Chapter 2

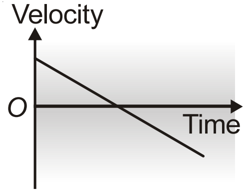
Motion in a Straight Line

Solutions (Set-1)

Very Short Answer Type Questions :

1. A ball is thrown upwards, draw its velocity-time graph.

Sol.



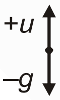
When a ball is thrown upwards, its velocity first decreases then, becomes zero at highest point and, again start increasing in the opposite direction as it comes back to the ground.

2. An object is thrown vertically upwards from the surface of earth. If the upward direction is taken as positive. What is the direction of the velocity and acceleration of the object during its upward and downward motion?

Sol. Upward motion

Velocity = +ve

Acceleration = –ve



Downward motion

Velocity = – ve

Acceleration = – ve

3. A ball is thrown upwards. What is the velocity and acceleration at the highest point?

Sol. At the top, the velocity of the ball is zero and acceleration of the ball is 9.8 m/s^2 downward.

4. What is the acceleration of a body when its velocity-time graph is (i) perpendicular to time axis (ii) parallel to time axis?

Sol. (i) infinity, (ii) zero.

5. Is it possible that an object moving with decreasing speed have constant acceleration?

Sol. Yes, during upward motion of an object thrown up under gravity.

6. The position s of a particle moving along a straight line at time t is given by $s = (at^3 + bt^5)$ m, where t is in second. Find its velocity at $t = 1$ s.

Sol. $v = \frac{ds}{dt} = 3at^2 + 5bt^4$.

at $t = 1$ s

$v = 3a + 5b$

7. What is the distance travelled by a body thrown vertically upward with a speed of 20 m/s, under the effect of gravity in the first second of its motion? (use g = 10 m/s^2)

Sol. u = + 20 m/s, g = 10 m/s^2, t = 1 s.

Using,

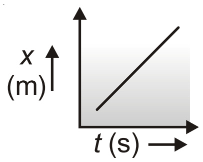
$$s = ut - \frac{1}{2}gt^2$$

$$s = 20 - \frac{1}{2}\times 10 = 15 \text{ m}$$

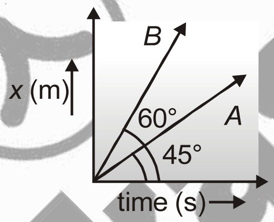
s = 15 m

8. Draw the position-time graph of an object moving with zero acceleration.

Sol.



9. The position-time graph of two objects A and B is shown below. Which one is moving with greater velocity?



Sol. Slope of position-time graph gives velocity and slope of graph = tanθ,

Slope of A = tan 45° = 1,

Slope of B = tan 60° = $\sqrt{3}$

B is moving with greater velocity as its slope is greater than A.

10. Mention the condition, in which an object in motion can be considered as a point object?

Sol. When its size is negligible as compared to the distance travelled by object.

Short Answer Type Questions :

11. A car starts moving from rest with a constant acceleration of 5 m/s^2 along a straight line. Find

(i) The distance travelled by it in the first 2 seconds.

(ii) The distance travelled by it in the 2nd second.

Sol. u = 0, a = 5 m/s^2, t = 2

using $s = ut + \frac{1}{2}at^2$

$$s = \frac{1}{2}\times 5\times 2^2 = 10 \text{ m}$$

10 m is the distance travelled by the car in 2 seconds. The distance travelled by the car in 1 second can be calculated as

$$s = \frac{1}{2} \times 5 \times 1 = 2.5 \text{ m}$$

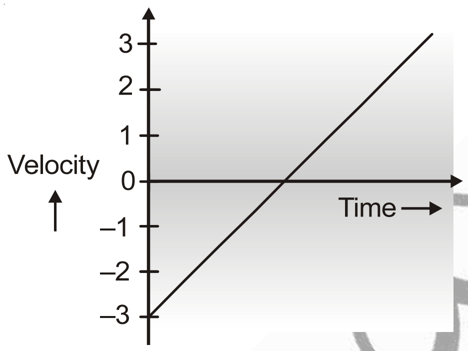
2.5 m is the distance travelled by the car in the 1st second. Hence the distance travelled by it in 2nd second = 10 – 2.5 = 7.5 m.

12. The position s of a particle moving along x-axis at time t is given by $s = (5 - 3t + 2t^2)$ m, where t is in seconds. Draw its velocity-time graph.

Sol. $v = \frac{ds}{dt} = -3 + 4t$

$v = 4t - 3$

as $v \propto t \Rightarrow$ graph will be a straight line and at $t = 0$, $v = -3$ so graph will be a straight line cutting y-axis at $v = -3$



13. Distinguish between speed and velocity.

Sol.

Speed	Velocity
(i) Speed is define as the rate of coverage of distance w.r.t. time	(i) Velocity is the speed of the object in a specific direction
(ii) Speed is a scalar quantity	(ii) Velocity is a vector quantity
(iii) The speed of an object can be zero or positive but never negative	(iii) The velocity of an object can be zero, positive and negative

14. A person travels along a straight road for the first half of the distance with a speed v_1 and the second half of the distance with speed v_2. What is the average speed of the person?

Sol. Time taken by person to travel first half length $t_1 = \frac{\left(\frac{d}{2}\right)}{v_1} = \frac{d}{2v_1}$

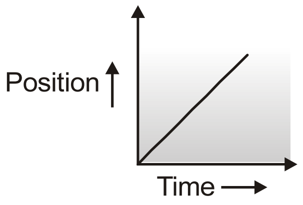
Time taken by person to travel second half length $t_2 = \frac{\left(\frac{d}{2}\right)}{v_2} = \frac{d}{2v_2}$

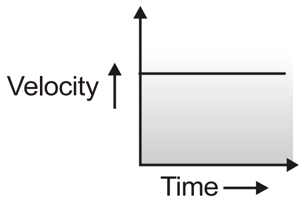
Total time = $t_1 + t_2 = \frac{d}{2}\left(\frac{1}{v_1} + \frac{1}{v_2}\right) = \frac{d(v_1 + v_2)}{2v_1v_2}$

Average speed = $\frac{\text{Distance}}{\text{Total time}} = \frac{d}{t_1 + t_2} = \frac{2v_1v_2}{(v_1 + v_2)}$

15. Define uniform motion of an object moving along a straight line. Draw position-time and velocity-time graphs of such a motion.

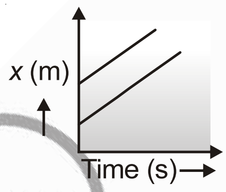
Sol. An object is said to be moving in uniform motion if it covers equal distances in equal intervals of time.





16. Define relative velocity of an object w.r.t. another. Draw the position-time graphs of two objects moving along a straight line in the same direction, when their relative velocity is zero.

Sol. Relative velocity is the velocity with which one object moves w.r.t. another object. The $x - t$ graphs of two objects moving with zero relative velocity along a straight line in the same direction is shown below.



17. What do you understand by a non-uniform motion? Explain, average velocity and instantaneous velocity of an object moving along a straight line.

Sol. An object is said to be in non-uniform motion, if its speed, direction or both speed and direction changes with time. Average velocity gives the constant velocity with which the object is moving over an interval of time whereas instantaneous velocity gives the velocity of the object at a particular instant of time during its motion.

18. When two bodies move uniformly towards each other, the distance between them decreases by 4 m/s. If both the bodies move in the same direction, with the same speeds, the distance between them increases by 2 m/s. What are the speeds of two bodies?

Sol. Let the speeds of the bodies be u and v according to the question.

$u + v = 4$ and $u - v = 2$

On solving these equation $u = 3$ m/s and $v = 1$ m/s

19. A train of 150 m length is going towards north direction at a speed of 10 m/s. A bird flies at a speed of 5 m/s towards the south direction parallel to the railway track. Find the time taken by the bird to cross the train.

Sol. Relative velocity of bird w.r.t. train = 5 + 10 = 15 m/s.

$$\text{Time} = \frac{\text{Distance}}{\text{Speed}}$$

$$\text{Time} = \frac{150}{15} = 10 \text{ s}$$

Time taken by the bird to cross the train is 10 s.

20. A boy travelling along a straight line, traversed one third of the total distance with a velocity of 4 m/s. The remaining part of the distance was covered with a velocity of 2 m/s and 6 m/s for the equal time intervals. Calculate the average velocity of the boy during his entire journey.

Sol. Let total distance = d.

