02

Motion in a Straight Line

TOPIC 1
Terms Related to Motion

01 A person travelling in a straight line moves with a constant velocity v_1 for certain distance 'x' and with a constant velocity v_2 for next equal distance. The average velocity v is given by the relation **[NEET (Odisha) 2019]**

(a) $\frac{1}{v} = \frac{1}{v_1} + \frac{1}{v_2}$ (b) $\frac{2}{v} = \frac{1}{v_1} + \frac{1}{v_2}$

(c) $\frac{v}{2} = \frac{v_1 + v_2}{2}$ (d) $v = \sqrt{v_1 v_2}$

Ans. *(b)*

For distance x, the person moves with constant velocity v_1 and for another x distance, he moves with constant velocity of v_2, then

Total distance travelled, $D = x + x = 2x$

Total time-taken, $T = t_1 + t_2$

$$= \frac{x}{v_1} + \frac{x}{v_2} \qquad \left[\because t = \frac{\text{Distance}}{\text{Velocity}}\right]$$

The average velocity,

$$V_{av} = \frac{\text{total distance}}{\text{total time}} = \frac{D}{T}$$

$$v = \frac{2x}{\frac{x}{v_1} + \frac{x}{v_2}} = \frac{2}{\frac{1}{v_1} + \frac{1}{v_2}} \qquad [\because v_{av} = v]$$

$$\Rightarrow \frac{1}{v_1} + \frac{1}{v_2} = \frac{2}{v}$$

02 Preeti reached the metro station and found that the escalator was not working. She walked up the stationary escalator in time t_1. On other days, if she remains stationary on the moving escalator, then the escalator takes her up in time t_2. The time taken by her to walk up on the moving escalator will be **[NEET 2017]**

(a) $\frac{t_1 + t_2}{2}$ (b) $\frac{t_1 t_2}{t_2 - t_1}$

(c) $\frac{t_1 t_2}{t_2 + t_1}$ (d) $t_1 - t_2$

Ans. *(c)*

Speed of walking $= \frac{h}{t_1} = v_1$

Speed of escalator $= \frac{h}{t_2} = v_2$

Time taken when she walks over running escalator

$$\Rightarrow \quad t = \frac{h}{v_1 + v_2}$$

$$\Rightarrow \quad \frac{1}{t} = \frac{v_1}{h} + \frac{v_2}{h} = \frac{1}{t_1} + \frac{1}{t_2}$$

$$\Rightarrow \quad t = \frac{t_1 t_2}{t_1 + t_2}$$

03 If the velocity of a particle is $v = At + Bt^2$, where A and B are constants, then the distance travelled by it between 1s and 2s is **[NEET 2016]**

(a) $3A + 7B$ (b) $\frac{3}{2}A + \frac{7}{3}B$

(c) $\frac{A}{2} + \frac{B}{3}$ (d) $\frac{3}{2}A + 4B3$

Ans. *(b)*

Velocity of the particle is given as

$$v = At + Bt^2$$

where A and B are constants.

$$\Rightarrow \quad \frac{dx}{dt} = At + Bt^2 \qquad \left[\because v = \frac{dx}{dt}\right]$$

$$\Rightarrow \quad dx = (At + Bt^2)\,dt$$

Integrating both sides, we get

$$\int_{x_1}^{x_2} dx = \int_1^2 (At + Bt^2)\,dt$$

$$\Rightarrow \quad \Delta x = x_2 - x_1 = A\int_1^2 t\,dt + B\int_1^2 t^2 dt$$

$$= A\left[\frac{t^2}{2}\right]_1^2 + B\left[\frac{t^3}{3}\right]_1^2$$

$$= \frac{A}{2}(2^2 - 1^2) + \frac{B}{3}(2^3 - 1^3)$$

$\therefore$ Distance travelled between 1s and 2s is

$$\Delta x = \frac{A}{2} \times (3) + \frac{B}{3}(7) = \frac{3A}{2} + \frac{7B}{3}$$

04 Two cars P and Q start from a point at the same time in a straight line and their positions are represented by $X_P(t) = at + bt^2$ and $X_Q(t) = ft - t^2$. At what time do the cars have the same velocity? **[NEET 2016]**

