 5 ms^{-2}. Determine whether they avoid the collision or not.

Q34. The variation of velocity of a particle moving along a straight line is shown in figure. Calculate the distance traversed in 4 second.



Q35. 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?

Q36. A body dropped from the top of a tower falls a through 40 m during the last two second of its fall. What is the height of the tower. Given: $g = 10$ m s^{-2}.

Q37. The speed of a motor launch with respect to still water is 7 m s^{-1} and the speed of the stream is 3 m s^{-1}. When the launch began travelling upstream, a float was dropped from it. The launch travelled 4.2 km upstream, turned about and caught up with the float. How long is it before the launch reached the float?

Q38. A ball is thrown vertically upwards with a velocity of 20 ms^{-1} from the top of a multi storey building. The height of the point from where the ball is thrown is 25.0 m from the ground. (a) How high will the ball rise? (b) How long will it be before the ball hits the ground? Take $g = 10$ ms^{-2}.

Q39. A body travels 200 cm in the first two second and 220 cm in the next four second. What will be the velocity at the end of seventh second from start?

Q40. The reaction time for an automobile driver is 0.7 second. If the automobile can be decelerated at 5 ms^{-2}, calculate the total distance travelled in coming to stop from an initial velocity of 30 km h^{-1}, after a signal is observed.

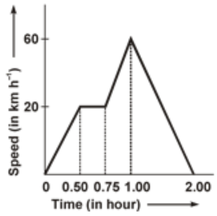
Q41. A body is thrown up with a velocity of 78.4 ms^{-1}. Find how high it will rise and how much time it will take to return to its point of projection.

Q42. A car accelerates from rest at a constant rate α for some time, after which it decelerates at a constant rate β to come to rest. If t is the total time elapsed, then calculate:

(a) the maximum velocity attained by the car

(b) the total distance travelled by the car.

Q43. A train moves from one station to another in two hours time. Its speed during the motion shown in the graph. Determine the maximum acceleration during the journey. Also calculate the distance covered during the time interval from 0.75 hour to 1 hour.



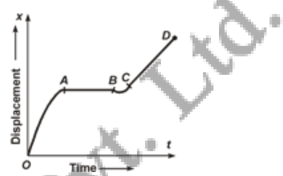
Q44. Given: The equations of motion of four particles *a*, *b*, *c* and *d*.

(a) $x_a = 3t + 9$; (b) $x_b = 4t^2 + t - 1$; (c) $x_c = 3t^3 - 4t^2 + 7t - 8$

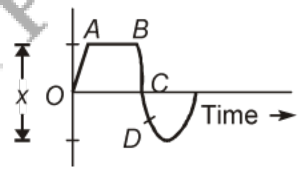
(d) $x_d = 4 \sin 45° - 6 \sin 60° + 7 \cos 30° - 18$.

Comment on the nature of motion of the four particles.

Q45. The figure shows the $x - t$ of a particle moving along a straight line. What is the sign of the acceleration during the intervals *OA*, *AB*, *BC* and *CD*?

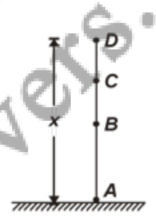


Q46. The figure gives the displacement of a particle along the *x*-axis as a function of time. What is the direction of velocity (a) between *O* and *A* (b) between *A* and *B* (c) between *C* and *D*?



Q47. Points *P*, *Q* and *R* are in a vertical line such that *PQ* = *QR*. A ball at *P* is allowed to fall freely. What is the ratio of the times of descent through *PQ* and *QR* ?

Q48. Water dips from a water-tap on to the floor *x* metre below. The first drop strikes the floor at the instant the fourth one begins to fall. Determine the positions of the drops when a drop just strikes the floor. Assume that the drops fall at regular intervals of time.



Q49. An object travels at a steady speed for a time t_1, then decelerates uniformly for time t_2 until it comes to rest. Sketch the following graphs for the motion:

(a) Displacement vs time (b) Velocity vs time (c) Acceleration vs time.

Q50. A body is projected vertically upwards from *A*, the top of a tower. It reaches the ground in t_1 second. If it is projected vertically downwards from *A* with the same velocity, it reaches the ground in t_2 second. If it falls freely from *A*, prove that it would reach the ground in $\sqrt{t_1 t_2}$ second.

Q51. The $x - t$ graph of a moving particle is shown in figure below. Comment on the signs of the velocities at the points *C*, *D*, *E* and *F*.

Q52. A motor car starts from rest and accelerates uniformly for 10 seconds to a velocity of 8 metre/sec. It then runs at a constant velocity and is finally brought to rest in 64 metres with a constant retardation. The total distance passed over is 584 metres. Find the value of acceleration, retardation and the total time taken. Represent the motion graphically.

Q53. 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?

Q54. A ball rolls down an inclined track 2 m long in 4 s. Find (a) acceleration (b) time taken to cover the second metre of the track and (c) speed of the ball at the bottom of the track.

Q55. A car has a speed of 30 km/hour at any one instant. 2 sec later its speed is 36 km/hour and 2 sec after that it is 42 km/hour. If it continues to accelerate like this find (a) the speed at 8 sec and 9 sec. (b) What was its speed 4 sec before it was 30 km/hour. (c) What is its acceleration?

Q56. Brakes are applied to a train travelling at 72 km per hour. After passing over 200 meters its velocity is reduced to 36 km per hour. At the same rate of retardation, how much further will it go before it is brought to rest?

Q57. A stone is dropped from a certain height. After falling for 5 second, the stone breaks through a plane of glass and instantaneously loses half of its velocity. If the stone then takes one more second to reach the ground, determine the height of the glass above the ground. Given: $g = 10\ ms^{-2}$.

Q58. A body moving with uniform acceleration describes 135 m in the last second of its motion. If is starts from rest, how long was it in motion and through what distance did it move if the distance covered in the first second is 15 m.

Q59. A player throws a ball upwards with an initial speed of 29.4 m s^{-1}.

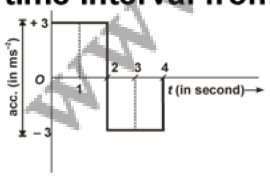
(a) What is the direction of acceleration during the upward motion of the ball?

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

(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.

(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).

Q60. A particle starts from rest at time $t = 0$ and suffers acceleration as shown in figure. Draw the velocity-time graph for the time interval from 0 to 4 second.



Q61. The velocity of a train increases at a constant rate α from zero to v and then remains constant for an interval and finally decreases to zero at a constant rate β. If x be the total distance covered by the particle, then prove that the total time taken is

$$t = \frac{x}{v} + \frac{v}{2}\left(\frac{1}{\alpha} + \frac{1}{\beta}\right)$$

Use only the graphical method.

Q62. A balloon is ascending at the rate of 14 ms^{-1} at a height of 98 m above the ground when a packet is dropped from the balloon. After how much time and with what velocity does it reach the ground?

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S1. The area of the shaded portion of the graph represent the ***Distance***.

S2. Yes, when brakes are applied to a moving cycle, the directions of velocity and acceleration are opposite.

S3. The directions of velocity and acceleration are not related to each other.

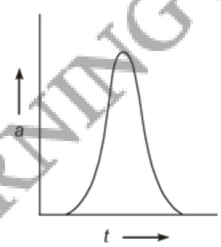
S4. The rain strikes car in the direction of the relative velocity of rain with respect to car.

S5. Straight line parallel to time-axis.

S6. The particle run in the circular path.

S7. Yes. It is possible in Projectile motion.

S8. The figure shows the acceleration-time graph.



S9. Mass does not influence time.

S10. Given $x = 6 + 18t + 9t^2$

Now, $v = \frac{dx}{dt} = 18 + 18t$

$$(v)_{t=2} = 18 + 18 \times 2 = 54 \text{ ms}^{-1}.$$

S11. Given, Height (h) = 100 m, $v = 0$, $u = ?$

We know,

$$v^2 = u^2 - 2gh$$

$$u^2 = 2gh$$

Now, second whose velocity

$u' = 24$ and height h'

$v' = 0$

$$v'^2 = u'^2 - 2gh'$$

$$h' = \frac{u'^2}{2g} = \frac{4u^2}{2g}$$

$$= \frac{4 \times \cancel{2g} \times h}{\cancel{2g}}$$

$$h' = 4 \times 100 \text{ m} = \mathbf{400\ m}.$$

S12. Both truck and car will stop at the same distance.

S13. It is the velocity which determines the direction of motion of a particle and not the acceleration. As an example, when a ball is thrown up, the acceleration is directed downwards but the direction of motion of the ball is in the direction of velocity.

S14. The kinematic equations are invariant under the effect of operation of time reversal. So, even if t is replaced by '$-t$', the kinematic equations do not change.

S15. The relative velocity of the slow-moving train w.r.t. the boy = (54 + 36) km h^{-1}

$$= 90 \times \frac{5}{18} \text{ m s}^{-1} = 25 \text{ m s}^{-1}$$

Now, $25 = \frac{100}{t}$ $\left[1 \text{ km h}^{-1} = \frac{5}{18} \text{ m s}^{-1}\right]$

or $t = \frac{100}{25} \text{ s} = \mathbf{4\ s}.$

S16. Let v_s and v_r represent the velocities of swimmer and river respectively.

Now, $v_s + v_r = 16$ ... (i)

and $v_s - v_r = 8$ ... (ii)

Adding, Eq. (i) and (ii), we have

$$2v_s = 16 + 8$$
$$= 24 \text{ km h}^{-1}$$

$$v_s = 12 \text{ km h}^{-1}$$

From Eq. (i), $12 + v_r = 16$ or $v_r = 4 \text{ km h}^{-1}$.

S17. Let the bill board be taken as the origin. let t be the required time. Let P represent the position where the police officer reaches the motorist.

For the motorist: (It is a case of uniform motion.)

When $t = 0, \quad x(0) = 0, \quad v = 45 \text{ km h}^{-1}$

$x(t) = x(0) + vt$ or $x(t) = vt$ $[\because\ x(0) = 0]$

$= 45 \text{ km h}^{-1} \times t = 45\,t \text{ km}$ ... (i)

For the police officer: (It is a case of accelerated motion.)

When $t = 0, \quad x(0) = 0, \quad v(0) = 0, \quad a = 10 \text{ km h}^{-2}$

Now, $$x(t) = x(0) + v(0)\,t + \frac{1}{2}\,at^2$$

$$x(t) = 0 + 0 + \frac{1}{2} \times 10 \times t^2 = 5t^2 \text{ km} \quad \text{... (ii)}$$

Comparing (i) and (ii), we get

$$5t^2 = 45\,t \quad \text{or} \quad t = \mathbf{9\ hour}.$$

S18. Given, $u = 6 \text{ ms}^{-1}, \quad v = 9 \text{ ms}^{-1}, \quad S = 72 \text{ m}$

Using $v^2 - u^2 = 2aS$

we get $9^2 - 6^2 = 2 \times a \times 72$

or $$144a = (15 \times 3) = 45 \quad \text{or} \quad a = \frac{45}{144} \text{ ms}^{-2} = \mathbf{0.3125\ ms^{-2}}$$

Again using $v = u + at$, we get

$$9 = 6 + \frac{45}{144}\,t$$

or $$\frac{45}{144}\,t = 3 \quad \text{or} \quad \frac{144}{15}\,s = \mathbf{9.6\ s}.$$

S19. Let d_s be the distance travelled by a vehicle before it stops

Using $v^2 - u^2 = 2aS$,

we get, $0^2 - v_0^2 = -2ad_s$

or $$d_s = \frac{v_0^2}{2a}$$

The stopping distance is proportional to the square of the initial velocity. Doubling the initial velocity increases the stopping distance by a factor of 4, provided deceleration is kept the same.

S20.

$$v = \frac{dx}{dt} = \frac{d}{dt}(a + bt^2)$$

$$= 2bt$$

$$= 5.0\,t \text{ m s}^{-1}$$

At $t = 0 \text{ s}, \quad v = \mathbf{0\ m\,s^{-1}}$ and at $t = 2 \text{ s}, \quad v = \mathbf{10\ m\,s^{-1}}$

$$\text{Average velocity} = \frac{x(4) - x(2)}{4 - 2} = \frac{a + 16b - a - 4b}{2}$$

$$= 6b = 6 \times 2.5 = \mathbf{15.0\ m\,s^{-1}}.$$

S21. $v(0) = 5 \times 10^3\,\text{m s}^{-1}, \quad a = 10^{12}\,\text{m s}^{-2},$

$v(t) = 2 \times v(0) = 2 \times 5 \times 10^3\,\text{m s}^{-1}, \quad t = ?$

Now, $v(t) = v(0) + at$

$\therefore$ $2 \times 5 \times 10^3 = 5 \times 10^3 + 10^{12}\,t$

or $10^{12}\,t = 5 \times 10^3$

or $t = \dfrac{5 \times 10^3}{10^{12}}\,\text{s}$

or $t = \mathbf{5 \times 10^{-9}\,s}$.

S22. Using, $v^2 - u^2 = 2aS,$

We get, $9v^2 - v^2 = 2gh$ or $h = \dfrac{8v^2}{2g}$ or $h = \dfrac{4v^2}{g}$.

S23. Yes, it is possible for a body to be accelerated even if the speed of the body is constant. As an example, consider a particle moving with uniform speed along the circumference of a circle. This particle shall possess acceleration called centripetal acceleration.

S24. $x = 2 - 5t + 6t^2$

Velocity, $v = \dfrac{dx}{dt} = \dfrac{d}{dt}(2 - 5t + 6t^2)$ or $v = -5 + 12t$

For initial velocity, $t = 0$

$\therefore$ Initial velocity $u = -5\ \text{ms}^{-1}$.

S25. An object released near the surface of the Earth is accelerated downward under the influence of the force of gravity. The acceleration due to gravity is represented by g. If air resistance is neglected, the object is said to be in *free fall*.

If the height through which the object falls is small compared to the Earth's radius, g can be taken to be constant, equal to $9.8\,\text{ms}^{-2}$. Free fall is thus a case of motion with uniform acceleration.

S26. Given, $a = \alpha t^2$ is a variable acceleration.

$\therefore$ $\dfrac{dv}{dt} = \alpha t^2 \Rightarrow dv = \alpha t^2\,dt$

$$\int dv = \int_0^t \alpha t^2 dt \Rightarrow v = \left|\frac{\alpha t^3}{3}\right|_0^t \Rightarrow v = \frac{\alpha t^3}{3}$$

Also $v = \dfrac{dx}{dt} \Rightarrow dx = vdt$

$\therefore \quad dx = \frac{\alpha t^3}{3} dt$

or $\quad \int_{x_i}^{x_f} dx = \int_0^t \frac{\alpha t^3}{3} dt \Rightarrow |x|_{x_i}^{x_f} = \frac{\alpha t^4}{12}$

$\therefore \quad x_f - x_i = \frac{\alpha t^4}{12} \qquad x_f = x_i + \frac{\alpha t^4}{12}$

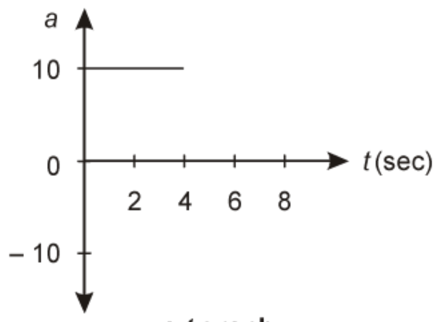
is the final position at time '*t*' seconds.