Time taken by the boy to travel $\frac{d}{3}$ distance $t_1 = \frac{d}{3\times 4} - = \frac{d}{12}$

Let t be the time for the remaining journey

d_1 distance moved by the boy in $\frac{t}{2} = 2t$

d_2 distance moved by the boy in $\frac{t}{2} = 6t$

$$d_1 + d_2 = \frac{2d}{3}$$

$$2t + 6t = \frac{2d}{3}$$

$$8t = \frac{2d}{3}$$

$$t = \frac{2d}{24}$$

Total time $t' = t_1 + t = \frac{d}{12} + \frac{2d}{24} = \frac{48d}{12\times 24}$

Average velocity = $\frac{\text{Displacement}}{\text{Total time}} = \frac{d}{48d}\times 12\times 24$ = 6 m/s

21. A car travelling at 50 km/h overtakes another car travelling at 32 km/h. Assuming each car to be 5 m long, find the time taken during the overtake.

Sol. Velocity of car 1 = 50 km/h

Velocity of car 2 = 32 km/h

v_{12} = velocity of car 1 w.r.t. car 2 = $v_1 - v_2$

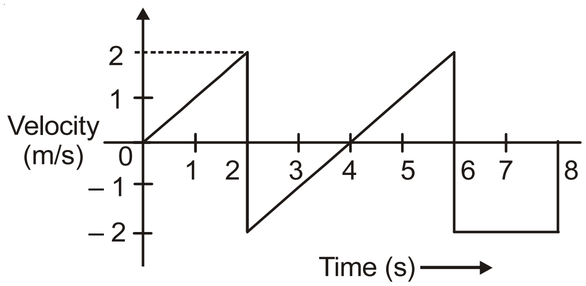
= 50 – 32 = 18 km/h

= 5 m/s

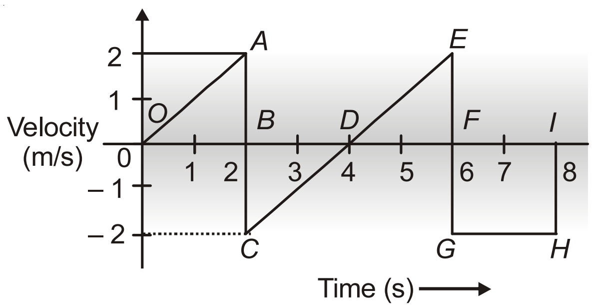
Relative velocity = $\frac{\text{Relative distance of separation}}{\text{Time}}$

Time = $\frac{5+5}{5} = \frac{10}{5} = 2$ s

22. The velocity-time graph of a particle moving along a straight line is as shown below. Calculate the distance covered between t = 0 to t = 8 seconds. Also calculate the displacement between the same interval.



Sol.



Distance covered by the particle = area under the velocity-time curve without considering the signs.

= ar(ΔOAB) + ar(ΔBCD) + ar(ΔDEF) + ar(square $FGHI$)

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

Distance = 10 m.

Displacement = area under the velocity-time curve (considering the signs).

= ar(ΔOAB) – ar(ΔBCD) + ar(ΔDEF) – ar(square $FGHI$)

$$= \frac{1}{2}\times 2\times 2-\frac{1}{2}\times 2\times 2+\frac{1}{2}\times 2\times 2-4$$

Displacement = – 2 m

Negative sign shows that the displacement is in the negative direction.

23. A car was moving at a rate of 18 km/h when the brakes were applied. If it comes to rest after travelling a distance of 5 m, calculate the average retardation produced in the car.

Sol. Using

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

$v = 0$, $u = 18$ km/h, 5 m/s, $a = ?$, $s = 5$ m

$-25 = 2 \times a \times 5$

$$a = -\frac{25}{10} = -2.5 \text{ m/s}^2$$

Retardation produced in the car is 2.5 m/s^2.

24. A ball is dropped from the top of a tower. The distance travelled by the ball in the last second is 40 m. Find the height of the tower. (given g = 10 ms^{-2})

Sol. Let the height of the tower be h. Time taken by the ball to reach the ground is t.

$$s = -\frac{1}{2}gt^2$$

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

The distance travelled by the ball in (t – 1) second.

$$s' = -\frac{1}{2}g(t-1)^2 \qquad \text{...(ii)}$$

Distance travelled by the ball in the last second, subtraction of equation (ii) from (i).

$$s - s' = \frac{1}{2}g(t^2 - (t-1)^2)$$

$\Rightarrow$ 40 = 5(2t – 1)

$\Rightarrow$ 2t – 1 = 8

$\Rightarrow$ t = 9/2

Substituting this value of t in (i)

$$s = -\frac{1}{2}\times 10\left(\frac{9}{2}\right)^2 = -\frac{81\times 5}{4} = -101.25\text{ m}$$

Height of the tower is 101.25 m

25. A stone is dropped from the roof of a tower of height h. The total distance covered by the stone in the last 2 seconds of its motion is equal to the distance covered by it in the first four seconds. Find the height h of the tower.

Sol. Let t be the time taken by the stone to reach the ground and h be the height of the tower.

Then, using $s = ut - \frac{1}{2}gt^2$

$$h = -\frac{1}{2}gt^2$$

Distance covered by the stone in (t – 2) seconds

$$h' = -\frac{1}{2}g(t-2)^2$$

Distance covered in last 2 seconds = $h - h'$

$$= -\frac{1}{2}g(t^2 - t^2 - 4 + 4t)$$

$$= -\frac{1}{2}g(4t - 4) \quad \text{...(i)}$$

Distance covered by the stone in the first 4 seconds.

$$s = -\frac{1}{2}g\times(4)^2 = -\frac{16}{2}g \quad \text{...(ii)}$$

Equating (i) and (ii),

$$-\frac{1}{2}g(4t-4) = -\frac{16}{2}g$$

4t – 4 = 16

4t = 20, t = 5 seconds

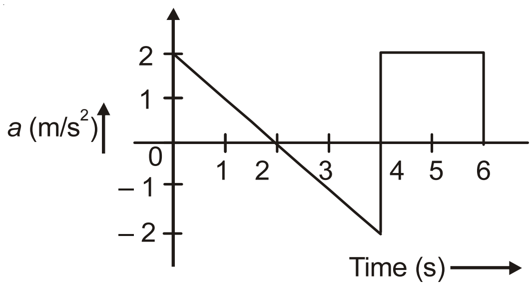
Substituting the value of t,

$$h = -\frac{1}{2}\times 9.8\times 25$$

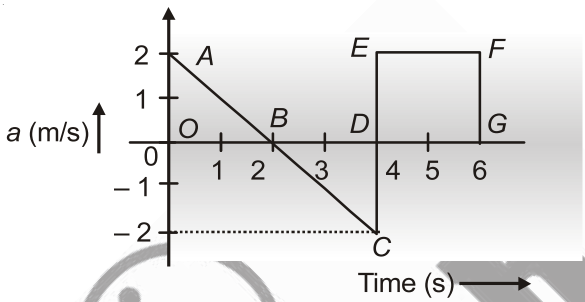
h = – 122.5 m

So the height of tower is 122.5 m

26. The acceleration-time graph of a particle moving along a straight line is shown in the figure given below, calculate the maximum velocity of the particle starting from rest in 6 seconds.



Sol. Change in velocity = area under the acceleration-time graph.



= ar(ΔAOB) – ar(ΔBCD) + ar(rectangle *DEFG*)

= $\frac{1}{2}\times 2\times 2-\frac{1}{2}\times 2\times 2+2\times 2=4$ m/s

Change in velocity ($v – u$) = 4 m/s.

The initial velocity of the object was zero.

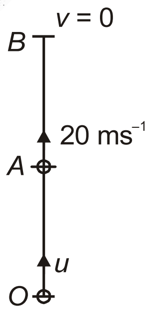
So the maximum velocity of the object is 4 m/s.

27. A ball is projected vertically upwards. Its speed at half of the maximum height is 20 m/s. Calculate the maximum height attained by it. (g = 10 m/s^2).

Sol. Let the maximum height attained by it is *h.*

u be the initial velocity of project ion.

Consider motion from *O* to *A*



at $\frac{h}{2}$, v = 20 m/s using $v^2 – u^2 = 2gh$

$\Rightarrow$ $400-u^2=-2\times 10\times\frac{h}{2}$

$\Rightarrow$ $400 + 10h = u^2$

Consider motion from *O* to *B*

At highest point $v = 0$

$\Rightarrow$ $– u^2 = – 2gh$

$\Rightarrow$ $400 + 10h = 2 \times 10 \times h$

$\Rightarrow$ $10h = 400$, $h = 40$ m

So, the maximum height attained by the ball is 40 m

Long Answer Type Questions :

28. The position (x) of a body moving along a straight line at time t is given by $x = (3t^2 - 5t + 2)$ m. Find its

 (i) Velocity at $t = 2$ s

 (ii) Acceleration at $t = 2$ s and draw the corresponding velocity-time (v-t) and acceleration-time (a-t) graphs

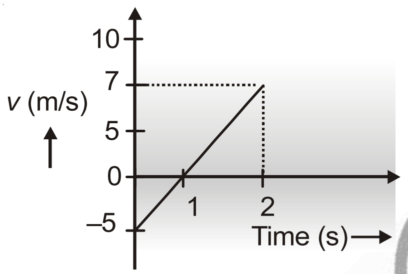
Sol. $x = 3t^2 - 5t + 2.$

$v = \frac{dx}{dt} = 6t - 5$ at $t = 2$ s.