(a) $\frac{a - f}{1 + b}$ (b) $\frac{a + f}{2(b - 1)}$

(c) $\frac{a + f}{2(1 + b)}$ (d) $\frac{f - a}{2(1 + b)}$

Ans. *(d)*

Velocity of each car is given by

$$V_P = \frac{dx_p(t)}{dt} = a + 2bt$$

and $$V_Q = \frac{dx_Q(t)}{dt} = f - 2t$$

It is given that $V_P = V_Q$

$$\Rightarrow \quad a + 2bt = f - 2t$$

$$\Rightarrow \quad t = \frac{f - a}{2(b + 1)}$$

05 A particle of unit mass undergoes one-dimensional motion such that its velocity varies according to $v(x) = \beta x^{-2n}$ where, β and n are constants and x is the position of the particle. The acceleration of the particle as a function of x, is given by **[CBSE AIPMT 2015]**

(a) $-2n\beta^2\ x^{-2n-1}$ (b) $-2n\beta^2\ x^{-4n-1}$
(c) $-2\beta^2\ x^{-2n+1}$ (d) $-2n\beta^2\ e^{-4n+1}$

Ans. *(b)*

Given, $v = \beta x^{-2n}$

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

$$\Rightarrow \quad a = v\frac{dv}{dx} = (\beta x^{-2n})(-2n\beta x^{-2n-1})$$

$$\Rightarrow \quad a = -2n\beta^2 x^{-4n-1}$$

06 The motion of a particle along a straight line is described by equation

$$x = 8 + 12t - t^3$$

where, x is in metre and t in sec. The retardation of the particle when its velocity becomes zero, is **[CBSE AIPMT 2012]**

(a) $24\ ms^{-2}$ (b) zero
(c) $6\ ms^{-2}$ (d) $12\ ms^{-2}$

Ans. *(d)*

Concept Double differentiation of displacement equation gives acceleration and single differentiation gives velocity of the body.

Given, $x = 8 + 12t - t^3$

We know $v = \dfrac{dx}{dt}$

and acceleration $a = \dfrac{dv}{dt}$

So, $v = 12 - 3t^2$ and $a = -6t$

At $t = 2$ s

$v = 0$ and $a = -6 \times 2$

$a = -12\ m/s^2$

So, retardation of the particle $= 12\ m/s^2$.

07 A body is moving with velocity 30 m/s towards East. After 10s, its velocity becomes 40 m/s towards North. The average acceleration of the body is **[CBSE AIPMT 2011]**

(a) $7\ m/s^2$ (b) $\sqrt{7}\ m/s^2$
(c) $5\ m/s^2$ (d) $1\ m/s^2$

Ans. *(c)*

Average acceleration

$$n = \frac{\text{Change in velocity}}{\text{Total time}}$$

$$a = \frac{|\mathbf{v}_f - \mathbf{v}_i|}{\Delta t} = \frac{\sqrt{30^2 + 40^2}}{10}$$

$$= \frac{\sqrt{900 + 1600}}{10} = 5\ ms^{-2}$$

08 A particle moves a distance x in time t according to the equation $x = (t+5)^{-1}$. The acceleration of particle is proportional to **[CBSE AIPMT 2010]**

(a) $(\text{velocity})^{3/2}$ (b) $(\text{distance})^2$
(c) $(\text{distance})^{-2}$ (d) $(\text{velocity})^{2/3}$

Ans. *(a)*

Given, distance $x = (t+5)^{-1}$ ...(i)

Differentiating Eq. (i) w.r.t. t, we get

$$\frac{dx}{dt} = (v) = \frac{-1}{(t+5)^2} \quad \text{...(ii)}$$

Again, differentiating Eq. (ii) w.r.t. t, we get

$$\frac{d^2x}{dt^2} = (a) = \frac{2}{(t+5)^3} \quad \text{...(iii)}$$

Comparing Eqs. (ii) and (iii), we get

$(a) \propto (v)^{3/2}$

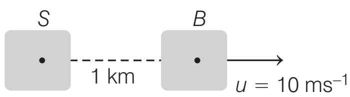
09 A bus is moving with a speed of $10\ ms^{-1}$ on a straight road. A scooterist wishes to overtake the bus in 100 s. If the bus is at a distance of 1 km from the scooterist, with what speed should the scooterist chase the bus? **[CBSE AIPMT 2009]**

(a) $20\ ms^{-1}$ (b) $40\ ms^{-1}$
(c) $25\ ms^{-1}$ (d) $10\ ms^{-1}$

Ans. *(a)*

Let v be the relative velocity of scooter (s) w.r.t. bus (B), then

$$v = v_S - v_B$$



$\therefore \quad v_S = v + v_B$ ...(i)