S27. $u = 20\ ms^{-1}, \quad a = g\ ms^{-2}$

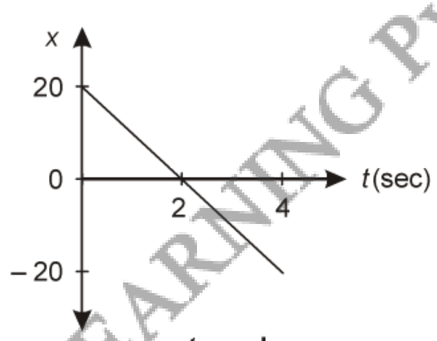
Time to reach the highest point,

$$t = \frac{u}{g} = 2 \text{ seconds.}$$

$$\text{Max. height} = \frac{1}{2} g \times 4 = 20 \text{ m.}$$



***a-t* graph**



***x-t* graph**

S28. Given $\quad v = 5 + 2\,(a_1 + a_2 t)$

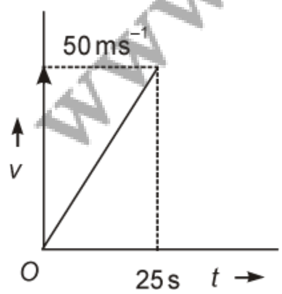
Now $\quad a = \frac{dv}{dt} = \frac{d}{dt}[5 + 2\,(a_1 + a_2 t)]$

$a = 2a_2.$

S29.

$$v = 180 \times \frac{5}{18}\ ms^{-1}$$

$$= 50\ ms^{-1}$$

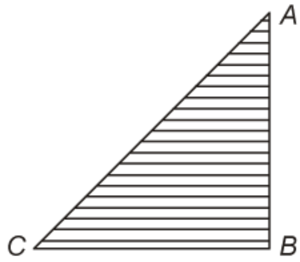


Distance covered = Area under graph = $\frac{1}{2} \times 25 \times 50$ m = **625 m**.

S30. Suppose the car is stopped instantaneously. This would mean that the velocity is reduced to zero in an infinitesimally small interval of time. This would further mean that the car has infinite deceleration. This is not possible. Thus, we cannot have a car which can stop instantaneously.

S31. 1 : 1. Both the balls will hit the ground with the same speed. This is because the first ball will cross the point of throw in the downward direction with a velocity of 8 km h^{-1}.

S32. As the mass *A* starts from rest.



Given, $u = 0, \quad S = 18\,\text{m}, \quad t = 3\,\text{sec} \quad \text{and} \quad a = ?$

Now, $S = \frac{1}{2}at^2$ or $18 = \frac{1}{2}a \times 9$

$\therefore$ $a = 4\ \text{ms}^{-2}$

i.e., the acceleration down the plane is 4 ms^{-2}

As the two masses return simultaneously without collision, total time taken by mass *B* is 3 sec. Thus it takes 1.5 sec to reach a point where it stops and then returns. Hence for the mass *B*

Initial velocity $u = ?, \quad v = 0, \quad t = 1.5 \quad \text{and} \quad a = -4\ \text{ms}^{-2}$

$\therefore$ $0 = u + (-4 \times 1.5)$

or $u = 6\ \text{ms}^{-1}$

hence initial velocity of *B* is 6 ms^{-1} and acceleration $-4\ \text{ms}^{-2}$.

S33. The two drivers will avoid the collision if the total distance covered by both is less than 80 m.

For one car $u = 72\ \text{km h}^{-1} = 20\ \text{ms}^{-1}, \quad a = -5\ \text{ms}^{-2}$

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

$$\therefore \quad S = \frac{0^2 - 20^2}{2 \times (-5)} = \frac{400}{10} = 40\ \text{m}$$

For the other car $u = 60\ \text{km h}^{-1} = \frac{50}{3}\ \text{ms}^{-1}, \quad a = -5\ \text{ms}^{-2}$

$$S = \frac{v^2 - u^2}{2as}$$

$$\therefore \quad S = \frac{0^2 - \left(\frac{50}{3}\right)^2}{2 \times (-5)} = 27.78\ \text{m}$$

Total distance = 40 + 27.78 = 67.78 m

As this distance is less than 80 m, hence collision will be avoided.

S34. The distance traversed in 4 second is given by the area under velocity-time graph.

Area under velocity-time graph = Area of ΔOEA + area of rectangle $AEFB$ + Area of trapezium $BFGC$ + Area of rectangle $CGHD$

$$= \left[\frac{1}{2}(1\times 20)+(1\times 20)+\frac{1}{2}(20+10)1+10\times 1)\right]\text{m}$$

$$= (10 + 20 + 15 + 10)\,\text{m} = \mathbf{55\ m}.$$

S35. Initial velocity of the car, u = 126 km/h = 35 m/s

Final velocity of the car, $v = 0$

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

Retardation produced in the car = a

From third equation of motion, a can be calculated as:

$$v^2 - u^2 = 2as$$

$$(0)^2 - (35)^2 = 2\times a\times 200$$

$$a = -\frac{35\times 35}{2\times 200} = -3.06\ \text{m/s}^2$$

From first equation of motion, time (t) taken by the car to stop can be obtained as:

$$v = u + at$$

$$t = \frac{v-u}{a} = \frac{-35}{-3.06} = \mathbf{11.44\,s}.$$

S36. Let h be the height of the tower, Let t be the time of fall.

Now, initial velocity, $u = 0$; acceleration, $a = 10\ \text{m s}^{-2}$

Using $S = ut + \frac{1}{2}at^2$,

we get $h = 0\times t + \frac{1}{2}\times 10\times t^2$

or $h = 5t^2$ ... (i)

Since the body travels 40 m during the last two second therefore the body covers (h – 40) second.

Again, using

$$S = ut + \frac{1}{2}at^2,$$

we get $h - 40 = 0\times t + \frac{1}{2}\times 10(t-2)^2$

or $$h - 40 = 5\,(t-2)^2 \quad \ldots \text{(ii)}$$

Subtracting (ii) from (i), we get

$$40 = 5\,[t^2 - (t - 2t)^2]$$

$$[t - (t-2)]\,[t + (t-2)] = 8 \quad \text{or} \quad 2t - 2 = 4$$

$$t = 3 \text{ second}$$

From equation (i),

$$\text{Height of tower} = 5\,t^2$$

$$h = 5 \times 3 \times 3 \text{ m} = \mathbf{45\,m}.$$

S37. Relative velocity of the launch while travelling upstream

$$= \text{launch velocity} - \text{stream velocity}$$

$$= (7 - 3)\text{ m s}^{-1} = 4 \text{ m s}^{-1}.$$

Time taken by the launch for travelling a distance of 4.2 km,

$$t_1 = \frac{4.2 \times 10^3}{4} = 1.05 \times 10^3 \text{ sec}$$

Suppose t is the time taken by the launch after dropping the float and meeting it again.

Distance travelled by the float during time

$$= 3\,(\text{m s}^{-1}) \times t\,(s) = 3t \text{ metre.}$$

Relative velocity of the launch while travelling downstream = $(7 + 3)\text{ m s}^{-1} = 10 \text{ m s}^{-1}$.

Distance travelled down the stream

$$= (4.2 \times 10^3 + 3t) \text{ metre.}$$

If t_2 is the time taken to cover this distance, then

$$t_2 = \frac{4.2 \times 10^3 + 3t}{10} \text{ s.}$$

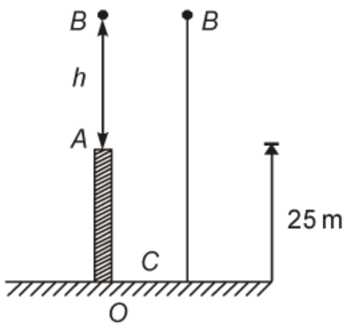
Again, $$t = t_1 + t_2 = 1.05 \times 10^3 + \frac{4.2 \times 10^3 + 3t}{10}.$$

$$t = 1.05 \times 10^3 + 0.42 \times 10^3 + 0.3t$$

On simplification, $t = 2100$ s = **35 minute**.

S38. (a) $$v(0) = +20 \text{ ms}^{-1}, \quad v(t) = 0 \text{ ms}^{-1},$$

$$a = -10 \text{ ms}^{-2}, \quad S = h$$



Using $v(t)^2 - v(0)^2 = 2\,ah$,

we get $0^2 - 20 \times 20 = 2\,(-10)\,h$

$$h = \frac{400}{20} \text{ m} = \mathbf{20\,m}$$

(b) $v(0) = +20\,ms^{-1}, \quad a = -10\,ms^{-2}$

$t = ?, \quad y(t) = -25$ m

Using $y(t) = v(0)t + \frac{1}{2}at^2$

we get, $-25 = 20t - \frac{1}{2} \times 10 \times t^2$

or $5t^2 - 20t - 25 = 0$

or $t^2 - 4t - 5 = 0$

or $t^2 - 5t + t - 5 = 0$

or $t(t-5) + 1(t-5) = 0$

On solving $t = -1$ s, 5 s.

Rejecting negative value of time, $t =$ **5 s**.

Note: For solving part (b), there is no need to separately consider paths *AB* and *BC*.

While using $S = ut + \frac{1}{2}at^2$, we have taken *S* as magnitude of displacement and not path length. The path length is clearly greater than the magnitude of displacement.

S39. At $t = 0, \quad x(0) = 0, \quad v(0) = u$ (say),

$x(t) = 200$ cm, $\quad t = 2$ s

$x(t') = (200 + 220)$ cm $= 420$ cm

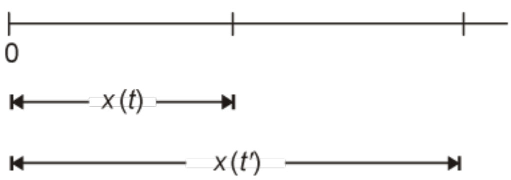
$t' = (2 + 4)$ s $= 6$ s.

If *a* be the uniform acceleration of the particle, then

$$x(t) = x(0) + v(0)\,t + \frac{1}{2}at^2$$

$$200 = 0 + u \times 2 + \frac{1}{2}a \times 4 \quad \text{or} \quad 100 = u + a \qquad \text{... (i)}$$

Again, $x(t') = x(0) + v(0)\,t + \frac{1}{2}at'^2$



$$420 = 0 + u \times 6 + \frac{1}{2} \times a \times 36$$

$$70 = u + 3a \qquad \text{..........(ii)}$$

$x(t) = 200$ cm

$x(t') = 420$ cm

Subtracting (i) from (ii), we get

$$-30 = 2a \quad \text{or} \quad a = -15 \text{ cm s}^{-2}$$

From Eq. (i), we get

$$u = 100 - (-15) = 115 \text{ cm s}^{-1}$$

Now, $t'' = 7 \text{ s}, \quad v(t'') = ?$

$$v(t'') = v(t) + at''$$

$\therefore$ $v(t'') = (115 - 15 \times 7) \text{ cm s}^{-1} = \mathbf{10 \text{ cm s}^{-1}}$.

S40. Since the reaction time of the driver is 0.7 second therefore the automobile, during this time, will continue to move with uniform velocity of 30 km h^{-1},

i.e., $30 \times \dfrac{5}{18} \text{ ms}^{-1} \quad \text{or} \quad \dfrac{25}{3} \text{ ms}^{-1}$.

Distance covered during 0.7 second = $\dfrac{25}{3} \times 0.7 \text{ m} = 5.83$

Let us chose that time as reference time ($t = 0$) when the automobile begins to decelerate.

So, at $t = 0, \quad x(0) - 0, \quad v(0) = \dfrac{25}{3}, \; a = -5 \text{ ms}^{-2}, \quad x(t) = ?, \quad v(t) = 0$

$$0^2 - \left(\frac{25}{3}\right)^3 = 2(-5)[x(t) - 0]$$

or $$x(t) = \frac{625}{9} \times \frac{1}{10} \text{ m}$$

Total distance travelled = 5.83 m + 6.94 m = **12.77 m**.

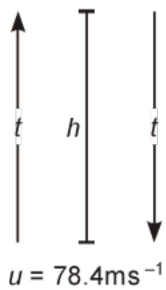
S41. Given, $u = 78.4 \text{ ms}^{-1}, \quad \text{time} = 2t = ?, \quad h = ?$

Let time (t) taken maximum height of the body h in this case $v = 0$

$$v^2 = u^2 - 2gh$$

$$h = \frac{78.4^2}{9.8 \times 2}$$

$$= 313.6 \text{ m}$$



$$v = u - gt$$

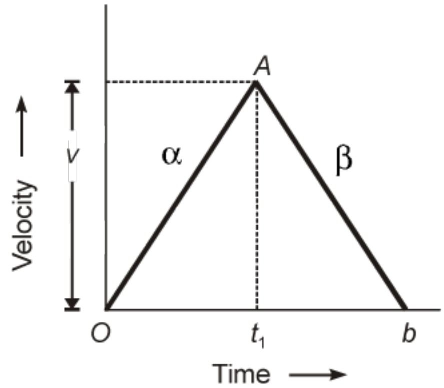
$$u = gt$$

$$t = u/g$$

$$= \frac{78.4}{9.8} = 8 \text{ sec.}$$

Total time taken $2t = 2 \times 8 =$ **16 sec**.

S42. (a) Starting from rest, let the car accelerate for a time t_1. Then, its velocity-time graph is a straight line *OA* sloping upwards. Let *v* be the maximum velocity attainted by the car. Slope of velocity-time graph *OA* gives the acceleration α.



$$\alpha = \frac{v}{t_1} \quad \text{or} \quad t_1 = \frac{v}{\alpha} \qquad \text{... (i)}$$

After attaining the maximum velocity, the car begins to decelerate. The velocity-time graph is *AB*. Its slope will give the retardation β.

$$\text{Now,} \quad \beta = \frac{v}{t - t_1} \quad \text{or} \quad t - t_1 = \frac{v}{\beta} \qquad \text{... (ii)}$$

Adding Eq. (i) and (ii), we get

$$t = v\left(\frac{1}{\alpha} + \frac{1}{\beta}\right)$$

or

$$v = \frac{\alpha\beta}{\alpha + \beta}\, t$$

which gives the maximum velocity attained by the car.

(b) Again, we know that the area under the velocity-time graph gives the distance covered.

$\therefore$ Distance covered = Area of $\Delta\, OAB$

$$= \frac{1}{2} \times t \times v = \frac{1}{2} \times t \times \frac{\alpha\beta}{\alpha + \beta}\, t = \frac{1}{2}\frac{\alpha\beta}{\alpha + \beta}\, t^2.$$

S43. We know that the slope of the velocity-time graph gives acceleration. It is clear from the graph that the slope is maximum between 0.75 h to 1 h.

Change in velocity in this interval = (60 – 20) km h^{-1} = 40 km h^{-1}

$\therefore$ Acceleration in this interval = $\dfrac{40\ \text{km h}^{-1}}{\frac{1}{4}\ \text{h}}$ = **160 km h^{-2}**

Distance covered during the time interval from 0.75 h to 1 h

= Area under the corresponding velocity-time graph

$$= \frac{1}{2}(20 + 60)\, 0.25 = 10\ \text{km}$$

[$\because$ Area of trapezium = (sum of || sides) **x** perpendicular distance between parallel sides]

S44. (a) $\dfrac{d}{dt}(x_a) = \dfrac{d}{dt}(3t + 9) = 3$

Since velocity is independent of time therefore the particle moves with uniform velocity.

(b) $\frac{d}{dt}(x_b) = 8t + 1;\quad v_b = 8t + 1;\quad \frac{d}{dt}(v_b) = 8;\quad a_b = 8$

The acceleration is independent of time. So, the particle moves with uniform acceleration.

(s) $\frac{d}{dt}(x_c) = \frac{d}{dt}(3t^3 - 4t^2 + 7t - 8) = 9t^2 - 8t + 7;\quad v_c = 9t^2 - 8t + 7;\quad a_c = \frac{d}{dt}(9t^2 - 8t + 7) = 18t - 8$

The acceleration is time-dependent. So, the particle moves with variable acceleration.

(d) x_d does not depend upon time. So, the particle is at rest.

S45. (a) Acceleration is –ve during the interval *OA*.

(b) Acceleration is zero during the interval *AB*.

(c) Acceleration is +ve during the interval *BC*.

(d) Acceleration is zero during the interval *CD*.

S46. **Slope of the given graph gives velocity.**

(a) Between *O* and *A*, the slope of *x*-*t* graph is +ve. Since the slope of *x*-*t* graph gives velocity, therefore, the direction of velocity is along +ve direction of *x*-axis.

(b) Between *A* and *B*, the position does not change with time. So, velocity is zero.

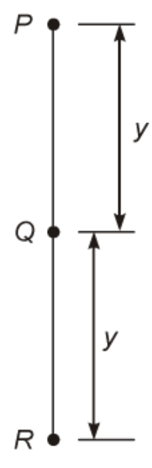
(c) Between *C* and *D*, the velocity is –ve.

