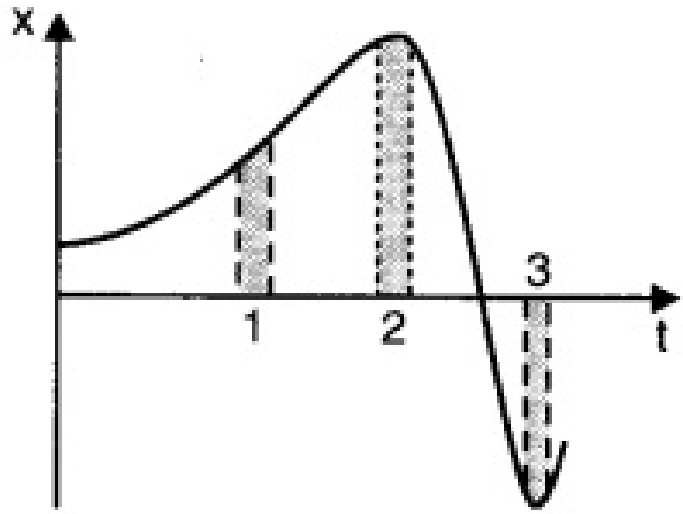
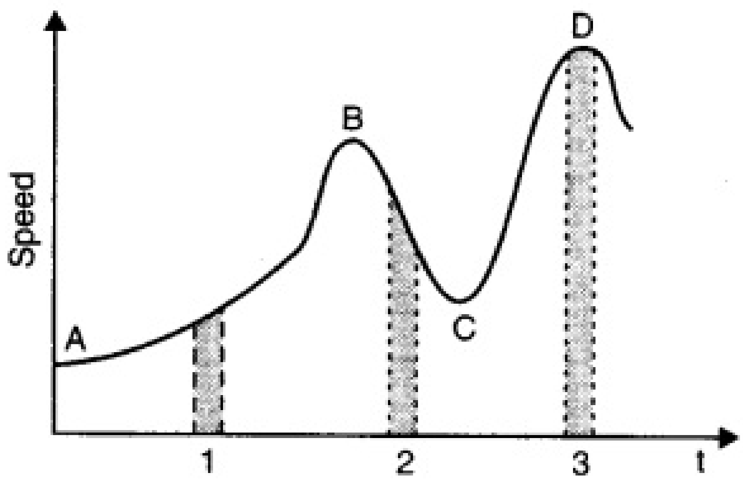
Question 3. 21. Figure gives the x-t plot of a particle in one-dimensional motion. Three different equal intervals of time are shown. In which interval is the average speed greatest, and in which is it the least? Give the sign of average velocity for each interval.



Answer: Greater in 3, least in 2; $v > 0$ in 1 and 2, $v < 0$ in interval 3.

Question 3. 22. Figure gives a speed-time graph of a particle in motion along a constant direction. Three equal intervals of time are shown. In which interval is the average acceleration greatest in magnitude? In which interval is the average speed greatest? Choosing the positive direction as the constant direction of motion, give the signs of v and a in the three intervals. What are the accelerations at the points A, B, C and D?



Answer:
The acceleration is greatest in magnitude in interval 2 as the change in speed in the same time is maximum in this interval.
The average speed is greatest in interval 3 (peak D is at maximum on speed axis).
The sign of v and a in the three intervals are:
$v > 0$ in 1, 2 and 3; $a > 0$ in 1
$a < 0$ in 2, $a=0$ in 3.
acceleration is zero at A,B,C and D.