$v = 12 - 5 = 7$ m/s, at $t = 0$.

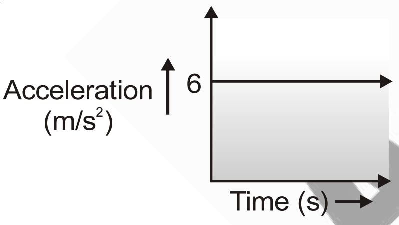
$v = -5$ m/s

$v \propto t$



Acceleration $a = \frac{dv}{dt} = 6 \text{ m/s}^2$ acceleration is constant.

$\therefore$ Acceleration-time graph is a straight line parallel to time axis intersecting acceleration axis at 6 m/s^2.



29. (i) Define reaction time with the help of an example.

 (ii) Deduce an expression to calculate the reaction time to catch a ball dropped from the top of a tower, if you caught it after it travelled a distance d in the downward direction.

Sol. (i) Reaction-time is that time which a person takes to observe, think and act for *e.g.*, If a person is driving a car and suddenly a boy appears on the road, then the time elapsed before he applies the car is the reaction time.

 (ii) Using $s = ut - \frac{1}{2}gt^2$

 $u = 0$, $s = d$, $t = t_r$ = reaction time

 $-d = -\frac{1}{2}gt_r^2$

 $t_r = \sqrt{\frac{2d}{g}}$

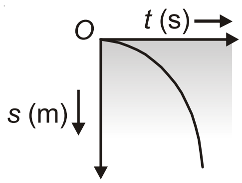
30. (i) What do you mean by free fall?

(ii) Taking upwards direction positive, point of projection as origin and neglecting air resistance, draw the position-time, velocity-time and acceleration-time graphs of an object under free fall.

Sol. If an object is released from a height near the surface of the earth. It is accelerated downwards under the influence of gravity pull, with acceleration due to gravity *g.* If the air resistance is neglected the object is said to be in free fall.

Position-time graph

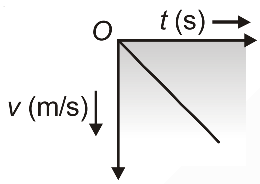
Using $s = -\frac{1}{2}gt^2 \Rightarrow s \propto t^2$



Velocity-time graph

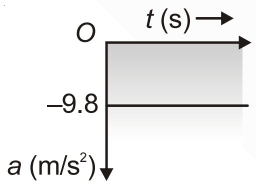
Using $v = -gt$

$v \propto t$



Acceleration-time graph

As acceleration is constant *i.e.* 9.8 m/s^2 and acting on the downward direction v negative.

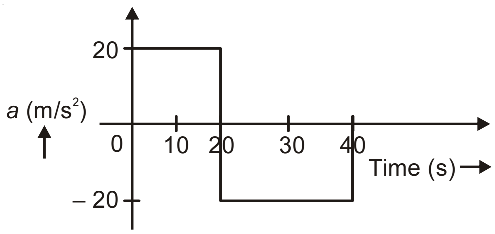


31. The acceleration-time graph of a body starting from rest is shown below. Calculate the

(i) Average acceleration

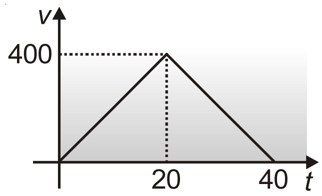
(ii) Average velocity

(iii) Average speed in the time interval $t = 0$ to $t = 40$ s



Sol. (i) Between $t = 0$ to $t = 20$ body was moving with constant acceleration of 20 m/s^2 and between $t = 20$ to $t = 40$ body was moving with a constant negative acceleration of 20 m/s^2. So average acceleration of the body is zero.

(ii) Corresponding v - t graph for the motion is



Displacement = Area of the Δ

$$= \frac{1}{2}\times 40\times 400$$

= 8000 m

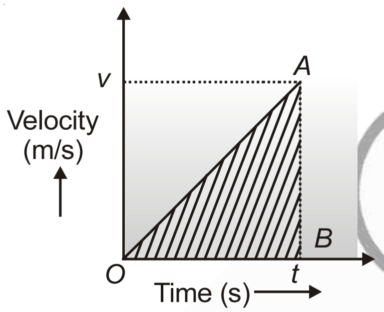
Average velocity = $\frac{8000}{40} = 200\ \text{ms}^{-1}$

(iii) Distance = displacement = 8000 m

Average speed = $\frac{8000}{40} = 200\ \text{ms}^{-1}$

32. A particle starts from rest and moves along a straight line with uniform acceleration *a.* Draw the velocity-time graph for the motion of the particle and deduce the kinematic equations of motion.

Sol.



Let after time t the velocity of the particle is v. Slope of the graph is equal to acceleration.

Slope = v/t

So $a = \frac{v}{t}$ $\boxed{v = at}$ …(i)

Distance travelled by the particle is given by the area under the velocity-time curve.

$$s = ar\,(\Delta OAB) = \frac{1}{2}\times t\times v = \frac{vt}{2}$$

$v = at$

So, $s = \frac{1}{2}at^2$ …(ii)

From equation (i), we get $v = at$

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

Substituting in equation (ii), we get

$$s = \frac{1}{2}a\left(\frac{v^2}{a^2}\right) = \frac{1}{2}\frac{v^2}{a}$$

$\boxed{v^2 = 2\,as}$ …(iii)

So equation (i), (ii) and (iii) are the equation of motions for this particle.

33. Define relative velocity. Deduce the expression of relative velocity of two objects, and discuss the corresponding cases for zero, positive and negative relative velocities.

Sol. When two objects *A* and *B* are moving with different velocities, then the velocity of one object *A* with respect to another object *B* is called the relative velocity of object *A* w.r.t. object *B*. Consider two objects *A* and *B* moving uniformly with uniform velocities V_A and V_B moving along a straight line. Let $x_A(0)$ and $x_B(0)$ be the positions of *A* and *B* respectively at $t = 0$ and $x_A(t)$ and $x_B(t)$ be the positions of *A* and *B* respectively at time *t* then

$$x_A(t) = x_A(0) + v_A t \quad \ldots\text{(i)}$$

$$x_B(t) = x_B(0) + v_B t \quad \ldots\text{(ii)}$$

Where $v_A t$ and $v_B t$ are the distances moved by *A* and *B* in time *t* respectively.

Subtracting (ii) from (i), we get

$$x_A(t) - x_B(t) = (x_A(0) - x_B(0)) + (v_A - v_B)t \quad \ldots\text{(iii)}$$

where $[x_A(t) - x_B(t)] = x$ is the displacement of object *A* w.r.t. *B* at time *t* and $[x_A(0) - x_B(0)] = x_0$ is the initial displacement of object *A* w.r.t. *B*

$$\Rightarrow \quad x = x_0 + (v_A - v_B)t$$

$$\Rightarrow \quad \frac{(x - x_0)}{t} = (v_A - v_B) \quad \ldots\text{(iv)}$$

$(x - x_0)$ is the change in position of *A* w.r.t. *B* and $(x - x_0)/t$ gives the time rate of change of position of object *A* w.r.t. *B i.e.*, the relative velocity of *A* w.r.t. *B*, hence

$$\boxed{v_{AB} = v_A - v_B} \quad \ldots\text{(v)}$$

Similarly by subtracting the equation (i) from (ii), we can get v_{BA} is the relative velocity of *B* w.r.t. *A*

$$\boxed{v_{BA} = v_B - v_A} \quad \ldots\text{(vi)}$$

Equations (iv) and (v) show

$$v_{BA} = -v_{AB}$$

Now,

If $v_A = v_B$, then $v_A - v_B = 0$ substituting this in equation (iii) we get

$$x_A(t) - x_B(t) = x_A(0) - x_B(0)$$

Therefore, their position-time graphs are straight lines parallel to each other and the relative velocity v_{AB} and v_{BA} is zero. As shown in the graph fig.(a)

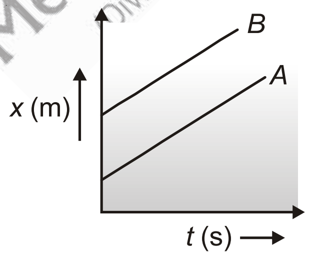


Fig. (a)

If $v_A < v_B$, $v_A - v_B$ is negative.