S47. Let, t_1 is the time taken from *P* to *Q* and t_2 is the time taken from *Q* to *R*.

For motion from *P* to *Q*, we apply

$$S = ut_1 + \frac{1}{2}gt_1^2 \qquad (\because\ u = 0)$$

$$y = \frac{1}{2}gt_1^2$$



Similarly, motion from *P* to *R*.

$$2y = \frac{1}{2}g(t_1 + t_2)^2$$

Now, $2t_1^2 = (t_1 + t_2)^2$

or $\sqrt{2}\,t_1 = t_1 + t_2$

or $t_1(\sqrt{2} - 1) = t_2$ or $\frac{t_1}{t_2} = \frac{1}{\sqrt{2} - 1}$.

S48. If *t* be the time-interval between two successive drops, then

Distance between *CD*

$$CD = ut + \frac{1}{2}gt^2 \qquad (\because\ u = 0)$$

$$CD = \frac{1}{2}gt^2 \quad \text{... (i)}$$

$$BD = 4 \times \frac{1}{2}gt^2 \quad \text{... (ii)}$$

and $$AD = 9 \times \frac{1}{2} \times gt^2 \quad (\because \; u = 0) \quad \text{... (iii)}$$

$\because$ $$AD = x$$

$$x = \frac{9}{2}gt^2$$

$$gt^2 = \frac{2x}{9}$$

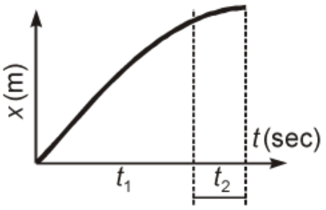
Put gt^2 value of Eq. (i) & (iii), we get

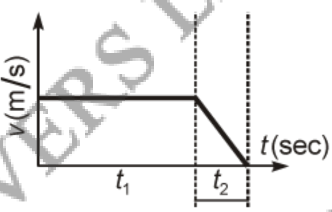
$$BD = 4 \times \frac{1}{\cancel{2}} \times \frac{\cancel{2}}{9}x$$

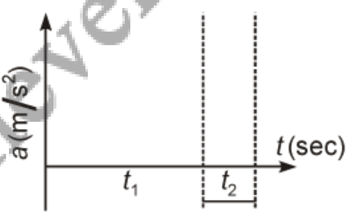
$$= \frac{4}{9}x,$$

$$CD = \frac{1}{\cancel{2}} \times \frac{\cancel{2}}{9}x$$

$$CD = \frac{x}{9}.$$

S49. (a) 

(b) 

(c) 

S50. Given:

$$h = -ut_1 + \frac{1}{2}gt_1^2 \quad \text{... (i)}$$

$$h = ut_2 + \frac{1}{2}gt_2^2 \quad \text{... (ii)}$$

Subtracting Eq. (i) and (ii), we get

$$0 = u(t_2 + t_1) + \frac{1}{2}gt_2^2 - \frac{1}{2}gt_1^2$$

or $$u(t_2 + t_1) + \frac{1}{2}g(t_2 + t_1)(t_2 - t_1) = 0$$

or $$u + \frac{1}{2} g (t_2 - t_1) = 0$$

or $$u = -\frac{g}{2} (t_2 - t_1)$$

Now, $$h = \frac{gt_1}{2} (t_2 - t_1) + \frac{1}{2} gt_1^2 = \frac{1}{2} gt_1 t_2$$

Again, when the body falls freely,

$$h = \frac{1}{2} gt^2; \quad \frac{1}{2} gt_1 t_2 = \frac{1}{2} gt^2$$

or $$t = \sqrt{t_1 t_2}\ .$$

S51. At C, the velocity is +ve. The tangent to the displacement-time graph at C makes an acute angle with the time-axis. So, slope and hence velocity is +ve.

(a) At D, the velocity is zero. (a) At E, the velocity is –ve. (a) At F, the velocity is +ve.

S52. Given, $u = 0$, $v = 8$ m/sec, $t = 10$ s

Substituting in the relation $v = u + at$, we get

$$a = \frac{v - u}{t} = \frac{8}{10} = 0.8 \text{ ms}^{-2}$$

Hence distance covered in 10 seconds

$$S = ut + \frac{1}{2} at^2 = 0 + \frac{1}{2} \times 0.8 \times 100 = 40 \text{ m}$$

The motor car moves for some time with uniform velocity of 8 metres/sec before suffering retardation. When the body suffers retardation, its

Initial velocity $u = 8$ m/sec, $v = 0$ and $S = 64$ m

Acceleration $$a = \frac{v^2 - u^2}{2S} = \frac{0 - 8^2}{2 \times 64} = -0.5 \text{ ms}^{-2}$$

or Retardation = 0.5 ms^{-2}

$\therefore$ Time taken to cover the distance during retardation

$$t = \frac{v - u}{a} = \frac{0 - 8}{-0.5} = 16 \text{ s}$$

Total distance travelled = 584 m

Distance travelled during accelerated and retarded motions

$$= 40 + 64 = 104 \text{ m}$$

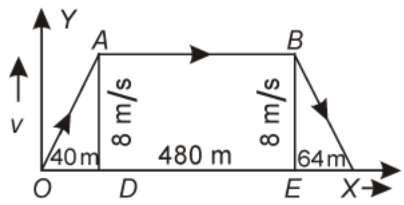
Distance travelled **with** constant velocity

$= 584 - 104 = 480$ m

Time taken to cover 480 m = 480/8 = 60 s

Total time to cover 584 m = 10 + 16 + 60 = 86 s

Graphical representation of motion is shown in the figure:



S53. ***For train A:***

Initial velocity, $u = 72$ km/h = 20 m/s

Time, $t = 50$ s

Acceleration, $a_1 = 0$.

Since it is moving with a uniform velocity.

From second equation of motion, distance (S_1) covered by train A can be obtained as:

$$S_1 = ut + \frac{1}{2}a_1t^2$$

$$= 20 \times 50 + 0 = 1000 \text{ m}.$$

For train B:

Initial velocity, $u = 72$ km/h = 20 m/s

Acceleration, $a = 1$ m/s^2

Time, $t = 50$ s

From second equation of motion, distance (S_{11})covered by train A can be obtained as:

$$S_{11} = ut + \frac{1}{2}at^2$$

$$= 20 \times 50 + \frac{1}{2} \times 1 \times (50)^2 = 2250 \text{ m}.$$

Hence, the original distance between the driver of train A and the guard of train B is 2250 –1000 = 1250 m.

S54. (a) Given, $S = 2$ m, $t = 4$ s, $u = 0$

Substituting in relation $S = ut + \frac{1}{2}at^2$, we get

$$2 = 0 + \frac{1}{2}a \times 4 \times 4$$

or $a = 2/8 = 0.25 \text{ ms}^{-2}$

Velocity at the end of 1 metre is given by

$$v^2 - u^2 = 2aS$$

or $$v^2 = 2 \times 0.25 \times 1 = 0.5$$

or $$v = \sqrt{0.5} = 0.707\ \text{ms}^{-1}.$$

Now time to cover first one metre is find out from the relation $v = u + at$, *i.e.*,

$$0.707 = 0 + at = 0.25\,t$$

or $$t = \frac{0.707}{0.25} = 2.83\ \text{s}$$

(b) Time taken to cover second metre = 4 – 2.83 = 1.17 s

(c) Speed at the bottom $v = u + at = 0 + 0.25 \times 4 = 1\ \text{ms}^{-1}$.

S55. Speed at any instant t = 30 km/hour = $\frac{30000}{3600} = \frac{25}{3}\ \text{ms}^{-1}$.

As the body covers equal distance in equal intervals of time, the motion is uniformly accelerated.

Velocity after (t + 2) sec = 36 km/h = 10 ms^{-1}

$\therefore$ Acceleration, $$a = \left(10 - \frac{25}{3}\right) \times \frac{1}{2} = \frac{5}{6}\ \text{ms}^{-2}$$

As the body starts from rest, $u = 0$

$$v = u + at$$

$\therefore$ $$\frac{25}{3} = 0 + \frac{5}{6}t$$

or $$t = \frac{25}{3} \times \frac{6}{5} = 10\ \text{s}$$

(a) Let v_1 be the speed of the body 8 s after the instance t, then

$$v_1 = 0 + \frac{5}{6}(10 + 8) = \frac{5}{6} \times 18 = 15\ \text{ms}^{-1} = \mathbf{54\ km\ h^{-1}}.$$

Similarly, if v_2 be the speed at 9 s after the instance t, then

$$v_2 = 0 + \frac{5}{6}(10 + 9) = \frac{95}{6}\ \text{ms}^{-1} = \mathbf{57\ km\ h^{-1}}.$$

(b) The speed 4 s before it was 30 km h^{-1} is given by

$$v = 0 + \frac{5}{6}(10 - 4) = \frac{5}{6} \times 6 = 5\ \text{ms}^{-1} = \mathbf{18\ km\ h^{-1}}.$$

S56. Initial velocity

$$u = 72\ \text{km/hour} = \frac{\cancel{72}^{\,4} \times 5}{\cancel{18}} = 20\ \text{ms}^{-1}$$

Final velocity $v = 36 \text{ km/hour} = \frac{36 \times 5}{18} = 10 \text{ ms}^{-1}$

Distance covered $S = 200 \text{ m}$

Now, $v^2 - u^2 = 2aS$

or $10^2 - 20^2 = 2a \times 200$

$\therefore$ $a = \frac{10^2 - 20^2}{400} = \frac{30 \times -10}{400} = -0.75 \text{ ms}^{-2}$

Let S' be the further distance covered by the train before coming to rest with the same retardation, then at this point

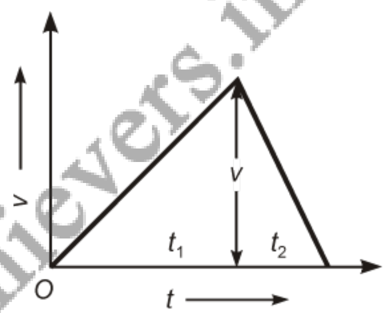
Initial velocity $u = 10$ m/sec and $v = 0$

$\therefore$ $2aS' = v^2 - u^2$

or $S' = \frac{0^2 - 10^2}{-2 \times 0.75}$ = **66.67 m**.

S57. Total time, $t = t_1 + t_2$

$a = \frac{v}{t_1}$



or $t_1 = \frac{v}{a}$

Similarly $t_2 = \frac{v}{2a}$

Now, $t = \frac{v}{a} + \frac{v}{2a} = \frac{3}{2}\frac{v}{a}$

or $v = \frac{2}{3} at$

or $h = \frac{1}{2} tv = \frac{1}{2} t \times \frac{2}{3} at = \frac{1}{3} at^2$

S58. The body starts from rest hence $u = 0$.

Let t be the total time of motion of the body and a be the uniform acceleration, then

Distance covered in t sec = $\frac{1}{2} at^2$

Distance covered in $(t - 1)$ sec = $\frac{1}{2} a(t-1)^2$

Distance covered in first sec = $\frac{1}{2} a = 15$

$\therefore$ Acceleration $a = 30 \text{ ms}^{-2}$

$$\text{Distance covered in last second} = \frac{1}{2}at^2 - \frac{1}{2}a(t-1)^2$$
$$= \frac{1}{2}a(2t-1)$$

$\therefore$ $$\frac{1}{2} \times 30\,(2t-1) = 135$$

or $$2t - 1 = \frac{135}{15} = 9$$

$\therefore$ $$t = 5 \text{ sec.}$$

Thus, the body was in motion for 5 seconds.

Total distance covered $\frac{1}{2} \times 30 \times 25 = 375$ m.

S59. Downward

Velocity = 0, acceleration = 9.8 m/s^2

$x > 0$ for both up and down motions, $v < 0$ for up and $v > 0$ for down motion, $a > 0$ throughout the motion

Explanation:

(a) Irrespective of the direction of the motion of the ball, acceleration (which is actually acceleration due to gravity) always acts in the downward direction towards the centre of the Earth.

(b) At maximum height, velocity of the ball becomes zero. Acceleration due to gravity at a given place is constant and acts on the ball at all points (including the highest point) with a constant value *i.e.*, 9.8 m/s^2.

(c) During upward motion, the sign of position is positive, sign of velocity is negative, and sign of acceleration is positive. During downward motion, the signs of position, velocity, and acceleration are all positive.

(d) Initial velocity of the ball, $u = 29.4$ m/s

Final velocity of the ball, $v = 0$ (At maximum height, the velocity of the ball becomes zero)

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

From third equation of motion, height (s) can be calculated as:

$$v^2 - u^2 = 2\,gs$$

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

$$= \frac{(0)^2 - (29.4)^2}{2 \times (-9.8)} = \mathbf{44.1\ m}.$$

From first equation of motion, time of ascent (t) is given as:

$$v = u + at$$

$$t = \frac{v - u}{a} = \frac{-29.4}{-9.8} = \mathbf{3\ s}.$$

Time of ascent = Time of descent

Hence, the total time taken by the ball to return to the player's hands = 3 + 3 = 6 s.

S60. At $t = 0, \quad v(0) = 0.$

It is clear from the given graph that acceleration has a constant value of 3 ms^{-2} from $t = 0$ to $t = 2$ second.

During this time interval, the velocity at any instant of time t may be given by

$$v(t) = v(0) + at = 0 + 3t = 3t\ ms^{-1}.$$

This is the equation of a straight line ($y = mx$) which passes through the origin and has a slope 3. This is represented by the portion OA of the velocity-time graph.

At $t = 0$, $v(0) = 0$

At $t = 1$, $v(t) = 3\ ms^{-1}$

At t = 2, $v(t) = 6\ ms^{-1}$

From $t = 2$s to $t = 4$s, the acceleration is given to be $-3\ ms^{-2}$.
Let this time interval be t'.

Then, $t' = t - 2$

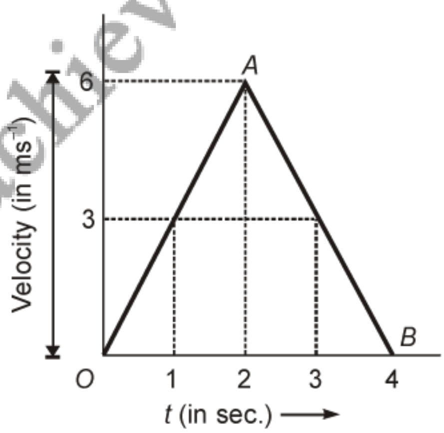
At $t = 2$s, $t' = 0$

Again at $t' = 0$ ($t = 2$s), $v(0) = 6\ ms^{-1}$.

Now, the velocity at any instant of time t' is given by

$$v(t') = v(0) + at' = 6 - 3t' = 6 - 3(t - 2) = 12 - 3t$$

which is the equation of a straight line whose slope is '– 3'.



S61. The portion OA of the velocity-time graph represents the constant acceleration α of the train.

$$\alpha = \frac{AB}{OB} \qquad \text{[slope of } OA]$$

or $$OB = \frac{AB}{\alpha} = \frac{v}{\alpha} \qquad [\because\ AB = v]$$

The portion CE of the velocity-time graph represents the retardation β of the train

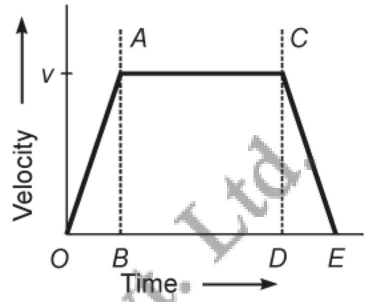
$$\beta = \frac{CD}{DE} \qquad \text{[slope of } CE\text{]}$$

or $$DE = \frac{CD}{\beta} = \frac{v}{\beta} \qquad [\because \; CD = v]$$

Area under the velocity-time graph $OACE$

$$= \frac{1}{2}(OE + AC)\,AB$$

This is equal to the total distance travelled by the train.