Question 3. 23. A three - wheeler starts from rest, accelerates uniformly with 1 m s-2 on a straight road for 10 s, and then moves with uniform velocity .plot the distance covered by the vehicle during the n th second (n=1,2,3........) versus n. what do you expect this plot to be during accelerated motion: a straight line or a parabola?
Answer:
Since

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

when $u = 0,\ a = 1\ ms^{-2}$

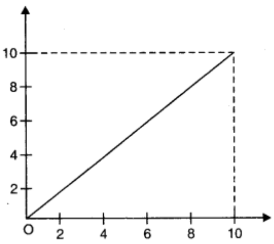
$\therefore$ $S_{nth} = 0 + \frac{1}{2}(2n-1) = \frac{1}{2}(2n-1)$

$\therefore$ For $n = 1, 2, 3$ ....

$$S_1 = \frac{1}{2}(2 \times 1 - 1) = 0.5\ m$$

$$S_2 = \frac{1}{2}(2 \times 2 - 1) = 1.5\ m$$

$$S_3 = \frac{1}{2}(2 \times 3 - 1) = 2.5\ m$$



$$S_4 = \frac{1}{2}(2 \times 4 - 1) = 3.5\ m$$

$$S_5 = \frac{1}{2}(2 \times 5 - 1) = 4.5\ m$$

$$S_6 = \frac{1}{2}(2 \times 6 - 1) = 5.5\ m$$

$$S_7 = \frac{1}{2}(2 \times 7 - 1) = 6.5\ m,\ S_8 = \frac{1}{2}\ (2 \times 8 - 1) = 7.5\ m$$

$$S_9 = \frac{1}{2}(2 \times 9 - 1) = 8.5\ m,\ S_{10} = \frac{1}{2}\ (2 \times 10 - 1) = 9.5\ m$$

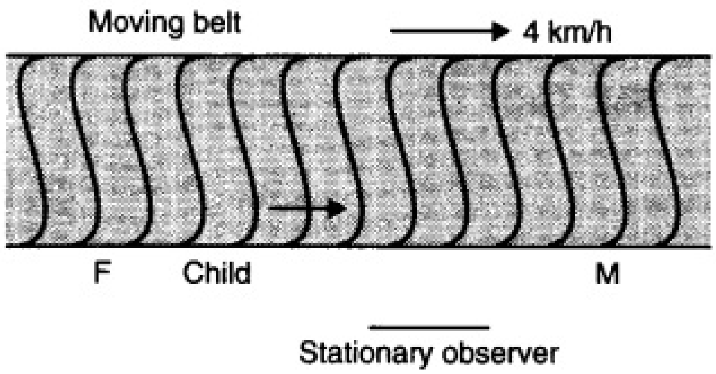
Question 3. 24. A boy standing on a stationary lift (open from above) throws a ball upwards with the maximum initial speed he can, equal to 49 m s^{-1}. How much time does the ball take to return to his hands? If the lift starts moving up with a uniform speed of 5 m s^{-1} and the boy again throws the ball up with the maximum speed he can, how long does the ball take to return to his hands?
Answer:
When either the lift is at rest or the lift is moving either vertically upward or downward with a constant speed, we can apply three simple kinetnatic motion equations presuming a = ± g (as the case may be).
In present case u = 49 ms^{-1} (upward) a = g = 9.8 ms^{-2} (downward).
If the ball returns to boy's hands after a time t, then displacement of ball relative to boy.
is zero i.e., s = 0. Hence, using equation s = ut + 1/2 at 2, we have

