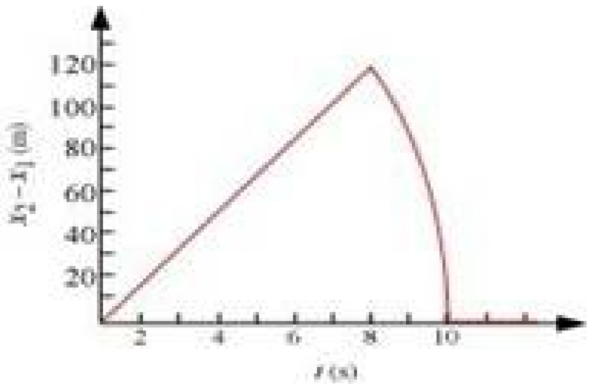
CBSE Test Paper 02
Chapter 3 Motion in A Straight Line

1. A particle moves along the x axis. Its position is given by the equation x = 2.00 + 3.00t - 4.00t^2 with x in meters and t in seconds. Determine its velocity in m/s when it returns to the position it had at t = 0. **1**
    a. -2.54
    b. -3.0
    c. -2.75
    d. -4.02
2. If the position- time graph is a straight line parallel to the time axis **1**
    a. The velocity is decreasing
    b. The velocity is constant but non zero
    c. The velocity is zero
    d. The velocity is increasing
3. A truck on a straight road starts from rest, accelerating at 2.00 $\mathrm{m/s^2}$ until it reaches a speed of 20.0 m/s. Then the truck travels for 20.0 s at constant speed until the brakes are applied, stopping the truck in a uniform manner in an additional 5.00 s. What is the average velocity in m/s of the truck for the motion described? **1**
    a. 15.7
    b. 16.2
    c. 154
    d. 17.5
4. A jet lands on an aircraft carrier at 30 m/s. What is its acceleration if it stops in 2.0 s? **1**
    a. 20 ms^{-2}
    b. -20 ms^{-2}
    c. -15 ms^{-2}
    d. -10 ms^{-2}
5. A truck on a straight road starts from rest, accelerating at 2.00 $\mathrm{m/s^2}$ until it reaches a speed of 20.0 m/s. Then the truck travels for 20.0 s at constant speed until the brakes are applied, stopping the truck in a uniform manner in an additional 5.00 s. How long in seconds is the truck in motion? **1**

a. 23.0
b. 37.3
c. 35.0
d. 32.0

6. Draw the position-time graph for a body at rest. **1**
7. A train is moving on a straight track with acceleration a. A passenger drops a stone. What is the acceleration of stone with respect to passenger? **1**
8. With zero speed a particle may not have non-zero velocity. Explain. **1**
9. Write the characteristics of displacement. **2**
10. Draw the displacement time graph for a uniformly accelerated motion. **2**
11. What is uniform motion? Give examples. **2**
12. Establish the kinematic equation $v^2 - u^2 = 2as$ from velocity-time graph for a uniformly accelerated motion. **3**
13. Obtain equation of motion for constant acceleration using the method of calculus. **3**
14. A jet plane beginning its take-off moves down the runway at a constant acceleration of 4.00 m/s^2. **3**
    i. Find the position and velocity of the plane 5.00 s after it begins to move.
    ii. If the speed of 70.0 m/s is required for the plane to leave the ground, how long a runway is required?
15. 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. **5**



Answer

1. b. -3.0

   Explanation: $x = 2.00 + 3.00t - 4.00t^2$

   At t = 0, we have x = 2,

   2 = 2 + 3.0t-4t^2

   => t(3-4t) = 0

   => t = 0 and t = $\frac{3}{4}$

   Velocity v = $\frac{dx}{dt} = 3 - 8t$

   = 3 - $8 \times \frac{3}{4}$ = 3-6 = -3 m/s

   Negative sign shows direction of velocity is opposite.

2. c. The velocity is zero

   Explanation: Position-time graph of horizontal straight line parallel to time axis represents that the position of the body does not changes with the passage of time. So it represents the rest state of motion.

   It means velocity of object is zero.