$\therefore$ $$x = \frac{1}{2}(OB + BD + DE + AC)\,AB$$

or $$x = \frac{1}{2}(OB + 2BD + DE)\,v$$

or $$2x = \left(\frac{v}{\alpha} + 2BD + \frac{v}{\beta}\right)v \quad \text{or} \quad \frac{2x}{v} = \frac{v}{\alpha} + 2BD + \frac{v}{\beta}$$

or $$2BD = \frac{2x}{v} - \frac{v}{\alpha} - \frac{v}{\beta} \quad \text{or} \quad BD = \frac{1}{2}\left(\frac{2x}{v} - \frac{v}{\alpha} - \frac{v}{\beta}\right)$$

Total time, $$t = OB + BD + DE$$

or $$t = \frac{x}{\alpha} + \frac{1}{2}\left(\frac{2x}{v} - \frac{v}{\alpha} - \frac{v}{\beta}\right) + \frac{v}{\beta}$$

or $$t = \frac{x}{v} + \frac{v}{2\alpha} + \frac{v}{2\beta} \quad \text{or} \quad \frac{x}{v} + \frac{v}{2}\left(\frac{1}{\alpha} + \frac{1}{\beta}\right).$$

S62. Let O be the origin and the vertically upward direction be the positive direction of x-axis.

At O, $$x = 0, \quad t = 0.$$

Height of O above the ground is 98 m.

When the packet is dropped from the balloon, it has the same velocity as that of the balloon, *i.e.*, 14 ms^{-1} in the vertically upward direction

$\therefore$ $$v(0) = 14 \text{ ms}^{-1}$$

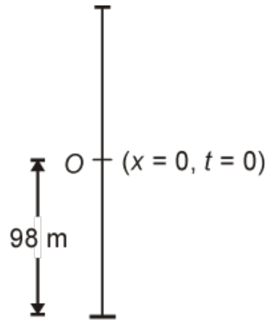
Acceleration due to gravity will act in the vertically down ward direction.

$\therefore$ $$a = -g = -9.8 \text{ ms}^{-2}$$

In order to reach the ground, the packet has to cover a vertically downward distance of 98 m. If the packet does so in time t; then

$$x(t) = -98 \text{ m}$$

Now, $$x(t) = x(0) + v(0)\,t + \frac{1}{2}\,at^2$$



or $$-98 = 0 + 14t + \frac{1}{2}(-9.8)\,t^2$$

or $$-98 = 14t - 4.9t^2$$

or $$4.9t^2 - 14t - 98 = 0$$

or $$49t^2 - 140t - 980 = 0 \quad \text{or} \quad 7t^2 - 20t - 140 = 0$$

$\therefore$ $$t = \frac{-(-20) \pm \sqrt{(-20)^2 - 4(7)(-140)}}{14}\text{ s}$$

$$= \frac{20 \pm 65.727}{14}\text{ s}$$

Ignoring –ve value, $$t = \frac{20 + 65.727}{14}\text{ s} = \mathbf{6.12\ s}$$

Let $v(t)$ be the velocity with which the packet reaches the ground.

Now, $$v(t) = v(0) + at = (14 - 9.8 \times 6.12)\text{ ms}^{-1} = \mathbf{-46\ ms^{-1}}$$

Negative sign indicates a vertically downward velocity,

Aliter: 'u' $= -14$ ms^{-1}, $v = ?$, $t = ?$, $S = 98$ m

Using $$v^2 - u^2 = 2aS,$$

We get $$v^2 - (-14)^2 = 2 \times 9.8 \times 98$$

or $$v^2 = 196 + 1920.8 = 2116.8$$

or $$v = \sqrt{2116.8}\text{ ms}^{-1} = \mathbf{46\ ms^{-1}}$$

Using $v = u + at$, we get $$46 = -14 + 9.8\,t$$

or $$9.8\,t = 60 \quad \text{or} \quad t = \frac{60}{9.8}\text{ s} = \mathbf{6.12\ s}.$$

Date: 13/10/2021

Q1. 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 ground?

Q2. The driver of a truck travelling with a velocity *v* suddenly notices a brick wall in front of him at a distance *d*. Is it better for him to apply brakes or to make a circular turn without applying brakes in order to just avoid crashing into the wall? Why?

Q3. Two parallel rail tracks run north-south. Train A moves due north with a speed of 54 km h^{-1} and train *B* moves due south with a speed of 90 km h^{-1}. What is the relative velocity of *B* with respect to *A* in ms^{-1}?

Q4. Prove that $\vec{v}_{AB} = \vec{v}_A - \vec{v}_B$, where symbols have their usual meaning.

Q5. Two particles *A* and *B* are moving along the same straight line. *B* is ahead of *A*. Velocities remaining unchanged, what would be the effect on the magnitude of relative velocity if *A* is ahead *B*?

Q6. 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 ?

Q7. Define the relative velocity. The distance between the two towns *M* and *N* is 400 km. Two cars *A* and *B* set off simultaneously from the towns *M* and *N* towards each other. The car *A* from *M* travels at a speed of v_A = 60 km h^{-1} and the car *B* from *N* at a speed of v_B = 40 km h^{-1}. Find analytically, the point, where they will meet and the time that will elapse before they meet.

Q8. Two parallel rail tracks run North-South. Train *A* moves North with a speed of 54 km h^{-1}. What is the (a) relative velocity of *B* w.r.t. *A*? (b) relative velocity of ground w.r.t. *B*? (c) velocity of a monkey running on the roof of the train *A* against its motion (with a velocity of 18 km h^{-1} w.r.t. the train *A*) as observed by a man standing on the ground?

Q9. Define the relative velocity. A jet airplane travelling at the speed of 500 km h^{-1} ejects the burnt gases at a speed of 1,200 km h^{-1} relative to the jet airplane. Find the speed of the burnt gases w.r.t. a stationary observer on earth.

Q10. 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?

Q11. What is relative velocity. Two trains 121 m and 99 m in length are running in opposite directions with velocities of 40 km h^{-1} and 32 km h^{-1}. In what time they will completely cross each other.

Q12. Define the relative velocity. Delhi is at a distance of 250 km from Chandigarh. A sets out from Chandigarh at a speed of 80 km h^{-1} and *B* sets out at the same time from Delhi at a speed of 45 km h^{-1}. When will they meet each other.

Q13. When two bodies move uniformly towards each other, the distance between them diminishes by 16 m every 10 s. If the bodies move with velocities of the same magnitude and in the same direction as before, the distance between them will increase by 3 m every 5 s. What is the velocity of each body?

Q14. Two parallel rail tracks run North-South. Train *A* moves North with a speed of 54 km h^{-1}, and train *B* moves South with a speed of 90 km h^{-1}. What is the (a) velocity of *B* with respect to *A*?, (b) velocity of ground with respect to *B*?, and (c) velocity of a monkey running on the roof of the train A against its motion (with a velocity of 18 km h^{-1} with respect to the train *A*) as observed by a man standing on the ground?

Q15. 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?

Date: 13/10/2021

S1. Speed of the jet airplane, v_{jet} = 500 km/h

Relative speed of its products of combust

$$v_{smoke} = -1500 \text{ km/h}$$

Speed of its products of combustion with respect to the ground = v'_{smoke}

Relative speed of its products of combustion with respect to the airplane,

$$v_{smoke} = v'_{smoke} - v_{jet}$$

$$-1500 = v'_{smoke} - 500$$

$$= -1000 \text{ km/h.}$$

combustion with respect to the plane,

$$v'_{smoke} = -1000 \text{ km/h}$$

The negative sign indicates that the direction of its products of combustion is opposite to the direction of motion of the jet airplane.

S2.

$$F_B \times d = \frac{1}{2} mv^2 \quad \text{[Work done = Change in kinetic energy]}$$

$$F_B = \frac{mv^2}{2d}$$

$$F_T = \frac{mv^2}{d} \quad (F_T = \text{Centripetal Force})$$

$$\therefore \quad F_T = 2F_B$$

Hence, it is better to apply brakes.

S3. Given, v_A = 54 km/hr and v_B = – 90 km/hr

Let due north direction be taken as +ve direction.

$$v_{BA} = v_B - v_A = -90 - 54$$

$$= -144 \text{ km/hr} = -144 \times \frac{5}{18} \text{ m/s}$$

$$= -40 \text{ m/s due to south.}$$

[-ve sign shows that velocity is in opposite direction]

S4. Consider two bodies A and B moving with velocities v_A and v_B. Let x_{1i} and x_{2i} be their initial positions. their position after time t is given by,

$$x_{1f} = x_{1i} + v_A t$$

and $x_{2f} = x_{2i} + v_B t$

Subtracting,

$$(x_{1f} - x_{2f}) = (x_{1i} - x_{2i}) + t(v_A - v_B)$$

$$(x_{1f} - x_{2f}) - (x_{1i} - x_{2i}) = t(v_A - v_B)$$

The change in separation in '*t*' is $t(v_A - v_B)$. $(v_A - v_B)$ is called relative velocity of *A* with respect to *B*. It is nothing but the change in separation per unit time.

S5. There will be no effect on the magnitude of relative velocity because relative velocity is $(\vec{v}_A - \vec{v}_B)$ which always remains constant.

S6. Speed of the police van, $v_p = 30$ km/h = 8.33 m/s

Muzzle speed of the bullet, $v_b = 150$ m/s

Speed of the thief's car, $v_t = 192$ km/h = 53.33 m/s

Since the bullet is fired from a moving van, its resultant speed can be obtained as:

$$= 150 + 8.33 = 158.33 \text{ m/s}$$

Since both the vehicles are moving in the same direction, the velocity with which the bullet hits the thief's car can be obtained as:

$$v_{bt} = v_b - v_t$$

$$= 158.33 - 53.33 = 105 \text{ m/s.}$$

S7. When two object *A* and *B* move in the same direction along a straight line, the magnitude of velocity of the object a minus the magnitude of the velocity of the object *B*.

Here, $v_A = 60 \text{ km h}^{-1}$ and $v_B = -40 \text{ km h}^{-1}$.

The negative sign has been taken for the reason that the car *B* is moving in a direction opposite to that of the car *A*.

Therefore, relative velocity of the car *A* w.r.t. *B*,

$$v_{AB} = v_A - v_B = 60 - (-40) = 100 \text{ km h}^{-1}$$

Distance between the towns *M* and *N*, $x = 400$ km

Therefore, time after which the two cars meet,

$$t = \frac{x}{|v_{AB}|} = \frac{400}{100} = \mathbf{4\ h}$$

The distance from the town *A*, at which the two cars meet,

$$S = v_A \times t = 60 \times 4 = \mathbf{240\ km}.$$

S8. Given, $\vec{v_A} = 54 \text{ km h}^{-1}$ (due North)

and $\vec{v_B} = 90 \text{ km h}^{-1}$ (due South)

Let us consider the positive direction of motion from South to North. Then,

$$\vec{v}_A = 54 \text{ km h}^{-1}$$

and $$\vec{v}_B = -90 \text{ km h}^{-1}$$

(a) $$\vec{v}_{BA} = \vec{v}_B - \vec{v}_A = (-90) + (-54) = -144 \text{ km h}^{-1}$$

$$= \mathbf{144 \text{ km h}^{-1} \text{ (due South)}}$$

(b) Let $\vec{v}_{GB}$ be the relative velocity of the ground w.r.t. the train B. Then,

$$\vec{v}_{GB} = \vec{v}_G - \vec{v}_B = 0 - (-90) = 90 \text{ km h}^{-1}$$

$$= \mathbf{90 \text{ km h}^{-1} \text{ (due South)}}$$

(c) Let $\vec{v}_M$ be velocity of the monkey w.r.t. a man on the ground and $\vec{v}_{MA}$ be velocity of the monkey w.r.t. the train A. Then,

$$\vec{v}_{MA} = 18 \text{ km h}^{-1} \text{ (against the motion of train } A)$$

$$= -18 \text{ km h}^{-1}$$

$$\vec{v}_{MA} = \vec{v}_M - \vec{v}_A$$

or $$\vec{v}_M = \vec{v}_A - \vec{v}_{MA} = 54 + (-18) = 36 \text{ km h}^{-1}$$

$$= \mathbf{36 \text{ km h}^{-1} \text{ (due North)}}.$$

S9. When two object A and B move in the same direction along a straight line, the magnitude of velocity of the object a minus the magnitude of the velocity of the object B.

Let us consider the positive direction of motion as to be away from the observer on the ground.

Suppose that v_J represents the velocity of the jet airplane w.r.t. the observer on the ground and v_{CJ} represents the relative velocity of the burnt gases w.r.t. jet airplane. Then,

$$v_J = 500 \text{ km h}^{-1} \quad \text{(away from the observer on the ground)}$$

and $$v_{CJ} = 1{,}200 \text{ km h}^{-1} \quad \text{(away from the observer on the ground)}$$

If v_C is the velocity of the combustion products (away from the observer on the ground), then

$$v_{CJ} = v_C - v_J$$

or $$v_C = v_{CJ} + v_J = -1{,}200 + 500 = -700 \text{ km h}^{-1}$$

$$= \mathbf{700 \text{ km h}^{-1}}. \quad \text{(away from the observer on the ground)}$$

S10. Velocity of car A, $v_A = 36 \text{ km/h} = 10 \text{ m/s}$

Velocity of car B, $v_B = 54 \text{ km/h} = 15 \text{ m/s}$

Velocity of car C, $v_C = 54 \text{ km/h} = 15 \text{ m/s}$

Relative velocity of car B with respect to car A,

$$v_{BA} = v_B - v_A$$

$$= 15 - 10 = 5 \text{ m/s}$$

Relative velocity of car C with respect to car A,

$$v_{CA} = v_C - (-v_A)$$
$$= 15 + 10 = 25 \text{ m/s}$$

At a certain instance, both cars B and C are at the same distance from car A, *i.e.*,

$$s = 1 \text{ km} = 1000 \text{ m}$$

Time taken (t) by car C to cover 1000 m = $\frac{1000}{25} = 40\text{ s}$

Hence, to avoid an accident, car B must cover the same distance in a maximum of 40 s.

From second equation of motion, minimum acceleration (a) produced by car B can be obtained as:

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

$$1000 = 5 \times 40 + \frac{1}{2} \times a \times (40)^2$$

$$a = \frac{1600}{1600} = 1 \text{ m/s}^2.$$

S11. When two object A and B move in the same direction along a straight line, the magnitude of velocity of the object A minus the magnitude of the velocity of the object B.

Relative speed of the first train w.r.t. the second train,

$$v_{12} = v_1 - v_2 = 40 - (-32) = 72 \text{ km h}^{-1} = 20 \text{ m s}^{-1}$$

Total distance travelled by each train so as to cross each other,

$$S = 121 + 99 = 220 \text{ m}$$

Therefore, time after which the two trains will cross each other,

$$t = \frac{S}{v_{12}} = \frac{220}{20} = \mathbf{11\ s}.$$

S12. When two object A and B move in the same direction along a straight line, the magnitude of velocity of the object A minus the magnitude of the velocity of the object B.

Relative speed of A w.r.t. B,

$$v_{AB} = v_A - v_B = 80 - (-45) = 125 \text{ km h}^{-1}$$

Therefore, time after which A and B will meet,

$$t = \frac{S}{v_{AB}} = \frac{250}{125} = \mathbf{2\ h}.$$

S13. Let v_A and v_B be the velocities of the two bodies A and B.

When two bodies are moving towards each other:

Relative velocity of body A w.r.t. B,

$$v = v_A - (-v_B) = v_A + v_B$$

Since distance diminishes by 16 m every 10 s,

$$v = \frac{16}{10} = 1.6 \text{ m s}^{-1}$$

or $$v_A + v_B = 1.6 \quad \text{... (i)}$$

When two bodies move in the same direction:

Relative velocity of body A w.r.t. B, $v' = v_A - v_B$

Since distance increases by 3 m every 5 s,

$$v' = \frac{3}{5} = 0.6 \text{ m s}^{-1}$$

or $$v_A - v_B = 0.6 \text{ m s}^{-1} \quad \text{... (ii)}$$

On solving the equation (i) and (ii), we get

$$v_A = \mathbf{1.1 \text{ m s}^{-1}}$$

and $$v_B = \mathbf{0.5 \text{ m s}^{-1}}.$$

S14. Choose the positive direction of x-axis to be from South to North. Then,

$$v_A = +54 \text{ km h}^{-1} = 15 \text{ m s}^{-1}$$

$$v_B = -90 \text{ km h}^{-1} = -25 \text{ m s}^{-1}$$

Relative velocity of B with respect to $A = v_{BA} = v_B - v_A = -40 \text{ m s}^{-1}$, *i.e.*, the train B appears to A to move with a speed of 40 m s^{-1} from North to South.