$$0 = 49 \pm -\frac{1}{2} \times 9.8 \times t^2$$

$$\Rightarrow \quad 4.9\ t^2 - 49t = 0 \Rightarrow t = 0 \text{ or } 10\ s$$

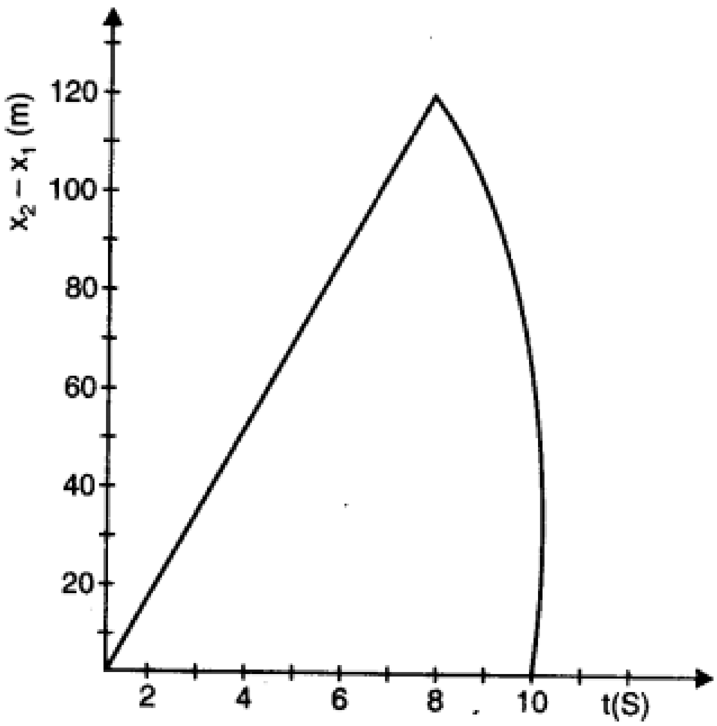
As $t = 0$ is physically not possible, hence time $t = 10$ s.

Question 3. 25. On a long horizontally moving belt (Fig.), a child runs to and fro with n speed 9 km h^{-1} (with respect to the belt) between his father and mother located 50 a part on the moving belt. The belt moves with a speed of 4 km h^{-1}. For an observe 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?



Answer:
Speed of child with respect to belt = 9 km h^{-1} Speed of belt = 4 km h^{-1}
(a) When the child runs in the direction of motion of the belt, then speed of child w.r.t. stationary observer = (9 + 4) km h^{-1} = 13 km h^{-1}.
(b) When the child runs opposite to the direction of motion of the belt, then speed of child w.r.t. stationary observer = (9 - 4) km h^{-1} = 5 km h^{-1}
(c) Speed of child w.r.t . either parent=9 km h^{-1}
Distance to be covered = 50 m = 0.05 km 0.05 km
Time=0.05 km/9k h^{-1}=0.0056 h =20 S
If the motion is viewed by one of the parents, then the answers to (a) and (b)are altered but answer to (c) remains unaltered.

Question 3. 26. Two stones are thrown up simultaneously from the edge of a cliff 200 m high with initial speeds of 15 ms^{-1} and 30 ms^{-1}. Verify that the graph shown in Fig. 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 ms^{-2}. Give the equations for the linear and curved parts of the plot.



Answer: For first stone,
x (0) = 200 m, v (0) = 15 ms^{-1}, a = -10 ms^{-2}
x_1 (t) = x (0) + v (0) t + 1/2 a t^2
x_1 (t) = 200 + 15t - $5t^2$
When the first stone hits the ground, x_1 (t) = 0
- $5t^2$ + 15t+ 200 = 0 On simplification, t = 8 s
For second stone, x (0) = 200 m, v (0) = 30 ms^{-1}, a = -10 ms^{-2}

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

When this stone hits the ground, $x_1(t) = 0$.-. $-5t^2 + 30t + 200 = 0$

Relative position of second stone w.r.t. first is given by $x_2(t) - x_1(t) = 15t$

Since there is a linear relationship between $x_2(t) - x_1(t)$ and t, therefore the graph is a straight line.

For maximum separation, t = 8 s So maximum separation is 120 m.