Relative velocity = Displacement / Time

$$= \frac{1000}{100} = 10\ ms^{-1}$$

Now, substituting the value of v in Eq. (i), we get

$$v_S = 10 + 10 = 20\ ms^{-1}$$

10 A particle moving along x-axis has acceleration f, at time t, given by $f = f_0\left(1 - \dfrac{t}{T}\right)$, where f_0 and T are constants. The particle at $t = 0$ has zero velocity. In the time interval between $t = 0$ and the instant when $f = 0$, the particle's velocity (v_x) is **[CBSE AIPMT 2007]**

(a) $f_0 T$ (b) $\frac{1}{2} f_0 T^2$ (c) $f_0 T^2$ (d) $\frac{1}{2} f_0 T$

Ans. *(d)*

Acceleration

$$f = f_0\left(1 - \frac{t}{T}\right)$$

or $f = \dfrac{dv}{dt} = f_0\left(1 - \dfrac{t}{T}\right)$ $\left[\because f = \dfrac{dv}{dt}\right]$

or $dv = f_0\left(1 - \dfrac{t}{T}\right)dt$ ...(i)

Integrating Eq. (i) on both sides,

$$\int dv = \int f_0\left(1 - \frac{t}{T}\right)dt$$

$$\therefore \quad v = f_0 t - \frac{f_0}{T}\cdot\frac{t^2}{2} + c \quad \text{...(ii)}$$

where, c is constant of integration.

Now, when $t = 0$, $v = 0$.

So, from Eq. (ii), we get $c = 0$

$$\therefore \quad v = f_0 t - \frac{f_0}{T}\cdot\frac{t^2}{2} \quad \text{...(iii)}$$

As, $f = f_0\left(1 - \dfrac{t}{T}\right)$

When, $f = 0$,

$$0 = f_0\left(1 - \frac{t}{T}\right)$$

As, $f_0 \neq 0$, so, $1 - \dfrac{t}{T} = 0$

$\therefore \quad t = T$

Substituting, $t = T$ in Eq. (iii), we get

$$v_x = f_0 T - \frac{f_0}{T}\cdot\frac{T^2}{2} = f_0 T - \frac{f_0 T}{2} = \frac{1}{2} f_0 T$$

11 A car moves from X to Y with a uniform speed v_u and returns to X with a uniform speed v_d. The average speed for this round trip is **[CBSE AIPMT 2007]**

(a) $\dfrac{2v_d v_u}{v_d + v_u}$ (b) $\sqrt{v_u v_d}$

(c) $\dfrac{v_d v_u}{v_d + v_u}$ (d) $\dfrac{v_u + v_d}{2}$

Ans. *(a)*

$$\text{Average speed} = \frac{\text{Total distance travelled}}{\text{Time taken}}$$

Let t_1 and t_2 be times taken by the car to go from X to Y and then from Y to X respectively.

Then, $t_1 + t_2 = \dfrac{XY}{v_u} + \dfrac{XY}{v_d}$

$$= XY\left(\frac{v_u + v_d}{v_u v_d}\right)$$

Total distance travelled $= XY + XY = 2XY$
Therefore, average speed of the car for this round trip is

$$v_{av} = \frac{2XY}{XY\left(\frac{v_u + v_d}{v_u v_d}\right)} \quad \text{or} \quad v_{av} = \frac{2v_u v_d}{v_u + v_d}$$

12 The position x of a particle w.r.t. time t along x-axis is given by $x = 9t^2 - t^3$, where x is in metre and t in sec. What will be the position of this particle when it achieves maximum speed along the $+x$ direction? **[CBSE AIPMT 2007]**

(a) 32 m (b) 54 m
(c) 81 m (d) 24 m

Ans. *(b)*

Given, the position x of a particle w.r.t. time t along x-axis

$$x = 9t^2 - t^3 \quad \text{...(i)}$$

Differentiating Eq. (i), w.r.t. time, we get speed, i.e.

$$v = \frac{dx}{dt} = \frac{d}{dt}(9t^2 - t^3)$$

or $\quad v = 18t - 3t^2 \quad$ ...(ii)

Again differentiating Eq. (ii), with respect to time, we get acceleration, i.e.