Relative velocity of ground with respect to

$$B = 0 - v_B = 25 \text{ m s}^{-1}.$$

In (c), let the velocity of the monkey with respect to ground be v_M. Relative velocity of the monkey with respect to A,

$$v_{MA} = v_M - v_A = -18 \text{ km h}^{-1} = -5 \text{ ms}^{-1}.$$

Therefore, $$v_M = (15 - 5) \text{ m s}^{-1} = 10 \text{ m s}^{-1}.$$

S15. Let V be the speed of the bus running between towns A and B.

Speed of the cyclist, $v = 20$ km/h

Relative speed of the bus moving in the direction of the cyclist

$$= V - v = (V - 20) \text{ km/h}$$

The bus went past the cyclist every 18 min *i.e.*, $\frac{18}{60}$ h (when he moves in the direction of the bus).

Distance covered by the bus = $(V - 20)\frac{18}{60}$ km ... (i)

Since one bus leaves after every T minutes, the distance travelled by the bus will be equal to

$$V \times \frac{T}{60} \quad \text{... (ii)}$$

Both equations (i) and (ii) are equal.

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

Relative speed of the bus moving in the opposite direction of the cyclist

$$= (V + 20) \text{ km/h}$$

Time taken by the bus to go past the cyclist

$$= 6 \text{ min} = \frac{6}{60} \text{ h}$$

$\therefore$

$$(V + 20)\frac{6}{60} = \frac{VT}{60} \quad \text{... (iv)}$$

From equations (iii) and (iv), we get

$$(V + 20) \times \frac{6}{60} = (V - 20) \times \frac{18}{60}$$

$$V + 20 = 3V - 60$$

$$2V = 80$$

$$V = 40 \text{ km/h}$$

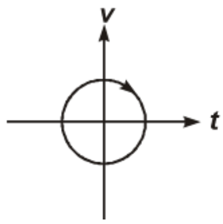
Substituting the value of V in equation (iv), we get

$$(40 + 20) \times \frac{6}{60} = \frac{40T}{60}$$

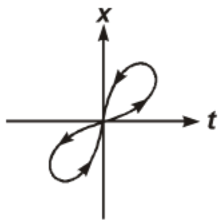
$$T = \frac{360}{40} = \mathbf{9\ min}.$$

Date: 13/10/2021

Q1. Look at the graphs carefully and state, with reasons, which of these *cannot* possibly represent one-dimensional motion of a particle.



Q2. Look at the graphs carefully and state, with reasons, which of these *cannot* possibly represent one-dimensional motion of a particle.



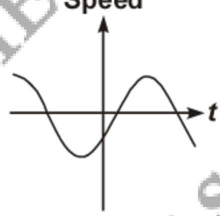
Q3. The length covered by a body is found to be directly proportional to the square of time. What is the nature of acceleration?

Q4. What is the significance of the slope of $x - t$ graph?

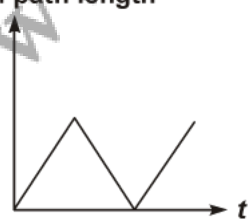
Q5. Which vector can be associated with a plane area? And what is its direction?

Q6. Under what condition will the distance and displacement of a moving object have the same magnitude?

Q7. Look at the graphs carefully and state, with reasons, which of these *cannot* possibly represent one-dimensional motion of a particle.



Q8. Look at the graphs carefully and state, with reasons, which of these *cannot* possibly represent one-dimensional motion of a particle.

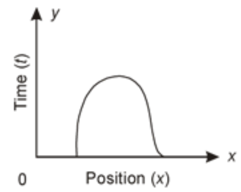


Q9. The motion of particle along x-axis is given by the equation $x = 9 + 5t^2$, where x is distance in cm and t is time in second. Find (a) the displacement after 3 second and 5 second (b) average velocity during the interval from $t = 3$ second to $t = 5$ second (c) instantaneous velocity at $t = 3$ second.

Q10. Two bodies of different masses m_1 and m_2 are dropped from two different heights 'a' and 'b'. What is the ratio of time taken by the two to drop through these distances?

Q11. A drunkard walking in a narrow lane takes 5 steps forward and 3 steps backward, followed again by 5 steps forward and 3 step 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.

Q12. Is the time variation of position shown in figure observed in nature possible?

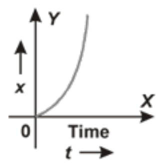


Q13. The displacement of a particle moving in one dimension under the action of a constant force is related to the time t by the equation $t = \sqrt{x} + 3$, where x is in metre and t is in second. Find the displacement of the particle when its velocity is zero.

Q14. An object is thrown vertically upwards with a velocity of 19.6 ms^{-1}. Calculate the distance and displacement of the object after 3 second?

Q15. A police constable is chasing a thief, who is initially 10 m ahead of the constable. The uniform speeds of the constable and the thief are 10 ms^{-1} and 8 ms^{-1} respectively. From the plot of position-time graphs for the constable and the thief, find the time, the constable will take to catch the thief and the distance, the constable has to run.

Q16. Adjoining figure shows the $x - t$ plot of one dimensional motion of a particle. Is it correct to say that the particle moves in straight line for $t < 0$? If not, suggest a suitable physical context for this graph.



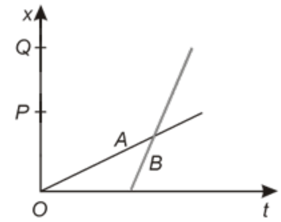
Q17. Stopping distance of vehicles: When brakes are applied to a moving vehicle, the distance it travels before stopping is called stopping distance. It is an important factor for road safety and depends on the initial velocity (v_0) and the braking capacity, or deceleration, $-a$ that is caused by the braking. Derive an expression for stopping distance of a vehicle in terms of vo and a.

Q18. (a) A boy drives a scooter at a speed of 40 kmh^{-1} for the first 10 km distance and then at a speed of 60 kmh^{-1} for the next 10 km. Find his average speed. Why the average speed of the scooter is not 45 kmh^{-1}, the mean of the two speeds?

(b) If the boy drives the scooter at a speed of 40 kmh^{-1} for the first 0.5 h and then at a speed of 60 kmh^{-1} for the next 0.5 h, Find his average speed.

Q19. 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 as shown in figure. 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).

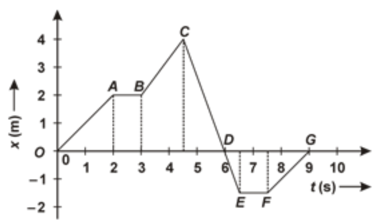


Q20. Free-fall: Discuss the motion of an object under free fall. Neglect air resistance.

Q21. A ball is thrown vertically upwards with a velocity of $20\ \text{m s}^{-1}$ from the top of a multistorey building. The height of the point from where the ball is thrown is 25.0 m from the ground. (a) How high will the ball rise ? and (b) how long will it be before the ball hits the ground? Take $g = 10\ \text{m s}^{-2}$.

Q22. Obtain equations of motion for constant acceleration using method of calculus.

Q23. The position-time graph for a dancer demonstrating dance steps along a straight line is as shown in the figure. What are the average speed and average velocity for each dance step?



Date: 13/10/2021

S1. The given *v-t* graph, does not represent one-dimensional motion of the particle. This is because a particle can never have two values of velocity at the same instant of time.

S2. The given *x-t* graph, does not represent one-dimensional motion of the particle. This is because a particle cannot have two positions at the same instant of time, while it has two positions at the same instant of time.

S3. Given length (x) $\propto$ {time (t)}^{2}

$$x \propto t^2$$

Now,

$$v = \frac{dx}{dt} \propto 2t$$

$$a = \frac{dv}{dt} \propto 2 \text{ (constant)}$$

Hence acceleration is constant.

$x \propto t^2 \;\therefore\; v \propto t$ and $a \propto t^0$ (*i.e.*) acceleration is constant.

S4. Slope of $x - t$ graph provides velocity of motion. The nature of motion is identified by the shape of the graph.

S5. Area vector, outward drawn Normal to the plane will be its direction.

S6. When the object moves in a straight line.

S7. The given *v-t* graph, does not represent one-dimensional motion of the particle. This is because speed being a scalar quantity cannot be negative.

S8. The given *v-t* graph, does not represent one-dimensional motion of the particle. This is because the total path length travelled by the particle cannot decrease with time.

S9. (a) Given, $x = 9 + 5t^2$

Now, at time $t = 3$

$$(x)_{t=3} = 9 + 5 \times (3)^2 = \mathbf{54\ cm}$$

at time $t = 5$ sec

$$(x)_{t=5} = 9 + 5 \times (5)^2 = \mathbf{134\ cm}$$

(b) Average velocity $= \dfrac{\text{Displacement}}{\text{Total time taken}}$

$$= \frac{134-54}{2}\,\text{cm s}^{-1} = \mathbf{40\,cm\,s^{-1}}.$$

(c) Instantaneous velocity,

$$v = \frac{dx}{dt} = \mathbf{10\,t};$$

Velocity at $t = 3$ s is:

$$v = 10 \times 3\,\text{cm s}^{-1} = \mathbf{30\,cm\,s^{-1}}.$$

S10. We know, $S = ut + \frac{1}{2}at^2$ ... (i)

$$u = 0, \quad t = t_1 \quad \text{and} \quad S = a$$

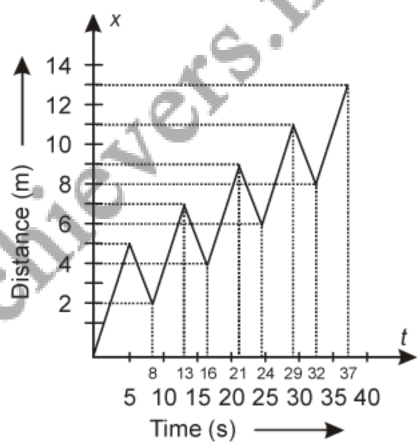
Setting this values in Eq. (i), we get

$$a = \frac{1}{2}gt_1^2 \quad \text{or} \quad t_1 = \sqrt{\frac{2a}{g}}$$

Similarly, $b = \frac{1}{2}gt_2^2 \quad \text{or} \quad t_2 = \sqrt{\frac{2b}{g}}$

$$\therefore \quad \frac{t_1}{t_2} = \sqrt{\frac{a}{b}}.$$

S11. The *x-t* graph for the motion of drunkard is shown in figure



It is clear from the graph that he takes 37 s to fall in the pit.

Distance of the pit from the start = 13 m

Time taken to move first 5 m = 5 s

5 steps (*i.e.*, 5 m) forward and 3 steps (*i.e.*, 3 m) backward means that net distance covered = 5 – 3 = 2 m

Time taken during process = 5 + 3 = 8 s.

Time taken in moving 8 m $= \frac{8 \times 8}{2} = 32$ s.

Distance of the pit from the drunkard after covering a net distance of 8 m = 13 – 8 = 5 m. Now, in next 5 steps forward, the drunkard will fall into the pit, for which he will take 5 s more *i.e.*, total time taken to fall in the pit = 32 + 5 = 37 s.

S12. No, when x increases, the time first increases and then decreases. It is not possible. It implies that at a given time, the body in motion is simultaneously at two different positions which is not possible.

S13. Given $\sqrt{x} = t - 3$

Squaring the both side

$$x = (t-3)^2$$

$$x = t^2 - 2t + 9$$

$$v = \frac{dx}{dt} = 2t - 2 = 0$$

$$2t - 2 = 0$$

$$t = 1$$

Now, $x = (t-3)^2$

$$=(1-3)^2 \Rightarrow \quad x = 4 \text{ m}$$

S14. Given, $u = 19.6$ m/s; $v = 0$ m/s

Now using relation $v = u + at$

$$v = u - gt$$

$$0 = 19.6 - 9.8\,t$$

$\Rightarrow$ $t = 2$ sec

Attained maximum height in 2 sec

$$h_{max} = ut - \frac{1}{2}gt^2$$

$$= 19.6 \times 2 - \frac{1}{2} 9.8 \times 2 \times 2 = \mathbf{19.6\ m}.$$

Distance covered in next 1 s

$$= 0 \times 1 - \frac{1}{2} \times 9.8 \times 1 \times 1 \text{ m} = \mathbf{4.9\ m}.$$

$\therefore$ Total distance covered

$$= (19.6 + 4.9) \text{ m} = \mathbf{24.5\ m}$$

Displacement = (19.6 – 4.9) m = **14.7 m**.

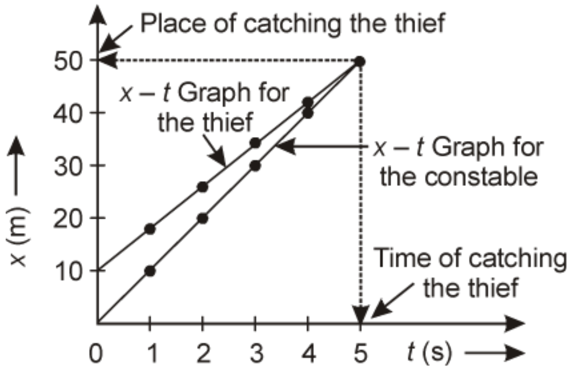
S15. Suppose that the point from which the constable starts chasing the thief is regarded as the origin of the position-time graph. Then,

initial distance of the constable from the origin = 0;

initial distance of the thief from the origin = 10 m;

speed of the constable = 10 m s^{-1}

and speed of the thief = 8 m s^{-1}



If follows that the constable will catch the thief after 5 s and during this time, he will cover a distance of 50 m.

S16. Since shape for $t < 0$ is not given we cannot be sure about the nature of path. The graph corresponds to, $x = \frac{1}{2}at^2$. So this can be compared to the motion of a body dropped from certain height.

S17. Let the distance travelled by the vehicle before it stops be *ds*. Then, using equation of motion $v_2 = v_0^2 + 2ax$, and noting that $v = 0$, we have the stopping distance

$$d_s = \frac{-v_0^2}{2a}$$

Thus, the stopping distance is proportional to the square of the initial velocity. Doubling the initial velocity increases the stopping distance by a factor of 4 (for the same deceleration).

For the car of a particular make, the braking distance was found to be 10 m, 20 m, 34 m and 50 m corresponding to velocities of 11, 15, 20 and 25 m/s which are nearly consistent with the above formula.

Stopping distance is an important factor considered in setting speed limits, for example, in school zones.

S18. (a) Let t_1 and t_2 be the time taken by the boy to cover the first distance of 10 km and the second distance of 10 km respectively. Then,

$$t_1 + t_2 = \frac{10}{40} + \frac{10}{60} = \frac{5}{12}\text{ h}$$

Total distance covered = 10 + 10 = 20 km

Therefore, average speed

$$v_{av} = \frac{20}{t_1 + t_2} = \frac{20}{5/12} = \mathbf{48\ km\ h^{-1}}$$

It is tempting to guess the average speed as

$$v_{av} = \frac{40 + 60}{2} = 50\text{ km h}^{-1},$$

which is not the correct answer. The average speed is equal to the mean of the two speeds, only if the boy drives the scooter for equal lengths of time (and not the equal distances).

(b) The distance covered in the first 0.5 h,

$$S_1 = v_1 \times t_1 = 40 \times 0.5 = 20 \text{ km}$$

The distance covered in the next 0.5 h,

$$S_2 = v_2 \times t_2 = 60 \times 0.5 = 30 \text{ km}$$

Therefore, average speed

$$v_{av} = \frac{S_1 + S_2}{t_1 + t_2} = \frac{20 + 30}{0.5 + 0.5} = \frac{50}{1} = \mathbf{50 \text{ km h}^{-1}}.$$

S19. (a) **A** lives closer to school than **B.**

Explanation: In the given *x*-*t* graph, it can be observed that distance *OP* < *OQ*. Hence, the distance of school from the **A's** home is less than that from **B's** home.