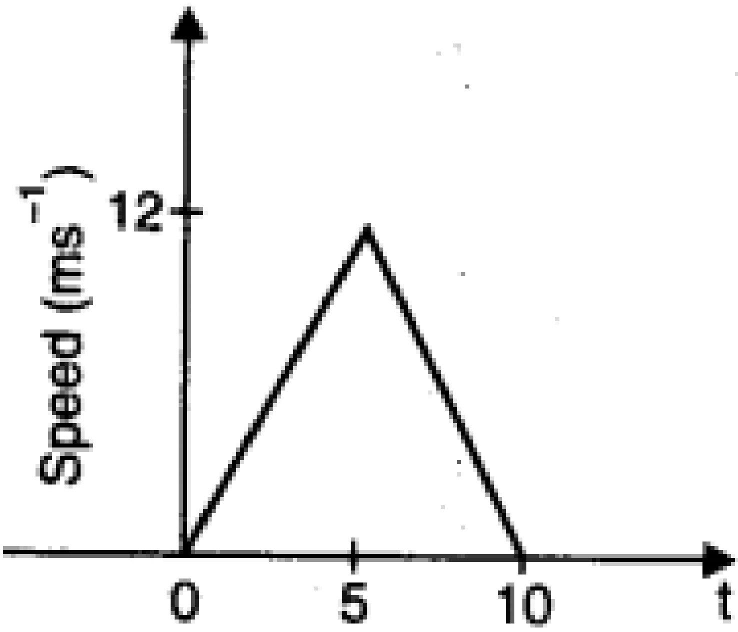
After 8 second, only the second stone would be in motion. So, the graph is in accordance with the quadratic equation.

Question 3. 27. The speed-time graph of a particle moving along a fixed direction is shown in Fig. 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)?



Answer:

(a) Distance travelled by the particle between t = 0 s to 10 s

$$= \text{area of } \Delta OAB = \frac{1}{2} \text{ base} \times \text{height}$$

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

$\therefore$ Average speed of particle $v_{av} = \dfrac{60 \text{ m}}{10 \text{ s}} = 6 \text{ ms}^{-1}$

(b) The distance traversed by the particle between

$t = 2$ s to $t = 6$ s

= distance from 2 to 5 s (S_1) + distance in 6th second (S_2)

Now, $u = 0,\ t = 5,\ v = 12 \text{ ms}^{-1}$

$\therefore$ Acceleration for 0 – 5 s, $a = \dfrac{v-u}{t} = \dfrac{12-0}{5} \text{ ms}^{-2} = 2.4 \text{ ms}^{-2}$

$\therefore$Distance covered from 2 to 5 s = distance covered in 5 s – distance covered in 2 s

$$S_1 = \frac{1}{2}a(5)^2 - \frac{1}{2}a(2)^2 = \frac{1}{2} \times 2.4 \times \left[(5)^2 - (2)^2\right]$$

$$= 25.2 \text{ m.}$$

For motion from 5 to 10 s, $u = +12 \text{ ms}^{-1}$ and $a = -2.4 \text{ ms}^{-2}$ and interval $t = 5$ s to $t = 6$ s means $n = 1$ for this motion.

$\therefore$ Distance covered in 6th second $S_2 = u + \dfrac{1}{2}a(2n-1)$

$$= 12 - \frac{2.4}{2}(2 \times 1 - 1) = 10.8 \text{ m}$$

$\therefore$ Total distance covered from $t = 2$ s to 6 s = $S_1 + S_2$

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

and average speed $= \dfrac{36 \text{ m}}{(6-2)\text{ s}} = 9 \text{ ms}^{-1}$.

Question 3. 28. The velocity-time graph of a particle in one-dimensional motion is shown below. Which of the following formula are correct for describing the motion of the particle over the time interval from t_1 to t_2?

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

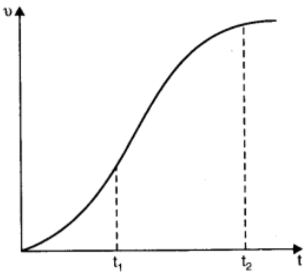
(b) $v(t_2) = v(t_1) + a(t_2 - t_1)$

(c) $a_{average} = [x(t_2) - x(t_1)]/(t_2 - t_1)$

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

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

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



Answer: (c),(d),(f).

As it is evident from the shape of v-t graph that acceleration of the particle is not uniform between time intervals t_1 and t_2. (since the given v-t graph is not straight). The equations (a), (b) and (e) represent uniform acceleration.

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