$$a = \frac{dv}{dt} = \frac{d}{dt}(18t - 3t^2)$$

or $\quad a = 18 - 6t \quad$ ...(iii)

Now, when speed of particle is maximum, its acceleration is zero, i.e.

$$a = 0$$

i.e. $18 - 6t = 0$ or $t = 3$ s

Putting in Eq. (i), we obtain position of particle at the time

$$x = 9(3)^2 - (3)^3 = 9(9) - 27$$
$$= 81 - 27 = 54 \text{ m}$$

13 A particle moves along a straight line OX. At a time t (in second), the distance x (in metre) of the particle from O is given by

$$x = 40 + 12t - t^3$$

How long would the particle travel before coming to rest? **[CBSE AIPMT 2006]**

(a) 24 m (b) 40 m (c) 56 m (d) 16 m

Ans. *(c)*

Concept First X by X differentiating displacement equation we get velocity of the body, since body comes to rest so velocity becomes zero. Now by putting the value of time t in displacement equation we get the distance travelled by the body when it comes to rest.

Distance travelled by the particle is

$$x = 40 + 12t - t^3$$

We know that, velocity is the rate of change of distance i.e. $v = \frac{dx}{dt}$.

$$\therefore \quad v = \frac{d}{dt}(40 + 12t - t^3)$$
$$= 0 + 12 - 3t^2$$

but final velocity $v = 0$

$$\therefore \quad 12 - 3t^2 = 0$$

or $\quad t^2 = \frac{12}{3} = 4$

or $\quad t = 2$ s

Hence, distance travelled by the particle before coming to rest is given by

$$x = 40 + 12(2) - (2)^3$$
$$= 40 + 24 - 8$$
$$= 64 - 8 = 56 \text{ m}$$

14. The displacement x of a particle varies with time t as $x = ae^{-\alpha t} + be^{\beta t}$, where a, b, α and β are positive constants. The velocity of the particle will **[CBSE AIPMT 2005]**

(a) decrease with time
(b) be independent of α and β
(c) drop to zero when $\alpha = \beta$
(d) increase with time

Ans. *(d)*

Given, $x = ae^{-\alpha t} + be^{\beta t}$

Velocity $v = \frac{dx}{dt} = -a\alpha e^{-\alpha t} + b\beta e^{\beta t}$

$$= A + B$$

where, $A = -a\alpha e^{-\alpha t}$

$$B = b\beta e^{\beta t}$$

The value of term $A = -a\alpha e^{-\alpha t}$ decreases and of term $B = b\beta e^{\beta t}$ increases with time. As a result, velocity goes on increasing with time.

15. A particle moves along a straight line such that its displacement at any time t is given by $s = 3t^3 + 7t^2 + 14t + 5$. The acceleration of the particle at $t = 1$ s is **[CBSE AIPMT 2000]**

(a) 18 m/s^2
(b) 32 m/s^2
(c) 29 m/s^2
(d) 24 m/s^2

Ans. *(b)*

Concept On double differentiation of displacement equation gives acceleration of body

i.e. $\quad a = \frac{d^2x}{dt^2}$

The displacement of a particle along a straight line is

$$s = 3t^3 + 7t^2 + 14t + 5 \quad \text{...(i)}$$

Differentiating Eq. (i) w.r.t. time, which gives the velocity

$$v = \frac{ds}{dt} = \frac{d}{dt}(3t^3 + 7t^2 + 14t + 5)$$
$$= \frac{d}{dt}(3t^3) + \frac{d}{dt}(7t^2) + \frac{d}{dt}(14t) + \frac{d}{dt}(5)$$
$$v = 3\frac{d}{dt}(t^3) + 7\frac{d}{dt}(t^2) + 14\frac{d}{dt}(t) + 0 \quad \text{...(ii)}$$

(as differentiation of a constant is zero)

Now use $\frac{d}{dt}(x^n) = nx^{n-1}$

So, $\quad v = 3(3)t^{3-1} + 7(2)(t^{2-1}) + 14(t^{1-1})$

$\Rightarrow \quad v = 9t^2 + 14t + 14 \quad$ ....(iii)

$(\because t^0 = 1)$

Again differentiating Eq. (iii) w.r.t. time, which gives the acceleration

$$a = \frac{dv}{dt} = \frac{d}{dt}(9t^2 + 14t + 14)$$
$$= 18t + 14 + 0 = 18t + 14$$