Substituting this in equation (iv) we get

$$x - x_0 < 0 \Rightarrow x < x_0$$

It means the separation between the two objects will go on decreasing and two objects will meet and object *B* will overtakes object *A* at this time. As shown in fig.(b)

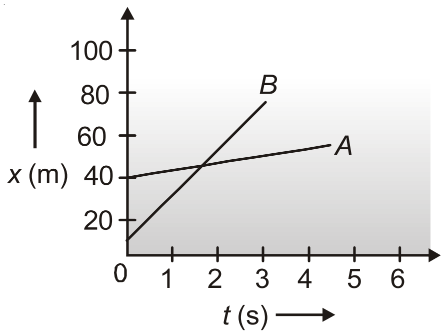


Fig. (b)

If $v_A > v_B$, $v_A - v_B$ is positive, substituting the value in equation (iv).

We get, $x - x_0 > 0$ *i.e.*, $(x - x_0)$ is positive.

It means the separation between the two objects will go on increasing with time. As shown in fig.(c)

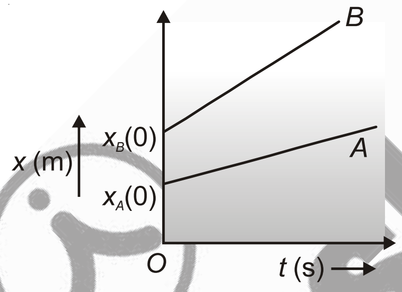
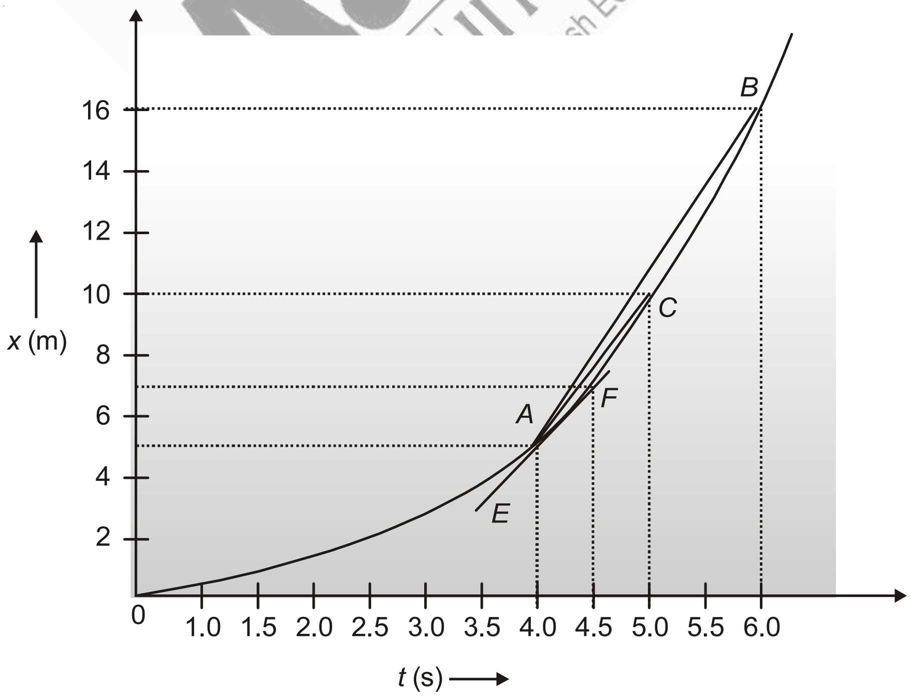


Fig. (c)

34. Define instantaneous velocity. Deduce the expression of instantaneous velocity using the position time graph.

Sol. Instantaneous velocity gives us the velocity of object, at a particular instant in a given interval of time. It is defined as the average velocity as the time interval Δt becomes infinitesimally small.

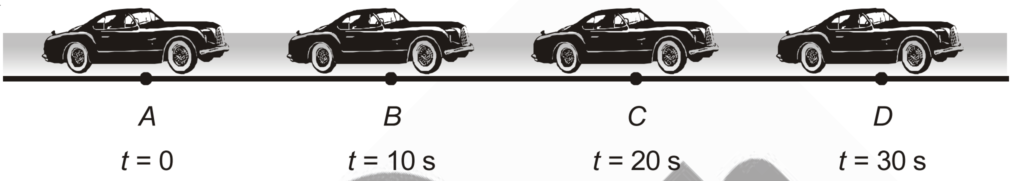
$$v = \lim_{\Delta t \to 0} \bar{v} = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t} = \frac{dx}{dt}$$



Consider the above position-time graph and suppose we have to find the instantaneous velocity at $t = 4$ s, we know that the average speed over a given time interval is given by the slope of the straight line joining the initial and final point over that time interval. *AB* is a straight line joining the positions $x = 5$ m, and $x = 16$ m. From the graph we can see as long as we keep on decreasing the time interval B point starts approaching *A* and, as Δt approaches to zero, the line *AB* becomes a tangent to the given curve at point *A* and the slope of this tangent with time axis would give the value of instantaneous velocity corresponding to point *A*.

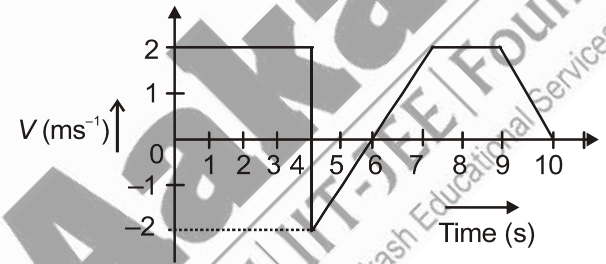
35. What do you understand by the term "reference point" and "frame of reference"? Explain with the help of example how the frame of reference describes the state of motion of an object.

Sol. To describe the position of an object we need a reference point or a set of coordinate axis (*x*, *y* and *z* axis). For example, suppose we are observing a car and at time $t = 0$, the car is at point *A* and at $t = 10$s, $t = 20$s and $t = 30$s car is at point *B*, *C* and *D* respectively. As the position of car is changing with time therefore, the car is in motion, and point *A* is the reference point for this observation. As we started observing its motion when it was at point *A*.



Now, according to us car is moving, but for a person sitting in the car, the car is at rest all the time w.r.t. him and we are moving. So "motion" and "rest" are relative and the state of object depends on the observer's frame of reference.

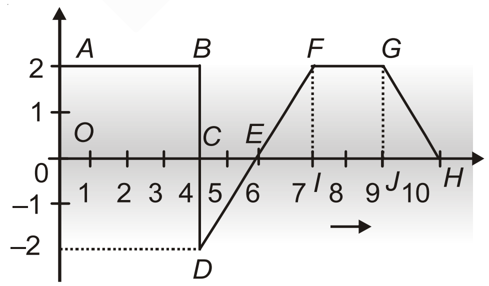
36. The velocity-time graph of a body moving in a straight line is shown below, find the displacement and the distance travelled by the body in 10 second.



Sol. Distance = ar(rectangle *OABC*) + ar(Δ*CDE*) + ar(Δ*EFI*) + ar(☐ *FIJG*) + ar(Δ*GJH*)

$$= 4\times2+\frac{1}{2}\times2\times2+\frac{1}{2}\times1\times2+2\times2+\frac{1}{2}\times1\times2$$

8 + 2 + 1 + 4 + 1 = 16 m



Displacement = (area of rectangle *OABC*) + ar(Δ*CDE*) + ar(Δ*EFI*) + ar(☐ *FIJG*) + ar(Δ*GHJ*)

$= 4 \times 2 - 2 + 1 + 4 + 1$

$= 8 - 2 + 6 = 12$ m.

37. Explain, path length and displacement with illustrations and distinguish them.

Sol. Consider the motion of a boy along a straight line say x-axis and let the origin of x-axis be the reference point *i.e.*, the point from where the boy started moving. A, B and C represent the positions of the boy at different instants of time. At t = 0 the boy was at point A *i.e.*, origin see the figure given below. Now lets consider the two cases of motion in the first case the boy moves from A to B and in the second case he moves back from B to C.

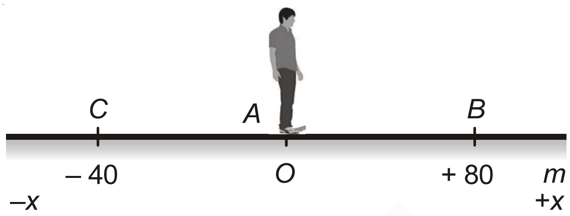


Fig. : x-axis, origin and position of boy at different instants of time

While moving from A to B, the distance covered by the boy is AB *i.e.*, 80 m. In the second case the distance moved by the boy is BA + AC *i.e.*, (80 + 40)m = 120 m. You can see in figure that point C lies on the negative side of x-axis, but while calculating the distance we are considering AC as + 40 m instead of – 40 m this is because the **distance travelled by a body can never be negative.** So in the second case while going from A to C though he is moving in the negative axis side but the distance travelled by him is positive. Distance is a scalar quantity as it has only magnitude and no direction. Now through out his journey the boy moves first from A to B then back from B to C. So the total distance travelled by him is (80 + 120) = 200 m. This is the **path length**. So we can define path length as the actual distance traversed by an object during its motion in a given interval of time. **Path length** is also a **scalar quantity** as it has only magnitude and no direction. The boy started his journey from A and finally reaches point C. This change in position is known as **displacement** which is a vector quantity. The displacement of boy at the end of his journey is – 40 m, which has magnitude 40 m and directed towards negative axis.