(b) **A** starts from school earlier than **B.**

Explanation: In the given graph, it can be observed that for $x = 0$, $t = 0$ for **A**, whereas for $x = 0$, t has some finite value for **B**. Thus, **A** starts his journey from school earlier than **B**.

(c) **B** walks faster than **A.**

Explanation: In the given *x*-*t* graph, it can be observed that the slope of **B** is greater than that of **A**. Since the slope of the *x*-*t* graph gives the speed, a greater slope means that the speed of **B** is greater than the speed **A**.

(d) **A** and **B** reach home at the same time.

Explanation: It is clear from the given graph that both **A** and **B** reach their respective homes at the same time.

(e) **B** overtakes **A** once on the road.

Explanation: **B** moves later than **A** and his/her speed is greater than that of **A.** From the graph, it is clear that **B** overtakes **A** only once on the road.

S20. An object released near the surface of the Earth is accelerated downward under the influence of the force of gravity exerted by the earth. The magnitude of acceleration due to gravity is represented by ***g***. If air resistance is neglected, the object is said to be in ***free fall***. If the height through which the object falls is small compared to the Earth.s radius, *g* can be taken to be constant, equal to 9.8 m s^{-2}. Free fall is thus a case of motion with uniform acceleration.

We assume that the motion is in *y*-direction, more correctly in – *y*-direction because we choose upward direction as positive. Since the acceleration due to gravity is always downward, it is in the negative direction and we have

$$a = -g = .\ 9.8 \text{ m s}^{-2}$$

The object is released from rest at $y = 0$. Therefore, $v_0 = 0$ and the equations of motion become:

$$v = 0 - g\,t \qquad = .9.8\,t \text{ m s}^{-1}$$

$$y = 0 - g\,t^2 \qquad = -4.9\,t^2 \text{ m}$$

$$v_2 = 0 - 2\,g\,y \qquad = -19.6\,y \text{ m}^2\text{ s}^{-2}$$

These equations give the velocity and the distance travelled as a function of time and also the variation of velocity with distance. The variation of acceleration, velocity, and distance, with time have been plotted in figure (a), (b) and (c).

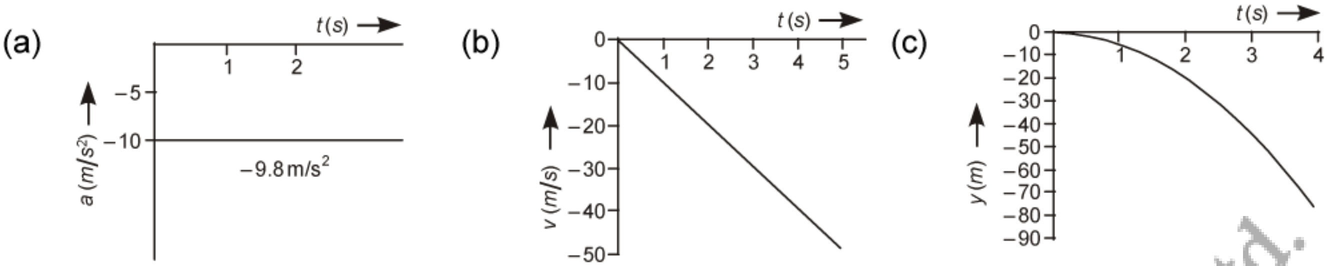
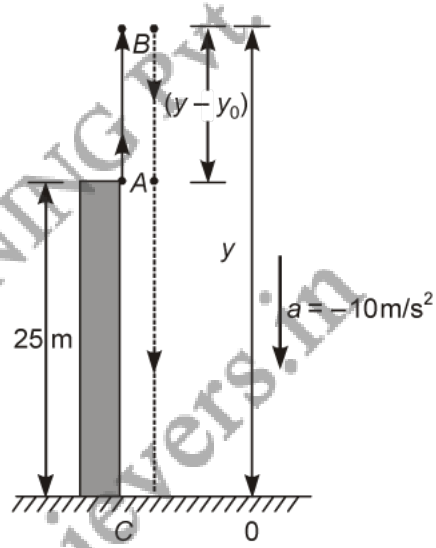


Figure: **Motion of an object under free fall: (a) Variation of acceleration with time. (b) Variation of velocity with time. (c) Variation of distance with time**

S21. (a) Let us take the y-axis in the vertically upward direction with zero at the ground, as shown in figure.



Now, $v_0 = +20 \text{ m s}^{-1}$,

$a = -g = -10 \text{ m s}^{-2}$,

$v = 0 \text{ m s}^{-1}$

If the ball rises to height y from the point of launch, then using the equation

$$v^2 = v_0^2 + 2a\,(y - y_0)$$

we get $\qquad 0 = (20)^2 + 2\,(-10)\,(y - y_0)$

Solving, we get, $\qquad (y - y_0) = 20$ m.

(b) We can solve this part of the problem in two ways. ***Note carefully the methods used***.

First Method: In the first method, we split the path in two parts : the upward motion (A to B) and the downward motion (B to C) and calculate the corresponding time taken t_1 and t_2. Since the velocity at B is zero, we have:

$$v = v_0 + at$$

$$0 = 20 - 10\,t_1$$

Or, $\qquad t_1 = 2$ s

This is the time in going from A to B. From B, or the point of the maximum height, the ball falls freely under the acceleration due to gravity. The ball is moving in negative y direction. We use equation

$$y = y_0 + v_0 t + \frac{1}{2} a t^2$$

We have, $\qquad y_0 = 45$ m, $\quad y = 0$, $\quad v_0 = 0$, $\quad a = -g = -10 \text{ m s}^{-2}$

$$0 = 45 + (1/2)\,(-10)\,t_2^2$$

Solving, we get $t_2 = 3$ s

Therefore, the total time taken by the ball before it hits the ground = $t_1 + t_2 = 2\,\text{s} + 3\,\text{s} = 5\,\text{s}$.

Second Method: The total time taken can also be calculated by noting the coordinates of initial and final positions of the ball with respect to the origin chosen and using equation

$$y = y_0 + v_0 t + \frac{1}{2}at^2$$

Now, $y_0 = 25\,\text{m}$ $y = 0\,\text{m}$

$v_0 = 20\,\text{m s}^{-1}$, $a = -10\,\text{m s}^{-2}$, $t = ?$

$$0 = 25 + 20t + (1/2)(-10)t^2$$

Or, $5t^2 - 20t - 25 = 0$

Solving this quadratic equation for t, we get

$$t = 5\text{s}$$

S22. By definition
$$a = \frac{dv}{dt}$$
$$dv = a\,dt$$

Integrating both sides
$$\int_{v_0}^{v} dv = \int_0^t a\,dt$$
$$= a\int_0^t dt \qquad (a \text{ is constant})$$
$$v - v_0 = at$$
$$v = v_0 + at$$

Further,
$$v = \frac{dx}{dt}$$
$$dx = v\,dt$$

Integrating both sides
$$\int_{x_0}^{x} dx = \int_0^t v\,dt$$
$$= \int_0^t (v_0 + at)\,dt$$
$$x - x_0 = v_0 t + \frac{1}{2}at^2$$
$$x = x_0 + v_0 t + \frac{1}{2}at^2$$

We can write
$$a = \frac{dv}{dt} = \frac{dv}{dx}\frac{dx}{dt} = v\frac{dv}{dx}$$

or, $v\,dv = a\,dx$

Integrating both sides, $\int_{v_0}^{v} v\,dv = \int_{x_0}^{x} a\,dx$

$$\frac{v^2 - v_0^2}{2} = a(x - x_0)$$

$$v^2 = v_0^2 + 2a(x - x_0)$$

The advantage of this method is that it can be used for motion with non-uniform acceleration also.

Now, we shall use these equations to some important cases.

S23. ***For the dance step depicted by OA:***

Path length = 2 m; displacement = 2 m; time taken; $t = 2$ s

$\therefore$ Average speed $= \frac{\text{Path length}}{\text{Time taken}} = \frac{2}{2} = \mathbf{1\ m\ s^{-1}}$

and average velocity $= \frac{\text{Displacement}}{\text{Time taken}} = \frac{2}{2} = \mathbf{1\ m\ s^{-1}}$

For the dance step depicted by AB:

Path length = 0; displacement = 0; time taken; $t = 1$ s

$\therefore$ Average speed $= \frac{0}{1} = \mathbf{0}$

and average velocity $= \frac{0}{1} = \mathbf{0}$

For the dance step depicted by BC:

Path length = 2 m; displacement = 2 m; time taken; $t = 1.5$ s

$\therefore$ Average speed $= \frac{2}{1.5} = \mathbf{1.33\ m\ s^{-1}}$

and average velocity $= \frac{2}{1.5} = \mathbf{1.33\ m\ s^{-1}}$

For the dance step depicted by CE:

Path length = 5.5 m; displacement = – 5.5 m; time taken; $t = 2$ s

$\therefore$ Average speed $= \frac{5.5}{2} = \mathbf{2.75\ m\ s^{-1}}$

and average velocity $= \frac{-5.5}{2} = \mathbf{-2.75\ m\ s^{-1}}$

For the dance step depicted by EF:

Path length = 0; displacement = 0; time taken; $t = 1$ s

$\therefore$ Average speed = $\frac{0}{1.5}$ = **0**

and average velocity = $\frac{0}{1.5}$ = **0**

For the dance step depicted by FG:

Path length = 1.5 m; displacement = 1.5 m; time taken; t = 1.5 s

$\therefore$ Average speed = $\frac{1.5}{1.5}$ = $\mathbf{1\ m\ s^{-1}}$

and average velocity = $\frac{1.5}{1.5}$ = $\mathbf{1\ m\ s^{-1}}$

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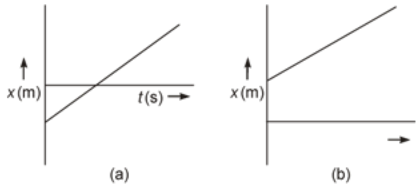
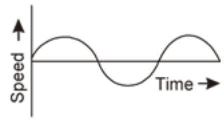
Q1. What conclusion can you draw if the average velocity is equal to instantaneous velocity?

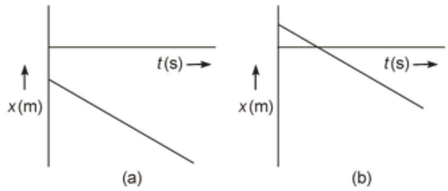
Q2. What is the common between the two graphs shown in figure (a) and (b)?



Q3. Is the speed-time graph shown in the figure, possible?

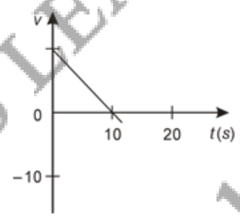


Q4. What is the common between the two graphs shown in figure (a) and (b)?



Q5. A train 100 m long is moving with a speed of 60 km h^{-1}. In what time shall it cross a bridge 1 km long?

Q6. What can you say about the nature of acceleration, associated with a mass whose $v - t$ graph is shown?

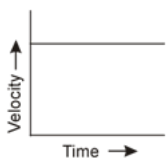


Q7. What will happen to a hydrogen balloon released on the moon?

Q8. Can a body have constant speed but a varying velocity?

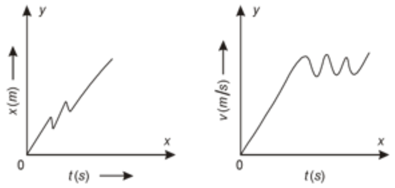
Q9. When a ball hits a wall with a velocity of 50 m/s and bounces back with the same speed, what is the change in momentum of the ball?

Q10. Velocity-time graph of a moving object is shown below. What is the acceleration of the object? Also draw displacement-time graph for the motion of the object.



Q11. A body starts from rest and moves along a straight line. It has uniformly accelerated motion upto time t_1. During the interval $t_2 - t_1$ it moves with uniform velocity. After time t_2 its motion is retarded, and it comes to rest at time t_3. Draw the velocity-time graph.

Q12. Do the following two graphs represent same type of motion? Name the motion.



Q13. Draw velocity-time graph for an object, starting from rest. Acceleration is constant and remains positive.

Q14. The position of an object moving along *x*-axis is given by $x = a + bt^2$ *where* $a = 8.5$ m, $b = 2.5\ \text{m s}^{-2}$ and *t* is measured in seconds. What is its velocity at $t = 0$ s *and* $t = 2.0$ s. What is the average velocity between $t = 2.0$ s and $t = 4.0$ s?

Q15. Read the statement below carefully and state with reasons and examples, if it is true or false:

with zero speed may have non-zero velocity.

Q16. Read the statement below carefully and state with reasons and examples, if it is true or false:

with constant speed must have zero acceleration.

Q17. Read the statement below carefully and state with reasons and examples, if it is true or false:

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

Q18. A bicyclist is travelling along a straight road for the first half time with speed v_1 and for the second half time with speed v_2. What is the average speed of the bicyclist?

Q19. A particle is moving with uniform velocity v along a straight line. What will be the position-time graph of the motion of the particle in the following cases?

(a) + *ve* x_0, + *ve* v (b) + *ve* x_0, – *ve* v (c) – *ve* x_0, + *ve* v (d) – *ve* x_0, – *ve* v

Given : x_0 represents the position of the particle at $t = 0$.

Q20. A passenger arriving in a new town wishes to go from the station to a hotel located 10 km away on a straight road from the station. A dishonest cabman takes him along a circuitous path 23 km long and reaches the hotel in 28 min. What is (a) the average speed of the taxi, (b) the magnitude of average velocity? Are the two equal?

Q21. Four persons *K*, *L*, *M*, *N* are initially at the four corners of a square of side 'd'. Each person now moves with a uniform speed *v* in such a way that *K* always moves directly towards *L*, *L* directly towards *M*, *M* directly towards *N* and *N* directly towards *K*. What is the time after which the four persons will meet?

Q22. A train 110 m long is travelling at 60 km h^{-1}. In what time it will cross a cyclist moving at 6 km h^{-1} (a) in the same direction (b) in the opposite direction?

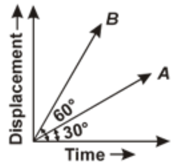
Q23. A car covers the first half of the distance between two places at a speed of 40 km h^{-1} and second half at 60 km h^{-1}. Calculate the average speed of the car.

Q24. A person travels along a straight road due east for the first half distance with speed v_1 and the second half distance with speed v_2. What is the average speed of the person?

Q25. An object moving on a straight line covers first half of the distance at speed *v* and second half of the distance at speed 2*v*. Find (a) average speed, (b) mean speed.

Q26. A body goes from A to B with a velocity of 40 m/s and comes back from B to A with a velocity of 60 m/s. What is the (a) average velocity during the whole journey and (b) average speed during the whole journey?

Q27. The two straight rays OA and OB on the same displacement-time graph make angle 30° and 60° with time axis respectively as shown in figure.



(a) Which ray represents greater velocity?

(b) What is the ratio of two velocities represented by OA and OB?

Q28. A stone falls from a cliff and travels 34.3 m in the last second before it reaches the ground. Calculate the height of the cliff.

Q29. A girl walks to her school at a distance of 1 km with a speed of 2 km h^{-1} and comes back with a speed of 3 km h^{-1}. Calculate the average speed for the round trip in km h^{-1}.

Q30. A gun is fired from a distance of 1.2 km from a hill. The echo of the sound is heard back at the same place after 8 second. Find the velocity of sound.

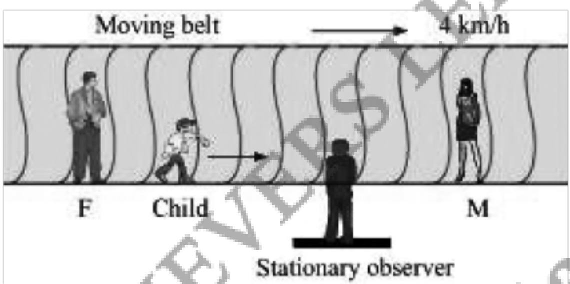
Q31. On a long horizontally moving belt (see figure), a child runs to and fro with a speed 9 km h^{-1} (with respect to the belt) between his father and mother located 50 m apart on the moving belt. The belt moves with a speed of 4 km h^{-1}. For an observer on a stationary platform outside, what is 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 taken by the child in (a) and (b)?