At $t = 1$ s,

$$a = 18(1) + 14 = 18 + 14 = 32 \text{ m/s}^2$$

16. The position x of a particle varies with time t, as $x = at^2 - bt^3$. The acceleration of the particle will be zero at time t equals to **[CBSE AIPMT 1997]**

(a) zero (b) $\frac{a}{3b}$
(c) $\frac{2a}{3b}$ (d) $\frac{a}{b}$

Ans. *(b)*

Acceleration, $a = \frac{dv}{dt} = \frac{d^2x}{dt^2}$,

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

The given equation is

$$x = at^2 - bt^3$$

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

Acceleration $a = \frac{dv}{dt} = 2a - 6bt$

but $\quad a = 0 \quad$ (given)

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

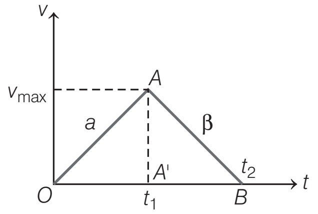
17. A car accelerates from rest at a constant rate α for some time, after which it decelerates at a constant rate β and comes to rest. If the total time elapsed is t, then the maximum velocity acquired by the car is **[CBSE AIPMT 1994]**

(a) $\left(\frac{\alpha^2+\beta^2}{\alpha\beta}\right)t$ (b) $\left(\frac{\alpha^2-\beta^2}{\alpha\beta}\right)t$

(c) $\frac{(\alpha+\beta)\,t}{\alpha\beta}$ (d) $\left(\frac{\alpha\beta\,t}{\alpha+\beta}\right)$

Ans. *(d)*

This situation is plotted on $(v\text{-}t)$ graph. In $(v\text{-}t)$ graph, OA represents the accelerated part and AB represents the decelerated part.



Let t_1 and t_2 be the times for part OA and AB respectively.

At point A velocity is maximum and let it be v_{max}.

$\therefore \quad v_{max} = \alpha t_1 = \beta t_2$

But $\quad t = t_1 + t_2 = \frac{v_{max}}{\alpha} + \frac{v_{max}}{\beta}$

$$= v_{max}\left(\frac{1}{\alpha}+\frac{1}{\beta}\right) = v_{max}\left(\frac{\alpha+\beta}{\alpha\beta}\right)$$

or $\quad v_{max} = t\left(\frac{\alpha\beta}{\alpha+\beta}\right)$

Alternative

This problem can also be solved by checking the dimensions on both sides. On checking the dimensions we note that the dimensions of option (d) match with that of velocity.

18. A particle moves along a straight line such that its displacement at any time t is given by $s = (t^3 - 6t^2 + 3t + 4)$ m

The velocity when the acceleration is zero, is **[CBSE AIPMT 1994]**

(a) $3\,\text{ms}^{-1}$ (b) $-12\,\text{ms}^{-1}$

(c) $42\,\text{ms}^{-1}$ (d) $-9\,\text{ms}^{-1}$

Ans. *(d)*

Given, $s = t^3 - 6t^2 + 3t + 4$

$\therefore$ Velocity $v = \frac{ds}{dt} = 3t^2 - 12t + 3 \quad$ ...(i)

Acceleration a is given by

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

$\therefore \quad a = 6t - 12 \quad$ ...(ii)

For $a = 0$, we have $0 = 6t - 12$

or $\quad t = 2$ s

Hence, at $t = 2$ s the velocity will be

$$v = 3\times2^2 - 12\times2 + 3 = -9\,\text{ms}^{-1}$$

19. A train of 150 m length is going towards North direction at a speed of 10 m/s. A parrot flies at the speed of 5 m/s towards South direction parallel to the railways track. The time taken by the parrot to cross the train is **[CBSE AIPMT 1992]**

(a) 12 s (b) 8 s (c) 15 s (d) 10 s

Ans. *(d)*

Concept Velocity of A w.r.t. B is given by $v_{AB} = v_A - v_B$.

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

$$= [10 - (-5)]\,\text{ms}^{-1} = 15\,\text{ms}^{-1}.$$

Time taken by the parrot to cross the train

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

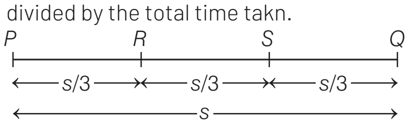
20. A bus travelling the first one-third distance at a speed of 10 km/h, the next one-third at 20 km/h and the last one-third at 60 km/h. The average speed of the bus is **[CBSE AIPMT 1991]**

(a) 9 km/h (b) 16 km/h

(c) 18 km/h (d) 48 km/h

Ans. *(c)*

Concept Average speed can be calculated as the total distance travelled divided by the total time takn.