Hence, we can define the displacement of an object in a given interval as the shortest distance between the initial and final position of the object in a particular direction. The magnitude of displacement is always less than or equals to the total distance *i.e.* the path length traversed by the body *i.e.*,

$$\boxed{|\text{Displacement}| \le \text{Distance}}$$

38. The acceleration 'a' in m/s^2 of a particle is given by $a = 3t^2 + 2t + 2$, where t is the time in seconds. If the particle starts with a velocity of 2 m/s at t = 0, then find

(i) Velocity at the end of 2 s

(ii) Position at x the end of 2 s, if at $t = 0$, $x = 2$ m

Sol. (i) $a = 3t^2 + 2t + 2$

$$a = \frac{dv}{dt}$$

$$v = \int a\,dt = \int (3t^2 + 2t + 2)dt$$

$$= \frac{3t^3}{3} + \frac{2t^2}{2} + 2t + c$$

at t = 0, v = 2 m/s

So c = 2 m/s

$v = t^3 + t^2 + 2t + 2$

at t = 2

v = 8 + 4 + 4 + 2 = 18 m/s $\boxed{v = 18 \text{ m/s}}$

(ii) $v = t^3 + t^2 + 2t + 2$

$$v = \frac{dx}{dt}$$

$$x = \int v dt$$

$$= \int t^3 + t^2 + 2t + 2dt$$

$$x = \frac{t^4}{4} + \frac{t^3}{3} + \frac{2t^2}{2} + 2t + c$$

at $t = 0$, $x = 2$ m, so $c = 2$ m

Therefore,

$$x = \frac{t^4}{4} + \frac{t^3}{3} + \frac{2t^2}{2} + 2t + 2$$

at $t = 2$ s

$$x = \frac{16}{4} + \frac{8}{3} + \frac{8}{2} + 4 + 2$$

$$x = 14 + \frac{8}{3} = \frac{42 + 8}{3}$$

$$= \frac{50}{3} = 16.6 \text{ m}$$

$$\boxed{x = 16.6 \text{ m}}$$

39. What do the following represent? [x = position, a = acceleration, v = velocity, s = distance]

(i) Slope of x-t graph (ii) Slope of v-t graph (iii) Area of v-t graph (iv) Area of a-t graph (v) Slope of s-t graph

Sol. (i) Velocity

(ii) Acceleration

(iii) Displacement

(iv) Change in velocity

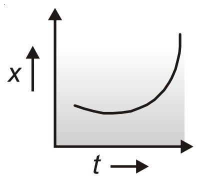
(v) Speed

40. Draw the various position-time (x-t) and velocity-time (v-t) graphs for

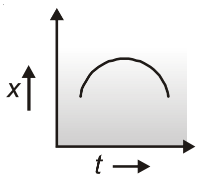
(i) Positive (ii) Negative (iii) Zero acceleration

Sol. ***x-t* graphs**

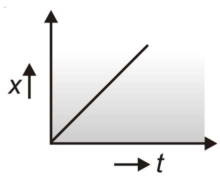
(i) Positive acceleration



(ii) Negative acceleration

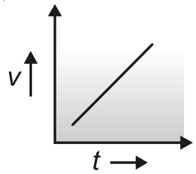


(iii) Zero acceleration

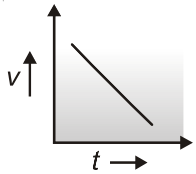


***v-t* graphs**

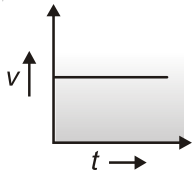
(i) Positive acceleration



(ii) Negative acceleration



(iii) Zero acceleration



❑ ❑ ❑

Chapter 2

Motion in a Straight Line

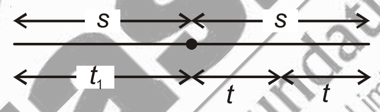
Solutions (Set-2)

1. A particle travels half the distance of a straight journey with a speed 5 m/s. The remaining part of the distance is covered with speed 6 m/s for half the remaining time, and with speed 4 m/s for the other half of the remaining time. The average speed of the particle is

(1) 3 m/s (2) 4 m/s (3) $\frac{3}{4}$ m/s (4) 5 m/s

Sol. Answer (4)

$s = 5t_1,\ s = 6t + 4t = 10t$



$$v_{av} = \frac{2s}{t_1 + 2t} = \frac{2s}{\frac{s}{5} + \frac{s}{5}} = 5 \text{ m/s}$$

2. The acceleration of a particle is given by the $a = x$ where x is a constant. If the particle starts at origin from rest, its distance from origin after time t is given by

(1) $\frac{xt^2}{2}$ (2) $\frac{x^2t^2}{2}$ (3) $\frac{\sqrt{x}t^2}{2}$ (4) $\frac{x^3t^3}{6}$

Sol. Answer (1)

$\vec{a} = x\hat{i}$

As $u = 0$;

Displacement $\vec{s} = \frac{1}{2}\vec{a}t^2 = \frac{1}{2}xt^2\hat{i}$

$\Rightarrow |\vec{s}| = \frac{xt^2}{2}$

3. The relation between the time t and position x for a particle moving on x-axis is given by $t = px^2 + qx$, where p and q are constants. The relation between velocity v and acceleration a is as

(1) $a \propto v^3$ (2) $a \propto v^2$ (3) $a \propto v^4$ (4) $a \propto v$

Sol. Answer (1)

$t = px^2 + qx$

$\frac{1}{v} = \frac{dt}{dx} = 2px + q$

$\Rightarrow \quad v = \frac{1}{2px + q}$

Also acceleration $a = \frac{dv}{dt} = \frac{-1 \times 2p}{(2px+q)^2} \times \frac{dx}{dt}$

$a = -2pv^2 \times v$

$\therefore \quad a \propto v^3$

4. A stone is dropped from the top of a tower and travels 24.5 m in the last second of its journey. The height of the tower is

(1) 44.1 m (2) 49 m (3) 78.4 m (4) 72 m

Sol. Answer (1)

Let the height of the tower be h. Then total time of fall is $\sqrt{\frac{2h}{g}}$.

Hence distance travelled in last second is

$$h - \frac{1}{2}g\left(\sqrt{\frac{2h}{g}} - 1\right)^2 = 24.5$$

$\Rightarrow \quad h = 44.1$ m

Total distance = 44.1 m

5. Two balls X and Y are thrown from top of tower one vertically upward and other vertically downward with same speed. If times taken by them to reach the ground are 6 s and 2 s respectively, then the height of the tower and initial speed of each ball are (g = 10 m/s^2)

(1) 60 m, 15 m/s (2) 80 m, 20 m/s (3) 60 m, 20 m/s (4) 45 m, 10 m/s

Sol. Answer (3)

Using $h = ut + \frac{1}{2}gt^2$, and using condition for product of roots, we have

$$t_1 t_2 = \frac{2h}{g} \Rightarrow h = \frac{t_1 t_2 g}{2} = \frac{6 \times 2 \times 10}{2} = 60 \text{ m}$$

$$\vec{s} = \vec{u}t + \frac{1}{2}\vec{a}t^2 \Rightarrow -60 = u \times 6 - \frac{1}{2} \times 10 \times 6^2 \Rightarrow u = 20 \text{ m/s}$$

6. A body starts from rest with an acceleration 2 m/s^2 till it attains the maximum velocity then retards to rest with 3 m/s^2. If total time taken is 10 second, then maximum speed attained is

(1) 12 m/s (2) 8 m/s (3) 6 m/s (4) 4 m/s

Sol. Answer (1)

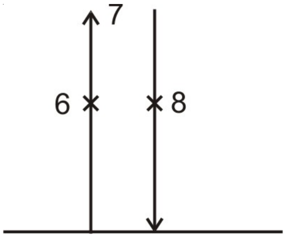
$$v_{max} = \frac{a_1 a_2}{a_1 + a_2} t = \frac{2 \times 3}{2 + 3} \times 10 = 12 \text{ m/s}$$

7. A body is thrown vertically upward with velocity u. The distance travelled by it in the 7th and 8th seconds are equal. The displacement in 8th seconds is equal to (take g = 10 m/s^2)

(1) 5 m (2) 10 m (3) 2.5 m (4) $\frac{5}{3}$m

Sol. Answer (1)

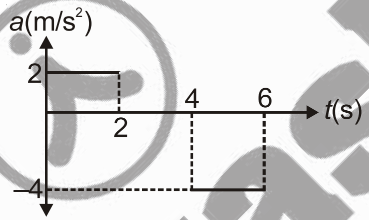
Time to reach maximum height is 7 second.