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



Q32. 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?

Q33. 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?

Q34. Two trucks started at the same time towards each other from cities A and B which are 480 km apart. The first truck took eight hours to travel from A to B. The second truck travelled from B to A in ten hours. If both the trucks travelled with constant speed, then at what time from starting do the trucks meet and at what distance from A?

Q35. A ball is dropped from a height of h metre above the ground and at the same instant another ball is projected upwards from the ground. The two balls meet when the upper ball falls through a distance $\frac{h}{3}$. Prove that the velocities of the two balls when they meet are in the ratio 2 : 1.

Q36. The motion of a car along y-axis is given by the relation $y = t^3 - 6t^2 + 9t + 5$, where y is in metre and t is in second. Calculate the position, acceleration and total distance travelled at $t = 5$ second.

Q37. 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?

Q38. 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 magnitude of average velocity, and average speed of the man over the interval of time (a) 0 to 30 min, (b) 0 to 50 min, (c) 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!]

Q39. Derive the three equations of motion by calculus method. Express conditions under which they can be used.

Q40. 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.

Q41. Draw velocity-time graph of uniformly accelerated motion in one dimension. From the velocity time graph of uniform accelerated motion, deduce the equations of motion in distance and time.

Q42. (a) With the help of a simple case of an object moving with constant velocity show that the area under velocity-time curve represents the displacement over a given time interval.

(b) Establish the relation $x = v_0 t + \frac{1}{2} a t^2$ graphically.

(c) A car moving with a speed of 126 km/h is brought to a stop within a distance of 200 m. Calculate the retardation of the car and the time required to stop it.

Date: 13/10/2021

S1. The particle is moving with constant velocity.

S2. Both represent positive velocity, because slope of graph is positive.

S3. No. Because speed cannot be negative.

S4. Both represent negative velocity, because slope of the both graph is negative.

S5. In train-bridge problems, the total distance to be covered

= Length of bridge + Length of train.

Total distance to be covered by train

$$= 1\text{ km} + 100\text{ m} = 1100\text{ m}$$

$$\text{Speed} = 60\text{ km h}^{-1} = 60 \times \frac{5}{18}\text{ m s}^{-1} = \frac{50}{3}\text{ m s}^{-1};$$

$$\text{Time} = \frac{1100}{50/3}\text{ s} = 66\text{ sec}.$$

S6. **Since slope is uniform.** So acceleration is constant.

S7. The balloon will fall with an acceleration of $g/6\text{ ms}^{-2}$.

S8. Yes, it is possible one if direction changes. **Example Uniform circular motion.**

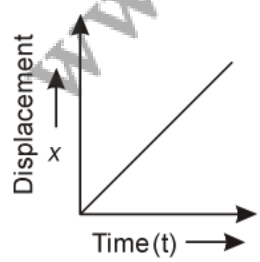
S9. Given, Velocity $= 50\text{ m s}^{-1}$

Let's Mass $= m$ kg

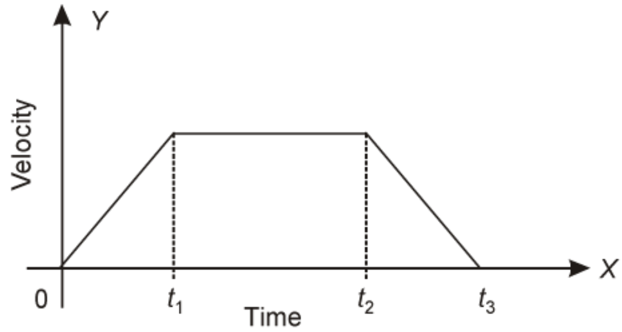
Now change in momentum $\Delta p = -2\,mv = -100\text{ kgm s}^{-1}$.

S10. Acceleration = zero.

$x - t$ graph is as shown below:

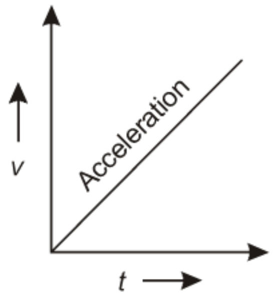


S11.



S12. Both the graphs represent the non-uniform type of motion.

S13.



S14. In notation of differential calculus, the velocity is

$$v = \frac{dx}{dt} = \frac{d}{dt}(a + bt^2) = 2bt = 5.0\ t\ \text{m s}^{-1}$$

At $t = 0$ s, $v = 0$ m s^{-1} and at $t = 2.0$ s, $v = 10$ m s^{-1}.

$$\text{Average velocity} = \frac{x(4.0) - x(2.0)}{4.0 - 2.0}$$

$$= \frac{a + 16b - a - 4b}{2.0} = 6.0 \times b$$

$$= 6.0 \times 2.5 = 15\ \text{m s}^{-1}.$$

S15. True.

Explanation: A car moving on a straight highway with constant speed will have constant velocity. Since acceleration is defined as the rate of change of velocity, acceleration of the car is also zero.

S16. False.

Explanation: This statement is false in the situation when acceleration is positive and velocity is negative at the instant time taken as origin. Then, for all the time before velocity becomes zero, there is slowing down of the particle. Such a case happens when a particle is projected upwards.

S17. False.

Explanation: Speed is the magnitude of velocity. When speed is zero, the magnitude of velocity along with the velocity is zero.

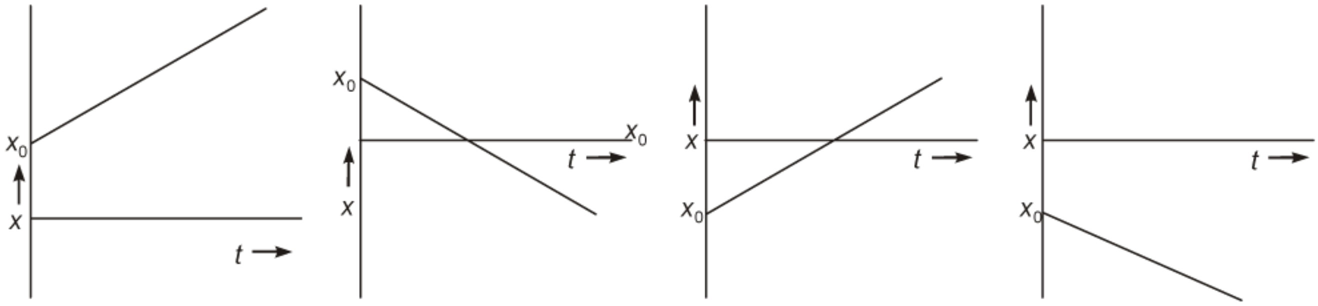
S18. Let t be the total time taken.

$$\text{Distance covered in the first half time} = v_1 \times \left(\frac{t}{2}\right) = \frac{v_1 t}{2},$$

Distance covered in the next half time = $v_2 \times \left(\frac{t}{2}\right) = \frac{v_2 t}{2}$,

$$\text{Average speed } v_{av} = \frac{\frac{v_1 t}{2} + \frac{v_1 t}{2}}{t} = \frac{v_1 + v_2}{2}.$$

S19.



(a) (b) (c) (d)

S20. Total distance travelled in 28 min = $\frac{28}{60}$ h

$\therefore$ Average speed of the taxi = $\frac{23}{\left(\frac{28}{60}\right)} = 49.29 \text{ km/h}$

Shortest distance between the hotel and the station = 10 km = Displacement of the car

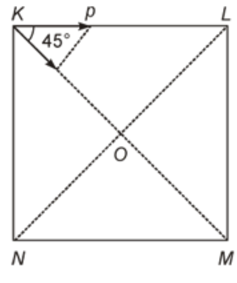
$\therefore$ Average velocity = $\frac{10}{\frac{28}{60}} = 21.43 \text{ km/h}$

Therefore, the two physical quantities (average speed and average velocity) are not equal.

S21. It is clear from the figure that they will meet at the centre of the square.

Component of velocity towards the centre O of the square

$$= v \cos 45° = \frac{v}{\sqrt{2}}$$



Displacement of each person = $\frac{\sqrt{d^2 + d^2}}{2} = \frac{d}{\sqrt{2}}$

Required time = $\frac{d/\sqrt{2}}{v/\sqrt{2}} = \frac{d}{v}$.

S22. Velocity of train $v_t = 60 \text{ km h}^{-1}$

Velocity of cyclist, $v_c = 6 \text{ km h}^{-1}$

(a) Relative velocity of train w.r.t. cyclist,

$$v_{tc} = (60 - 6) \text{ km h}^{-1}$$

$$= 54 \text{ km h}^{-1} = 54 \times \frac{5}{18} = 15 \text{ m s}^{-1}.$$

Now, $$15 = \frac{110}{t} \quad \text{or} \quad t = \frac{110}{15}\,\text{s} = \mathbf{7.33\,s}.$$

When the two bodies are moving in the same direction, the relative speed is equal to the difference of the individual speeds.

(b) Relative velocity of train w.r.t. cyclist,

$$v_{tc} = (60 + 6)\ \text{km h}^{-1} = 66\ \text{km h}^{-1} = 66 \times \frac{5}{18}.$$

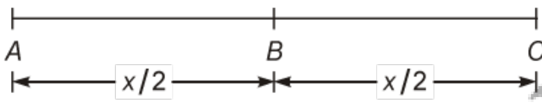
Now $$t = \frac{110 \times 18}{66 \times 5}\,\text{s} = \mathbf{6\,s}.$$

When the two bodies are moving in the opposite directions, the relative speed is equal to the sum of the individual speeds.

The above results hold good only for one-dimensional motion.

S23. Let the car cover the distance (= $x/2$) from A to B at a speed of 40 km h^{-1} in time t_1 hour.

Then $$40 = \frac{x/2}{t_1} \quad \text{or} \quad t_1 = \frac{x}{80}\ \text{hour}$$



Similarly, the car travels a distance (= $x/2$) from B to C at a speed of 60 km h^{-1} in time t_2 hour.

Then $$60 = \frac{x/2}{t_2} \quad \text{or} \quad t_2 = \frac{x}{120}\ \text{hour}$$

Now, $$\text{average speed} = \frac{x/2 + x/2}{x/80 + x/120}\ \text{km h}^{-1}$$

$$= \frac{80 \times 120}{200}\ \text{km h}^{-1} = 48\ \text{km h}^{-1}.$$

S24. Let S be the total distance travelled.

$$\text{Time taken for the first half distance} = \frac{S/2}{v_1} = \frac{S}{2v_1}$$

$$\text{Time taken for the second half distance} = \frac{S/2}{v_2} = \frac{S}{2v_2}$$

$$\text{Total time taken} = \frac{S}{2v_1} + \frac{S}{2v_2}$$

$$\text{Average speed,} \quad v_{av} = \frac{S}{\frac{S}{2v_1} + \frac{S}{2v_2}} = \frac{2v_1v_2}{v_1 + v_2}$$

S25. Let total distance be x.

$$\text{Distance of first half} = \frac{x}{2}, \quad \text{Speed} = v$$

$$\text{Time taken } t_1 = \frac{\frac{x}{2}}{v} = \frac{x}{2v}$$

$$\text{Distance of second half} = \frac{x}{2}, \quad \text{Speed } 2v$$

$$\text{Time taken } t_2 = \frac{\frac{x}{2}}{2v} = \frac{x}{4v}$$

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

$$= \frac{x}{\frac{x}{2v} + \frac{x}{4v}} = \frac{4v}{3}.$$

(b) $$\text{Mean speed} = \frac{v + 2v}{2} = \frac{3v}{2}.$$

S26. Since, there is net displacement = 0

$$\text{Average velocity} = \frac{\text{Total displacement}}{\text{Time}} = 0$$

Hence average velocity is zero

$$\text{Total distance} = 2AB$$

$$\text{Total time} = \frac{AB}{50} + \frac{BA}{60}$$

$$\text{Average speed} = \frac{\text{Total distance}}{\text{Time}} = \frac{2\,AB}{\frac{AB}{40} + \frac{AB}{60}} = \mathbf{48\ m/s}.$$

S27. (a) OB, because the slope OB is greater than the OA.

(b) Ratio of two velocities

$$\frac{v_A}{v_B} = \frac{\tan 30^\circ}{\tan 60^\circ} = \frac{1/\sqrt{3}}{\sqrt{3}} = \frac{1}{3}$$

S28.

$$S_{n^{th}} = u + \frac{a}{2}(2n - 1);$$

$$34.3 = \frac{9.8}{2}(2n - 1)$$

$$n = 4;$$

Now, $$h = \frac{1}{2} \times 9.8 \times 4 \times 4\,\text{m} = \mathbf{78.4\,m}.$$

S29. $$\text{Total time} = \frac{1}{2} + \frac{1}{3} = \frac{5}{6}\,h,$$

$$v_{ac} = \frac{1+1}{5/6} = \frac{12}{5}\,\text{km}\,\text{h}^{-1} = 2.4\,\text{km}\,\text{h}^{-1}.$$

S30. Echo will be heard when the sound reaches back the place of firing. So total distance travelled by sound is 2×1.2 km = 2.4 km = 2400 m

$$\text{Velocity} = \frac{2400\,\text{m}}{8\,\text{s}} = 300\,\text{m}\,\text{s}^{-1}.$$

S31. Speed of the belt, v_B = 4 km/h

Speed of the boy, v_b = 9 km/h

Since the boy is running in the same direction of the motion of the belt, his speed (as observed by the stationary observer) can be obtained as:

Velocity of boy with respect to belt

$$v_{bB} = v_b + v_B = 9 + 4 = 13 \text{ km/h}$$

Since the boy is running in the direction opposite to the direction of the motion of the belt, his speed (as observed by the stationary observer) can be obtained as:

$$v_{bB} = v_b + (-v_B) = 9 - 4 = 5 \text{ km/h}$$

Distance between the child's parents = 50 m

As both parents are standing on the moving belt, the speed of the child in either direction as observed by the parents will remain the same *i.e.*, 9 km/h = 2.5 m/s.

Hence, the time taken by the child to move towards one of his parents is $\frac{50}{2.5} = 20$ s .

If the motion is viewed by any one of the parents, answers obtained in (a) and (b) get altered. This is because the child and his parents are standing on the same belt and hence, are equally affected by the motion of the belt. Therefore, for both parents (irrespective of the direction of motion) the speed of the child remains the same i.e., 9 km/h.

For this reason, it can be concluded that the time taken by the child to reach any one of his parents remains unaltered.

S32. Straight line

Distance covered by a body in n^{th} second is given by the relation

$$D_n = u + \frac{a}{2}(2n - 1) \qquad \text{... (i)}$$

Where, u = Initial velocity

a = Acceleration

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

In the given case,

$$u = 0 \quad \text{and} \quad a = 1\ \text{m/s}^2$$

$$D_n = \frac{1}{2}(2n - 1) \qquad \text{... (ii)}$$

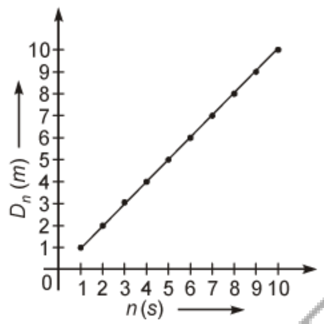
This relation shows that:

$$D_n \propto n \qquad \text{... (iii)}$$

Now, substituting different values of n in equation (iii), we get the following table:

n	1	2	3	4	5	6	7	8	9	10
D_n	0.5	1.5	2.5	3.5	4.5	5.5	6.5	7.5	8.5	9.5

The plot between n and D_n will be a straight line as shown:



Since the given three-wheeler acquires uniform velocity after 10 s, the line will be parallel to the time-axis after n = 10 s.