3. a. 15.7

   Explanation: As start from rest,

   So Initial velocity u = 0 m/s

   Final velocity v = 20 m/s

   Acceleration a = 2 m/s^2

   Let Time during this period = t_1

   Also let distance covered $= s_1$

   We know,

   v-u = at

   So, $20 - 0 = 2t_1$

   $t_1 = \frac{20}{2} = 10\ s$

   Also, $v^2 - u^2 = 2as_1$

$=> 400-0=2\times 2\times s_1$

$s_1=\frac{400}{4}=100\ m$

Now travel with constant speed of 20 m/s for time $t_2=20\ s$

Distance covered $s_2=20\times 20=400\ m$

Time taken to stop $t_3=5\ s$

Before stopping it covers distance $=s_3$

$s_3=\frac{1}{2}(20-0)5=50\ m$

Total distance covered = 100+400+50 = 550 m

Total time of motion t= 10+20+5 = 35 s

Average velocity $v_{avg}=\frac{total\ distance}{total\ time}$

$=\frac{550}{35}$ = 15.7 m/s

4. c. -15 ms^{-2}

Explanation: Initial velocity u = 30 m/s

As it stops then final velocity v = 0 m/s

Time taken t = 2.0 s

We know, v-u = at

=> 0-30= 2a

=> a = $\frac{-30}{2}=-15\ m/s^2$

-ve sign shows velocity is decreasing.

5. c. 35.0

Explanation: As start from rest,

So Initial velocity u = 0 m/s

Final velocity v = 20 m/s

Acceleration a = 2 m/s^2

Let Time during this period = t_1

We know,

v-u = at

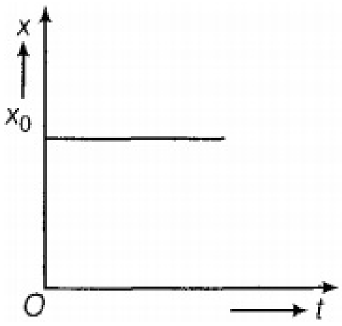
So, $20-0=2t_1$

$t_1=\frac{20}{2}=10\ s$

Now travel with constant speed of 20 m/s for time $t_2=20\ s$

Time taken to stop $t_3=5\ s$

Total time of motion t= 10+20+5 = 35 s

6. 

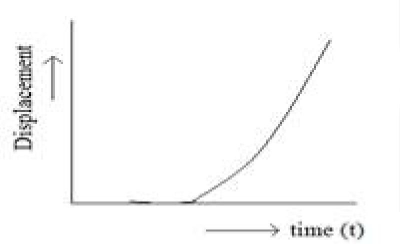
In the above x-t graph, the straight line parallel to time axis shows that the body is at rest at position x_0 at all times .

7. $\sqrt{a^2 + g^2}$ where g is Acceleration due to gravity.

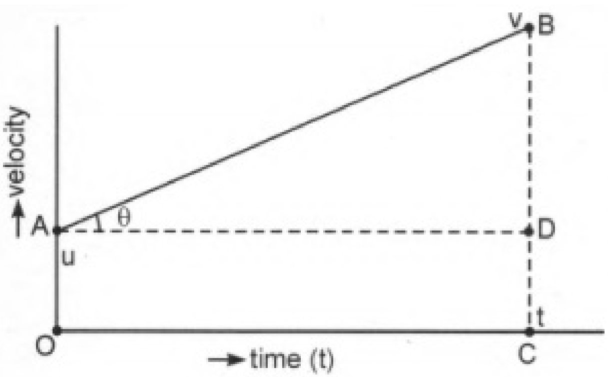
8. No. It is not possible for an object to have zero speed but non-zero velocity. It is because in a straight line motion when the magnitude of speed is zero, then with or without considering its direction, velocity will be zero only.

9. i. It is a vector quantity having both magnitude and direction.
   ii. Displacement of a given body can be positive, negative or zero.

10. Graph is parabolic in shape.



11. If a body covers equal distances in equal intervals of time, howsoever small these time intervals may be, then the Motion of a body is said to be uniform. For e.g, motion of Earth around its own axis, motion of the hour and minute hands of a watch are examples of uniform motion.

12. 