Displacement in the first second of its descent will be $= \frac{1}{2} \times g \times 1^2 = 5$ m

Distance in first second of descent is 5 m.

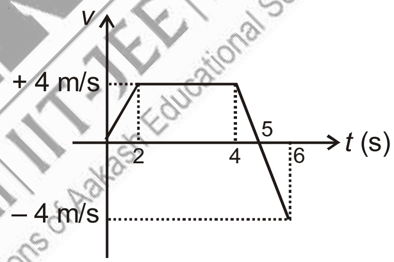
8. A particle starts from rest. Its acceleration is varying with time as shown in the figure. When the particle comes to rest, its distance from its starting point is



(1) 20 m (2) 24 m (3) 36 m (4) 14 m

Sol. Answer (4)

v-t graph for the a-t graph can be drawn as

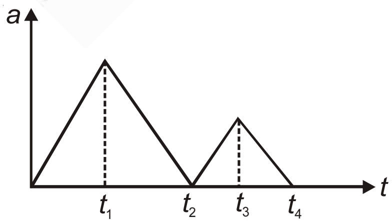


Total distance travelled during the journey.

$$s = \frac{1}{2} \times 2 \times 4 + 4 \times 2 + \frac{1}{2} \times 4 \times 1$$

= 4 + 8 + 2 = 14 m

9. A particle starts moving from rest on a straight line. Its acceleration a verses time t is shown in the figure. The speed of the particle is maximum at the instant



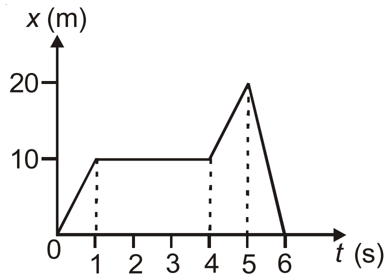
(1) t_1 (2) t_2 (3) t_3 (4) t_4

Sol. Answer (4)

Acceleration is never negative throughout the interval from 0 to t_4 hence velocity continuously increases from 0 to t_4 sec.

$\therefore$ Velocity is maximum at t_4.

10. Figure shows the graph of x-coordinate of a particle moving along x-axis as a function of time. Average velocity during t = 0 to 4 s and instantaneous velocity at t = 4.113 s respectively will be



(1) 5 m/s, 10 m/s (2) 2.5 m/s, 10 m/s (3) Zero, zero (4) 10 m/s, 2.5 m/s

Sol. Answer (2)

$$v_{av} = \frac{s_2 - s_1}{t_2 - t_1} = \frac{10}{4} = 2.5\,\text{m/s}$$

$$v_{ins} = \text{slope of } x - t = \frac{10}{1} = 10 \text{ m/s}$$

11. Two particles P and Q are initially 40 m apart P behind Q. Particle P starts moving with a uniform velocity 10 m/s towards Q. Particle Q starting from rest has an acceleration 2 m/s^2 in the direction of velocity of P. Then the minimum distance between P and Q will be

(1) 45 m (2) 15 m (3) 35 m (4) 30 m

Sol. Answer (2)

Separation will be minimum if relative velocity of A w.r.t. B is zero.

$\Rightarrow$ 0 = (10 – 0) + (0 – 2) t $\Rightarrow$ t = 5 s.

Now minimum separation using relative concepts

$$d = 40 - \left[10 \times 5 - \frac{1}{2} \times 2 \times 5^2\right] = 40 - 25 = 15 \text{ m}$$

12 A body moves from x = –1 to x = 4 and then to x = –4. Which of the following is correct?

(1) Its displacement is zero (2) The distance covered by it is 5 units

(3) Its displacement is –3 (4) Distance covered by it is 9 units

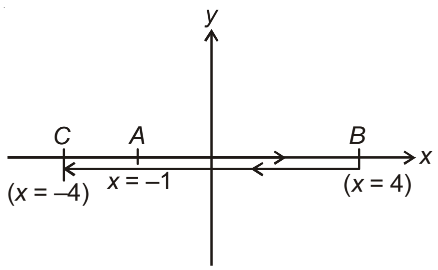
Sol. Answer (3)

Distance (D) = AB + BC

= 1 + 4 + 4 + 4

= 13

Displacement = AC = –3



13. If $y = \frac{1}{a-z}$, find $\frac{dz}{dy}$

(1) $(a-z)^2$ (2) $-(z-a)^2$ (3) $(z+a)^2$ (4) $-(z+a)^2$

Sol. Answer (1)

$$y = \left(\frac{1}{a-z}\right)$$

$$\Rightarrow \frac{dy}{dz} = \frac{(-1)(-1)}{(a-z)^2}$$

$$\Rightarrow \frac{dz}{dy} = (a-z)^2$$

14. If $y = a \sin x + b \cos x$, then $\left(\frac{dy}{dx}\right)^2 + y^2$ is

(1) Function of x (2) Function of y (3) Function of x and y (4) Constant

Sol. Answer (4)

$y = a \sin x + b \cos x$

$$\frac{dy}{dx} = a\cos x - b\sin x$$

$$\left(\frac{dy}{dx}\right)^2 + y^2 = (a\cos x - b\sin x)^2 + (a\sin x + b\cos x)^2$$

$= a^2 + b^2$ which is constant

15. The position x of a particle varies with time as $x = at^2 - bt^3$. The acceleration of particle is zero at time t equal to

(1) $\frac{a}{b}$ (2) $\frac{2a}{3b}$ (3) $\frac{a}{3b}$ (4) Zero

Sol. Answer (3)

$x = at^2 - bt^3$

$$\frac{dx}{dt} = 2at - 3bt^2$$

$$\left(\frac{d^2x}{dt^2}\right) = 2a - 6bt$$

$$2a - 6bt = 0 \Rightarrow t = \frac{a}{3b}$$

16. A particle moves along a straight line such that its displacement at any instant 't' is given by $x = t^3 - 6t^2 + 3t + 4$ meters. The velocity when the acceleration is zero is

(1) 3 ms^{-1} (2) 12 ms^{-1} (3) 42 ms^{-1} (4) –9 ms^{-1}

Sol. Answer (4)

$$x = t^3 - 6t^2 + 3t + 4$$

$$v = \frac{dx}{dt} = 3t^2 - 12t + 3$$

$$a = \frac{dv}{dt} = 6t - 12$$

$a = 0 \quad \Rightarrow \quad t = 2$ s

at $t = 2$, $v = 3(2)^2 - 12(2) + 3$

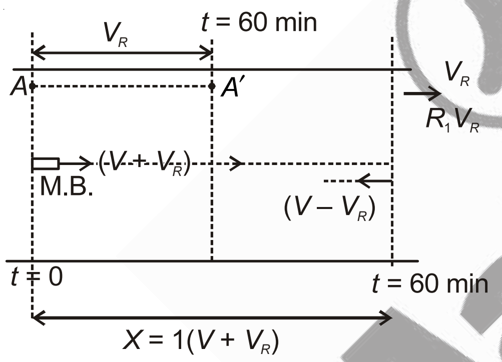
$v = 12 - 24 + 3$

$v = -9$ m/s

17. A motor boat going downstream overcomes a float at a point *A*. 60 minutes later it turns and after some time passes the float at a distance of 12 km from the point *A*. The velocity of the stream is (assuming constant velocity for the boat in still water)

(1) 6 km h^{-1} (2) 3 km h^{-1} (3) 4 km h^{-1} (4) 2 km h^{-1}

Sol. Answer (1)



Let river flow speed is V_R since raft moves a distance 6 km when they again meet and we have

$$\frac{6}{V_R} = 1 + \left(\frac{V}{V}\right)$$

$\Rightarrow \quad V_R = 3$ km/hr

18. Identify the correct statement.

(1) Distance travelled represents the magnitude of displacement

(2) Average speed represents the magnitude of average velocity

(3) Average acceleration = $\dfrac{\text{Average velocity}}{\text{Time}}$

(4) Instantaneous speed = magnitude of instantaneous velocity

Sol. Answer (4)

Magnitude of instantaneous speed is equal to instantaneous velocity.

19. Ball *A* is thrown vertically upward with a speed of 19.6 m/s from the top edge of a high building. As it passes the edge on the way down, a second ball *B*, is thrown downward at 19.6 m/s. Which of the following is correct?

(1) Ball *A* hits the ground before *B*
(2) The two balls hit the ground at the same time
(3) Ball *B* hits the ground before *A*
(4) Not enough information is given

Sol. Answer (2)

Both ball will hit the ground at same time, because velocity of both object are same at the time ball *B* was thrown downward.