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

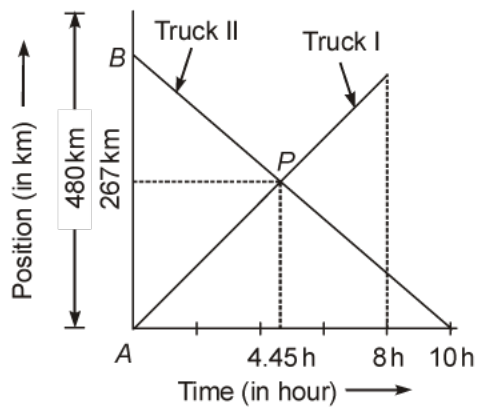
S33. Instantaneous velocity is given by the first derivative of distance with respect to time *i.e.*,

$$v_{\text{In}} = \frac{dx}{dt}$$

Here, the time interval dt is so small that it is assumed that the particle does not change its direction of motion. As a result, both the total path length and magnitude of displacement become equal is this interval of time.

Therefore, instantaneous speed is always equal to instantaneous velocity.

S34. Let us choose the city A as the reference point.



For first truck (which travels from A to B)

At $t = 0$, $x(0) = 0$

At $t = 8$ h, $x(t) = 480$ km

For second truck (which travels from B to A)

At $t = 0$, $x(0) = 480$ km

At $t = 10$ h, $x(t) = 0$

With the help of this data for the two trucks, we can plot distance-time graphs as shown in figure.

The two straight line graphs intersect at the point P. This point of intersection gives both the position and time of meeting.

The time corresponding to point P is 4.45 h while the distance (from A) corresponding to P is 267 km.

Thus, the trucks will meet at a distance of 267 km from A, 4.45 h after starting.

S35. For the first ball,

$$\frac{h}{3} = \frac{1}{2}gt^2 \quad \text{... (i)}$$

For the second ball,

$$h - \frac{h}{3} = vt - \frac{1}{2}gt^2 \quad \text{... (ii)}$$

Adding (i) and (ii),

$$h = vt \quad \text{or} \quad t = \frac{h}{v}$$

From equation (i),

$$\frac{h}{3} = \frac{1}{2}g\left(\frac{h}{v}\right)^2$$

or $$v = \sqrt{\frac{3}{2}gh}\ .$$

Velocity of the first ball at the position where it meets the second ball is given by

$$v_1^2 - 0^2 = 2g \times \frac{h}{3} \quad \text{or} \quad v_1 = \sqrt{\frac{2\,gh}{3}}\ .$$

The velocity of the second ball at the place where it meets the first ball is given by

$$v_2^2 - v^2 = -2g\left(h - \frac{h}{3}\right)$$

or $$v_2^2 = v^2 - 2g \times \frac{2h}{3}$$

or $$v_2^2 = \frac{3}{2}gh - \frac{4\,gh}{3} = \left(\frac{3}{2} - \frac{4}{3}\right)gh$$

or $$v_2^2 = \frac{1}{6}gh, \quad v_2 = \sqrt{\frac{gh}{6}}$$

Now, $$\frac{v_1}{v_2} = \sqrt{\frac{2\,gh}{3}} \times \sqrt{\frac{6}{gh}} = \frac{2}{1}, \qquad 2:1.$$

S36. To calculate the position at $t = 5$ second, substitute $t = 5$ in the given equation.

$$\therefore \quad y = 5^3 - 6 \times 5^2 + 9 \times 5 + 5$$
$$= 125 - 150 + 45 + 5 = 25$$

Differentiating the given equation with time t, we get

$$\frac{dy}{dt} = 3t^2 - 12t + 9.$$

Differentiating again w.r.t. t, we get acceleration,

$$\frac{d^2y}{dt^2} = 6t - 12.$$

Acceleration at $t = 5$ s is 6 x 5 – 12, *i.e.*, 18 m s^{-2}.

In order to calculate the distance covered in 5 second, let us calculate the value of y at different times.

$$y_0 = 5\,\text{m}, \quad y_1 = 9\,\text{m}, \quad y_2 = 7\,\text{m},$$
$$y_3 = 5\,\text{m}, \quad y_4 = 9\,\text{m} \quad \text{and} \quad y_5 = 25\,\text{m}$$

Distance covered in first second = $|9 - 5|$ m = 4m. Similarly, distance covered in 2nd second, 3rd second, 4th second and 5th second are $|7 - 9|$ m *i.e.*, 2m, $|5 - 7|$ m *i.e.*, 2m, $|9 - 5|$ m *i.e.*, 4 m, $|25 - 9|$ m *i.e.*, 16m respectively.

Total distance covered is 4 + 2 + 2 + 4 + 16 *i.e.*, 28 m.

S37. (a) The magnitude of displacement over an interval of time is the shortest distance (which is a straight line) between the initial and final positions of the particle.

The total path length of a particle is the actual path length covered by the particle in a given interval of time.

For example, suppose a particle moves from point *A* to point *B* and then, comes back to a point, *C* taking a total time *t*, as shown below. Then, the magnitude of displacement of the particle = *AC*.

Whereas, total path length = *AB* + *BC*

It is also important to note that the magnitude of displacement can never be greater than the total path length. However, in some cases, both quantities are equal to each other.

(b) Magnitude of a average velocity = $\dfrac{\text{Magnitude of displacement}}{\text{Time interval}}$

For the given particle,

$$\text{Average velocity} = \frac{AC}{t}$$

$$\text{Average speed} = \frac{\text{Total path length}}{\text{Time interval}} = \frac{AB + BC}{t}$$

Since ($AB + BC$) > AC, average speed is greater than the magnitude of average velocity. The two quantities will be equal if the particle continues to move along a straight line.

S38. Time taken by the man to reach the market from home,

$$t_1 = \frac{2.5}{5} = \frac{1}{2}\text{ h} = 30 \text{ min}$$

Time taken by the man to reach home from the market,

$$t_2 = \frac{2.5}{7.5} = \frac{1}{3}\text{ h} = 20 \text{ min}$$

Total time taken in the whole journey = 30 + 20 = 50 min

(a) 0 to 30 min

$$\text{Average velocity} = \frac{\text{Displacement}}{\text{Time}} = \frac{2.5}{\frac{1}{2}} = 5 \text{ km/h} \qquad \text{... (a (i))}$$

$$\text{Average speed} = \frac{\text{Distance}}{\text{Time}} = \frac{2.5}{\frac{1}{2}} = 5 \text{ km/h} \qquad \text{... (b (i))}$$

(b) 0 to 50 min

$$\text{Time} = 50 \text{ min} = \frac{5}{6}\text{ h}$$

Net displacement = 0

Total distance = 2.5 + 2.5 = 5 km

$$\text{Average velocity} = \frac{\text{Displacement}}{\text{Time}} = 0 \qquad \text{... (a (ii))}$$

$$\text{Average speed} = \frac{\text{Distance}}{\text{Time}} = \frac{5}{\left(\frac{5}{6}\right)} = 6 \text{ km/h} \qquad \text{... (b (ii))}$$

(c) 0 to 40 min

Speed of the man = 7.5 km

Distance travelled in first 30 min = 2.5 km

Distance travelled by the man (from market to home) in the next 10 min

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

Net displacement = 2.5 – 1.25 = 1.25 km

Total distance travelled = 2.5 + 1.25 = 3.75 km

$$\text{Average velocity} = \frac{1.25}{\left(\frac{40}{60}\right)} = \frac{1.25 \times 3}{2} = 1.875 \text{ km/h} \qquad \text{... (a(iii))}$$

$$\text{Average speed} = \frac{3.75}{\left(\frac{40}{60}\right)} = 5.625 \text{ km/h} \qquad \text{... (b(iii))}$$

S39. Consider an object moving in straight line with uniform acceleration = a.

Let at $t = 0$ velocity of the body = u

at $t = t$ velocity of the body = v

(a) ***Velocity-time relation:*** Let dv be the change in velocity in time interval. dt. Then acceleration.

$$a = \frac{dv}{dt} \quad \text{or} \quad dv = a\,dt$$

Integrating from $0 \to t$ when velocity changes from $u \to v$

$$\int_u^v dv = a\int_0^t dt$$

or $$v - u = at$$

or $$\mathbf{v = u + at} \qquad \text{... (i)}$$

(b) ***Distance-time relation:*** Consider an object moving in a straight line with uniform acceleration 'a'. Let at any instant t, dx be the displacement of the object in time interval at. Then instantaneous velocity v is given by

$$v = \frac{dx}{dt} \quad \text{or} \quad dx = v\,dt$$

or $$dx = (u + at)\,dt \qquad [\text{from Eq. (i) } v = u + at]$$

Let x_0 = displacement at $t = 0$

x = displacement at $t = t$

Integrating within limits

$$\int_{x_0}^{x} dx = \int_0^t (u + at)dt = u\int_0^t dt + a\int_0^t t\,dt$$

$$x - x_0 = ut + \frac{1}{2}at^2$$

or $$\mathbf{x = x_0 + ut + \frac{1}{2}at^2} \qquad \text{... (ii)}$$

If $x - x_0 = s$ = distance covered by an object in time t then

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

(c) ***Velocity-displacement relation:*** Consider a particle moving in a straidght line with initial velocity u, and uniform acceleration 'a'. Then,

$$a = \frac{dv}{dt} = \frac{dv}{dx} \times \frac{dx}{dt} = v\frac{dv}{dx}$$

$$adx = vdv$$

Let u be the velocity of object at position x_0.

v be the velocity of object at position x Integrating above within limits

$$\int_u^v vdv = \int_{x_0}^x a\,dx$$

$$a(x - x_0) = \frac{v^2}{2} - \frac{u^2}{2}$$

$$v^2 - u^2 = 2a(x - x_0)$$

Putting, $x - x_0 = s$, we get

$$v_2 - u_2 = 2as \qquad \text{... (iii)}$$

The above three laws are valid under the conditions, only when the acceleration is uniform.

S40. Let v be the speed on reaching the floor

$$v^2 - u^2 = 2\,as$$

or $$v^2 - (0)^2 = 2 \times 9.8 \times 90$$

$$v^2 = 1764$$

or $$v = 42 \text{ m s}^{-1}$$

Let t_1 be the time taken by the ball in reaching the ground.

$$v = u + at$$

or $$42 = 0 + 9.8\,t_1$$

$\Rightarrow$ $$t_1 = 4.28 \text{ s}.$$

(a) The speed of the ball will go on increasing at a constant rate from 0 m/s to 42 m/s for 4.28 seconds. This is shown by the line OA.

At A, the ball strikes the floor and its speed is decreased by $\frac{1}{10} \times 42 = 4.2$ (*i.e.*, $42 - 4.2 = 37.8$) m/s.

This is shown by the line AB.

(b) The ball goes up vertically with a speed u = 37.8 m/s and at the highest point its speed v becomes zero.

Suppose it reaches the highest point in time t_2

$$v = u + at_2$$

$$0 = 37.8 - 9.8\ t_2$$

or $$t_2 = \frac{37.8}{9.8} = 3.85 \text{ s.}$$

Therefore, the speed of the ball goes on decreasing at constant rate from 37.8 m/s to 0 for 3.85 s.

$$v^2 = u^2 + 2\,as$$

or $$(0)^2 - (37.8)^2 = -2\ \ 9.8\ \ s$$

or $$s = \frac{(37.8)^2}{2 \times 9.8} = 72.9 \text{ m}$$

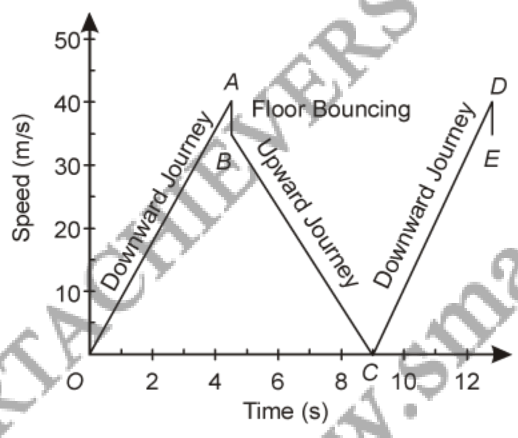
Thus, the ball rises to the height 72.9 m. The decrease in speed in the upward motion is shown by *BC*.

(c) After reaching the highest point, the ball will take the same time as in (b), *i.e.*, 3.85 s to come down and strike the floor. Its speed will increase from 0 to 37.8 m/s. The speed with which it bounced back. This is shown by *CD*.

(d) On hitting the floor, its speed will decrease by $\frac{1}{10}$ of 37.8 = 3.78

$$37.8 - 3.78 = 34.02 \text{ m/s}$$

This is represented by *DE*.



The total time since the ball was dropped = 4.28 s + 3.85 s + 3.85 s = 11.98 s = 12 s.

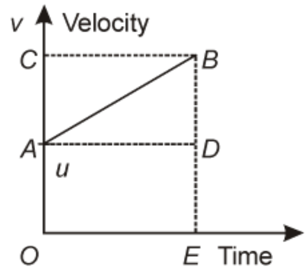
S41. Consider an object moving along a straight line with uniform acceleration *a*. Let *u* be the initial velocity at $t = 0$ and v the final velocity after time t.

From graph $OA = ED = u$

$OC = EB$

$OE = t = AD$

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



area under velocity time graph for a given time interval represents the distance covered by a uniformly accelerated object in a given time interval.

From graph, acceleration, a = slope of velocity-time graph AB.

$$\therefore \quad a = \frac{BD}{AD} = \frac{DB}{t}$$

or $\quad DB = at$

Distance travelled by object in time t is

s = Area of trapezium $OABE$

= Area of rectangle $OADE$ + Area of triangle ADB

$$= OA \times OE + \frac{1}{2} DB \times AD = ut + \frac{1}{2}at^2$$

$$v^2 - u^2 = 2as$$

Distance travelled by an object in time interval t is

s = Area of trapezium $OABE$

$$= \frac{1}{2}(EB + OA) \times OE$$

$$= \frac{1}{2}(EB + ED) \times OE \qquad \{\because \ OA = ED)$$

Acceleration, a = slope of velocity time graph AB

$$a = \frac{DB}{AD} = \frac{EB - ED}{OE}$$

$$OE = \frac{EB - ED}{a}$$

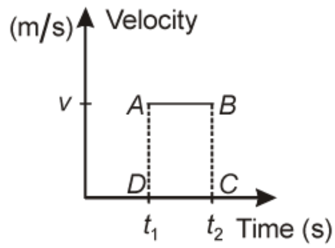
$$s = \frac{1}{2}(EB + ED) \times \frac{(EB - ED)}{a}$$

$$= \frac{1}{2a}(EB^2 - ED^2)$$

$$= \frac{1}{2a}(v^2 - u^2)$$

$$v^2 - u^2 = 2as.$$

S42. (a) Let a body with constant velocity v, between time t_1 and t_2 as shown in graph.

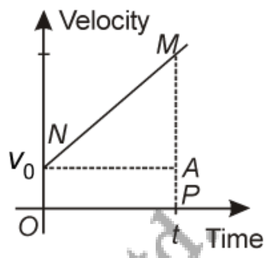


$$\text{Area below} = \text{area } ABCD = v(t_2 - t_1)$$

Also, the displacement = velocity × time

$$= \boldsymbol{v \times (t_2 - t_1)} \qquad \text{[Thus proved.]}$$

(b) Slope of $v - t$ graph is constant. So there is uniform acceleration. Area below the graph gives the displacement (x).



$$\text{Displacement} = \text{Area of trapezium}$$

$$= ON \times OP + \frac{1}{2} NA \times MA$$

$$= v_0 \times t + \frac{1}{2}(t)(v - v_0)$$

Since $$a = \frac{v - v_0}{t}$$

We have, $$x = v_0 t + \frac{1}{2} t\, at = \boldsymbol{v_0 t + \frac{1}{2} at^2}.$$

(c) u = 126 km/hr = 35 m/sec, v = 0, s = 200 m.

Using, $$v^2 = u^2 + 2as,$$

$$a = \frac{v^2 - u^2}{2s} = \frac{35^2}{2 \times 200}$$

$$= -3.00 \text{ ms}^{-2}$$

$$v = u + at$$

$$0 = 35 - 3 \times t$$

$$t = \frac{35}{3} = \mathbf{11.66\ sec}.$$