The velocity-time graph for uniformly accelerated motion has been shown in the figure with the initial velocity at t = 0 as u and final velocity at time t as v. Then magnitude of the total displacement in the given time is equal to the area under the v-t graph . Hence, displacement of moving a particle in time t is given by:

s = area of trapezium OABC

= $\frac{1}{2}(OA + CB) \times OC$

= $\frac{1}{2}(u + v) \times t$ .... (i)

However, from the definition of acceleration, we know that

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

Substituting this value of time t in equation (i), we get Displacement

s = $\frac{1}{2}(u + v) \times \frac{(v-u)}{a}$ = $\frac{(v^2-u^2)}{2a}$

$\Rightarrow$ 2as = $v^2 - u^2$ or $v^2 = u^2 + 2as$

13. From the definition of average acceleration, we have

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

Integrating on both sides and taking the limit for velocity u to v and for time 0 to t, we get

$\int_u^v dv = \int_0^t adt = a\int_0^t dt = a[t]_0^t$ [a is constant]

v - u = at

v = u + at .... (i)

Now, from the definition of velocity, we have

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

Integrating on both sides and taking the limit for displacement x_0 to x and for time 0 to t, we get

$\int_{x_0}^x dx = \int_0^t vdt = \int_0^t (u + at)dt = v_0\,[t]_0^t + a\left[\frac{t^2}{2}\right]_0^t$

$x - x_0 = ut + \frac{1}{2}at^2$

$x = x_0 + ut + \frac{1}{2}at^2$ .... (ii)

Now, we can write

$a = \frac{dv}{dt} = \frac{dv}{dx}\frac{dx}{dt} = v\frac{dv}{dx}$ or vdv = adx

Integrating on both sides and taking the limit for velocity u to v and for displacement x_0 to x, we get

$\int_u^v vdv = \int_{x_0}^x adx; \frac{v^2-u^2}{2} = a(x - x_0)$

$v^2 = u^2 + 2a(x - x_0)$ .... (iii)

Equations (i), (ii) and (iii) are the required equations of motion.

14. i. We take the origin the x - axis to be the initial position of the plane, so that $x_0 = 0$.

    Here we have, a = 4.00 $m/s^{2,}$ v = 0 and x = 0

    Since u =0, we have v = at and $x = \frac{1}{2}at^2$

    At t = 5.00

    v = (4.00 m/s^2)(5.00 s) = 20.0 m/s

    $x = \frac{1}{2}\left(4.00 m/s^2\right)(5.00 s)^2$

    x = 50.0 m

    ii. Since u = 0, $v_x^2 = 2a_x x$

    solving for x, we obtain

    $x = \frac{v^2}{2a} = \frac{(70.00 m/s)^2}{2(4.00 m/s^2)} = 613 m$

15. For first stone,

Initial velocity, $u_1 = 15 m/s$

Acceleration, $a = -10 m/s^2$

Now, using the second equation of motion,

$x_1 = x_0 + u_1 t + (1/2)at^2$

$x_0 = 200 m$ is the height of the cliff.

Therefore,

$x_1 = 200 + 15t - 5t^2$ .... (i)

When stone hits the ground, $x_1 = 0$

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

$\Rightarrow \quad t^2 - 3t - 40 = 0$

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

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

i.e., $t = 8$ s or $t = -5s$

t cannot be negative as the stone is projected at a certain time.

Therefore, t = 8 sec

For second stone,

Initial velocity, $u_2 = 30 m/s$

Acceleration, $a = -g = -10m/s^2$

Now, using the second equation of motion,

$x_2 = x_0 + u_2t + (1/2)at^2$

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

When stone hits the ground, $x_2 = 0$

So, $-5t^2 + 30t + 200 = 0$

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

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

$\Rightarrow \quad t(t-10) + 4(t-10) = 0$

$\Rightarrow \quad t(t-10)(t+4) = 0$

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

t cannot be negative again.

$\therefore t = 10\text{sec}$

On subtracting equations (i) and (ii), we have

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

$x_2 - x_1 = 15t$ .... (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 8s.

At t = 8 sec, stones are separated by a maximum distance.

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

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

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

Therefore, the equation of linear path is:

$x_2 - x_1 = 15t,$

and the equation of curved path is given by:

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