20. In the above situation, the speed with which a particular ball hits the ground is

(1) Greater for *A*
(2) Greater for *B*
(3) Same for both
(4) Different for the two balls

Sol. Answer (3)

Speed of both the balls will be same at the time of hitting the ground.

Paragraph for Q. Nos. 21 to 26

A ball *A* is thrown up vertically with speed *u*. At the same instant another ball *B* is released from rest at a height *h* vertically above the point of projection of *A*. Taking the moment of projection as $t = 0$ and acceleration due to gravity is '*g*', answer the following questions.

21. At any time instant *t*, the magnitude of relative acceleration of *A* with respect to *B* is

(1) g
(2) $2g$
(3) $-2g$
(4) Zero

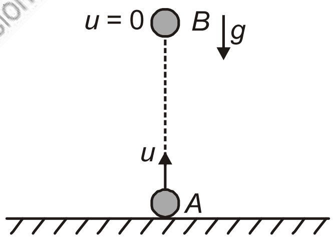
Sol. Answer (4)

$$a_{A,B} = a_A - a_B$$
$$= 0$$

22. At any time instant *t*, the speed of *A* relative to *B* is

(1) u
(2) $u - 2gt$
(3) $\sqrt{u^2 - 2gh}$
(4) $u - gt$

Sol. Answer (1)



$$a_{A,B} = 0$$
$$V_{A,B} = u - 0$$
$$= u$$

Since acceleration is zero and hence relative speed will be constant which is *u*.

23. The separation between the bodies at any time instant *t* is

(1) h
(2) $h - ut$
(3) $h - ut + \frac{gt^2}{2}$
(4) $h - ut + gt^2$

Sol. Answer (2)

Separation between *A* and *B* at any time *t* is equal to

$$S = h - ut$$

24. The time instant at which they collide is

(1) $\frac{h}{u}$ (2) $\frac{2h}{u}$ (3) $\sqrt{\frac{2h}{g}}$ (4) $\frac{2h}{g}$

Sol. Answer (1)

Time of collision (t_0)

$$t_0 = \frac{h}{u}$$

25. At the moment of collision, the position of *A* is at a distance

(1) *h* above ground

(2) $h - \frac{gh^2}{2u^2}$ above ground

(3) $\frac{gh^2}{2u^2}$ below the point of release of *B*

(4) Both (2) & (3) are correct

Sol. Answer (4)

$$S_A = u_A t - \frac{1}{2}gt^2$$

$$S_A = (u)\left(\frac{h}{u}\right) - \frac{1}{2}g\left(\frac{h}{u}\right)^2$$

$$S_A = h - \frac{gh^2}{2u^2} \text{ above ground}$$

26. At the moment of collision, the position of *B* is at a distance

(1) *h* above ground

(2) $h - \frac{gh^2}{2u^2}$ above ground

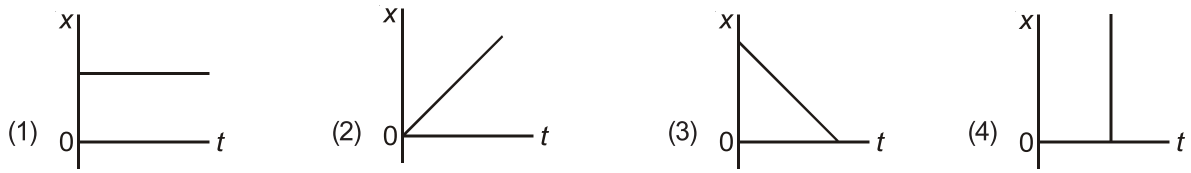
(3) $\frac{gh^2}{2u^2}$ below the point of release of *B*

(4) Both (2) & (3) are correct

Sol. Answer (4)

$$S_B = \frac{1}{2}g\,t^2 = \frac{1}{2}g\left(\frac{h}{u}\right)^2 = \frac{gh^2}{2u^2}$$

27. Which graph represents an object at rest?

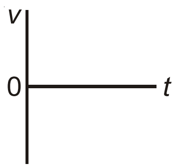


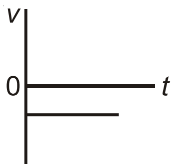
(1) (2) (3) (4)

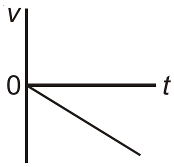
Sol. Answer (1)

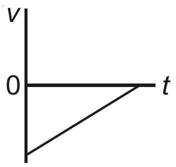
Slope of displacement *vs* time graph gives us information of velocity.

28. Which graph represents constant positive acceleration?

(1) 

(2) 

(3) 

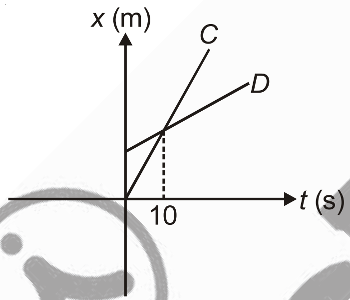
(4) 

Sol. Answer (4)

Slope of velocity *vs* time graph is acceleration.

Paragraph for Q. Nos. 29 to 32

The figure shows position time graph of two riders *C* and *D*. Based on the information represented by the graph, answer the following questions.



29. At $t = 0$ s

(1) Rider *C* is ahead of rider *D*

(2) Rider *D* is ahead of rider *C*

(3) Rider *C* and *D* are at the same position

(4) Not enough information is given

Sol. Answer (2)

At $t = 0$

$X_C = 0, X_D > 0$

Hence *D* is ahead of *C*.

30. At $t = 0$ s

(1) *C* is moving, and *D* is at rest

(2) *D* is moving, and *C* is at rest

(3) *C* and *D* are both moving

(4) *C* and *D* are both at rest

Sol. Answer (3)

$$v = \frac{dX}{dt}$$

$$V_C = \frac{dX_C}{dt}, \quad V_D = \frac{dX_D}{dt}$$

Hence, $V_C > V_D$

and both moving.

31. At $t = 0$ s

(1) *C* has a greater velocity than *D*

(2) *D* has a greater velocity than *C*

(3) *C* and *D* have the same velocity

(4) *C* is accelerating

Sol. Answer (1)

$$\frac{dX_C}{dt} > \frac{dX_D}{dt}$$

$\Rightarrow \; V_C > V_D$

32. At t = 10 s

(1) C and D are at the same position

(2) C and D have the same velocity

(3) The velocity of D is greater than the velocity of C

(4) C is in front of D

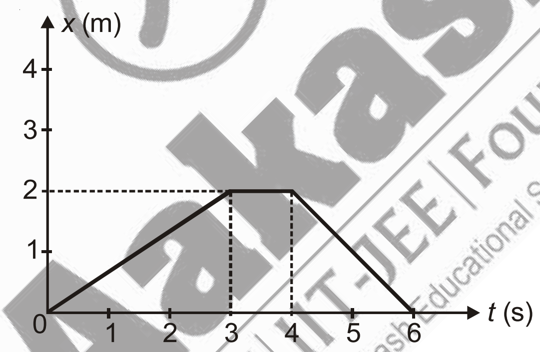
Sol. Answer (1)

At $t = 0$

$X_C = X_D$

Paragraph for Q. Nos. 33 to 38

The following figure shows position time graph of an object moving along x-axis. Based on the information represented by the graph, answer the following questions.



33. The position of the object at t = 4 s is

(1) 1 (2) 2 (3) 3 (4) 4

Sol. Answer (2)

From x - t graph

at t = 4 s

$x = 2$

34. The displacement of the object for the time interval t = 0 to t = 3 s is

(1) 1 (2) 2 (3) 3 (4) 2.5

Sol. Answer (2)

At $t = 0$, $X = 0$ m

At $t = 3$, $X = 2$ m

$\Delta X = 2$ m

35. The position of the particle is x = 1m at time instant t =

(1) 1 s (2) 5 s (3) 1 s as well as 5 s (4) 1.5 s as well as 5 s

Sol. Answer (4)

From equation of x - t graph

at t = 1.55 and t = 5

36. The average velocity for the time interval t = 0 to t = 4 s is

(1) 1 m/s (2) 2 m/s (3) 0.5 m/s (4) 0.75 m/s

Sol. Answer (3)

$$V_{avg} = \frac{\Delta x}{\Delta t}$$

at $t = 0,\ x = 0$

at $t = 4,\ x = 2$

$$V_{avg} = \frac{2}{4} = 0.5\text{ m/s}$$

37. The average speed and average velocity have same numerical value for the time interval

(1) 0 – 2 s (2) 0 – 5 s (3) Both (1) & (2) (4) 0 – 6 s

Sol. Answer (1)

$$V_{avg} = \frac{\Delta x}{dt}$$

Average speed and average velocity will be same when distance and displacement becomes same.

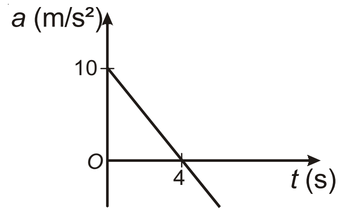
38. The average speed for the time interval 0 – 6 s is

(1) 0.67 m/s (2) 0.5 m/s (3) 2 m/s (4) 0

Sol. Answer (1)

$$V_{avg} = \frac{(2+2)}{6} = \left(\frac{4}{6}\right) = \frac{2}{3}\text{ m/s}$$

39. The acceleration-time graph of a particle is as shown. At what time the particle acquires its initial velocity?



(1) 12 s (2) 5 s (3) 8 s (4) 16 s

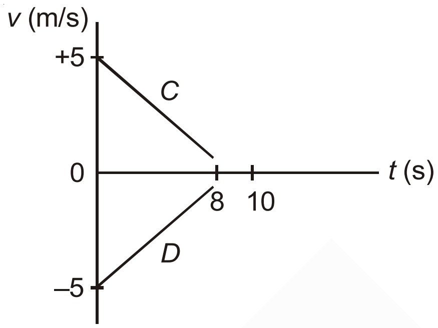
Sol. Answer (3)

In a - t graph area gives information about change in velocity.

Paragraph for Q. Nos. 40 and 41

The Figure shows velocity-time graph of two riders *C* and *D*. Based on the information represented by the graph, answer the following.

40. During the first 8 s



(1) *C* has decreasing speed and *D* has increasing speed

(2) *C* and *D* both have decreasing speed

(3) *C* and *D* have the same velocity

(4) *C* has the same average velocity as *D*

Sol. Answer (2)

Both *C* and *D* have decreasing speed as shown in graph.

41. Based on all the graphical information

(1) They meet at the same position at t = 8 s

(2) They will meet at the same position, at t = 10 s

(3) They will never meet at the same position

(4) Not enough information is given to decide if they meet

Sol. Answer (4)

C and *D* will meet each other which depends on their initial position.

Paragraph for Q. Nos. 42 to 44

The velocity of an object depends on the frame of reference. For example a man can run on ground with a speed of say 8 m/s. This means that the velocity of person w.r.t. ground is 8 m/s. Now suppose the same person stands on the roof of a train moving with a speed of 10 m/s. If man does not walk on the train, he will still move with respect to ground with a speed of 10 m/s. Here we will say that velocity of man w.r.t. train is zero while the velocity of man w.r.t. ground is 10 m/s. Now if the man begins to run on the roof with speed 8 m/s in forward direction his velocity w.r.t. train will be 8 m/s and w.r.t. ground it will be 18 m/s. If man runs backward its velocity w.r.t. ground will be 2 m/s.

In general

$$\vec{v}_{M/G} = \vec{v}_{M/T} + \vec{v}_{T/G}$$

Here, $\vec{v}_{M/G}$ is velocity of man w.r.t. ground

$\vec{v}_{M/T}$ is velocity of man w.r.t. train

$\vec{v}_{T/G}$ is velocity of train w.r.t. ground

Similarly a boat can be rowed in still water at a speed u. The speed of boat w.r.t. ground, while moving in a stream of water flowing at speed v, will be $u + v$ while moving downstream (forward) and $u - v$ while moving upstream (backward). Based on the above information, answer the following questions.

42. A person can swim in still water at a speed 5 m/s. How much time will he take to move a distance of 120 m in stream of water flowing at 1 m/s upstream and downstream respectively?

(1) 24 s, 24 s (2) 20 s, 30 s (3) 30 s, 20 s (4) 30 s, 24 s

Sol. Answer (3)

$$t_{\text{up}} = \frac{120}{5-1} = 30 \text{ s}$$

$$t_{\text{down}} = \frac{120}{5+1} = 20 \text{ s}$$

43. A person covers a certain distance downstream in 15 s and upstream in 30 s. How much time will be take to cover the same distance in still water?

(1) 22.5 s (2) $15\sqrt{2}$ s (3) 20 s (4) None of these

Sol. Answer (3)

Given,

$$15 = \frac{D}{V + V_r} \quad \text{...(i)}$$

$$30 = \left(\frac{D}{V - V_r}\right) \quad \text{...(ii)}$$

We have to find $t = \left(\frac{D}{V}\right)$

from (i) & (ii)

t = 20 s

44. A person can run on ground with a maximum speed of 6 m/s. The person stands on the rear end of roof a train moving with constant velocity. The length of train is 120 m. The man begins to run at this maximum a capacity towards the front end, reaches the front end, immediately turns back and run towards the rear end. Find the net displacement of the man w.r.t. ground by the time he reaches back to rear end. The velocity of train is 10 m/s

(1) 0 (2) 400 m (3) 200 m (4) 100 m

Sol. Answer (2)

Man will reach again at the back end of train after time

$$\Delta t = \frac{120 \times 2}{6} = 40 \text{ s}$$

Hence displacement = 40 × 10

= 400 m

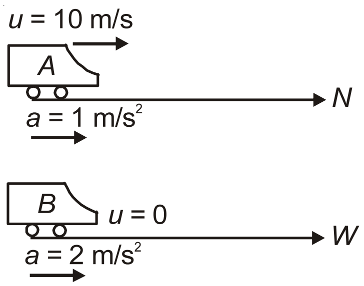
Paragraph for Q. Nos. 45 to 52

Two cars start from same point on a straight road due North. While car *A* starts with an initial velocity of 10 m/s and an acceleration of 1 m/s^2, car *B* starts from rest with an acceleration of 2 m/s^2. Answer the following questions.

45. As seen by a passenger in car *A*,

(1) Car *B* moves backward
(2) First, the car *B* moves backward and then forward
(3) Car *B* moves forward
(4) First, the car *B* moves forward and then backward

Sol. Answer (2)



$u_{B,\,A} = u_B - u_A$

$= 0 - 10$

$= -10$ m/s

$a_{B,\,A} = 2 - 1 = +1$ m/s

Hence car *A* is accelerating towards north and its velocity (Initial) is 10 m/s towards south with respect to *A*.

46. As seen by a passenger in car *B*,

(1) Car *A* moves backward
(2) First, the car *A* moves backward and then forward
(3) Car *A* moves forward
(4) First, the car *A* moves forward and then backward

Sol. Answer (4)

$u_{A,\,B} = -u_{B,\,A} = 10$

$a_{A,\,B} = -1$

47. The separation between the cars

(1) Continuously increases
(2) Continuously decreases
(3) First increases, then decreases and finally increases again
(4) First decreases, then increases and finally decreases again

Sol. Answer (3)

Separation 1st increases and then increases.

48. Taking the moment of start as $t = 0$, the separation between the cars at the moment $t = 5$ s is

(1) 37.5 m with *A* ahead of *B*
(2) 37.5 m with *B* ahead of *A*
(3) 50 m with *B* ahead of *A*
(4) 50 m with *A* ahead of *B*

Sol. Answer (1)

$v_{A,B} = u_{A,B} + a_{A,B}\, t$

$0 = 10 - (1)\, t$

$t = 10$ s

$$S_5 = (10)5 - \frac{1}{2}\times(1)\,(5)^2 = 50 - \frac{25}{2} = \frac{75}{2}\text{ m}$$

49. The position of car A at this moment (t = 5 s) is

(1) 62.5 m due North of starting point
(2) 37.5 m due North of starting point
(3) 62.5 m due South of starting point
(4) 37.5 m due South of starting point

Sol. Answer (1)

$$S_A = u_A t + \frac{1}{2}a_A\, t^2 = (10)\times 5 + \frac{1}{2}\times 1\times(5)^2 = 50 + \frac{25}{2} = \frac{125}{2}\text{ m}$$

50. The position of car B at this moment (t = 5 s) is

(1) 25 m due North of starting point
(2) 37.5 m due North of starting point
(3) 25 m due South of starting point
(4) 37.5 m due South of starting point

Sol. Answer (1)

$$S_B = u_B t + \frac{1}{2}a_B t^2$$

51. The moment of time at which the separation between the cars is same as that at t = 5 s, is given by t =

(1) 15 s
(2) 20 s
(3) 10 s
(4) 7 s

Sol. Answer (1)

At t = 5 s

$$\Delta X = \left(\frac{75}{2}\right)$$

Use relative velocity as in question (48).

52. The separation between the cars is zero at the moment t = 0. The moment of time at which the separation again becomes zero is t =

(1) 10 s
(2) 20 s
(3) 25 s
(4) 35 s

Sol. Answer (2)

$$x = ut + \frac{1}{2}a\,t^2$$

$$0 = 10t - \frac{1}{2}\times 1\,t^2$$

$$\Rightarrow \quad t = 20\text{ sec}$$

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