Let t_1, t_2, t_3 be times taken in covering distances PR, RS and SQ respectively.

$\therefore \quad t_1 = \frac{(s/3)}{10}, \quad t_2 = \frac{(s/3)}{20}$

and $\quad t_3 = \frac{(s/3)}{60}$

$\therefore$ Average speed $= \frac{\text{Total distance}}{\text{Total time}}$

$$= \frac{s}{t_1 + t_2 + t_3}$$

$$= \frac{s}{\frac{(s/3)}{10} + \frac{(s/3)}{20} + \frac{(s/3)}{60}}$$

$$= \frac{s}{(s/18)} = 18\text{ km/h}$$

21. A car moves a distance of 200 m. It covers the first-half of the distance at speed 40 km/h and the second-half of distance at speed v km / h. The average speed is 48 km/h. Find the value of v. **[CBSE AIPMT 1991]**

(a) 56 km/h (b) 60 km/h

(c) 50 km/h (d) 48 km/h

Ans. *(b)*

Average speed $= \frac{\text{Total distance}}{\text{Total time}}$

Let t_1, t_2 be time taken during first-half and second-half respectively.

So, $\quad t_1 = \frac{100}{40}$ s

and $\quad t_2 = \frac{100}{v}$ s

So, according to average speed formula

$$48 = \frac{200}{\left(\frac{100}{40}\right) + \left(\frac{100}{v}\right)}$$

or $\quad \frac{1}{40} + \frac{1}{v} = \frac{2}{48} = \frac{1}{24}$

or $\quad \frac{1}{v} = \frac{2}{120} = \frac{1}{60}$

$\Rightarrow \quad v = 60$ km/h

22. A car covers the first-half of the distance between two places at 40 km/h and other half at 60 km/h. The average speed of the car is **[CBSE AIPMT 1990]**

(a) 40 km/h (b) 48 km/h

(c) 50 km/h (d) 60 km/h

Ans. *(b)*

Let the distance between two places be d and t_1 is time taken by car to travel first-half length, t_2 is time taken by car to travel second-half length. Time taken by car to travel first-half length,

$$t_1 = \frac{\left(\frac{d}{2}\right)}{40} = \frac{d}{80}$$

Time taken by car to travel second-half length,

$$t_2 = \frac{\left(\frac{d}{2}\right)}{60} = \frac{d}{120}$$

$\therefore$ Total time $= t_1 + t_2$

$$= \frac{d}{80} + \frac{d}{120}$$

$$= d\left(\frac{1}{80} + \frac{1}{120}\right) = \frac{d}{48}$$

$\therefore$ Average speed

$$= \frac{d}{t_1 + t_2} = \frac{d}{\left(\frac{d}{48}\right)} = 48 \text{ km/h}$$

Alternative

$$v_{av} = \frac{2v_1v_2}{v_1 + v_2} = \frac{2 \times 40 \times 60}{40 + 60} = 48 \text{ km/h}$$

TOPIC 2

Kinematics Equations of Uniformly Accelerated Motion

23. A car starts from rest and accelerates at 5 m/s^2. At $t = 4$s, a ball is dropped out of a window by a person sitting in the car. What is the velocity and acceleration of the ball at $t = 6$ s? (Take, $g = 10 \text{ m/s}^2$) **[NEET 2021]**

(a) 20 m/s, 5 m/s^2

(b) 20 m/s, 0

(c) $20\sqrt{2}$ m/s, 0

(d) $20\sqrt{2}$ m/s, 10 m/s^2

Ans. *(d)*

Given, the initial velocity of a car, $u = 0$

The acceleration of a car, $a = 5 \text{ m/s}^2$

At $t = 4$ s, $v = u + at$

$\Rightarrow$ $v = 0 + (5)4 \Rightarrow v = 20$ m/s

Thus, the final velocity of car at $t = 4$ s is 20 m/s.

At $t = 4$ s, the ball is dropped out of a window by a person sitting in the car.

The velocity of the ball in the x-direction,

$v_x = 20$ m/s (due to the car)

Therefore, in the y-direction, the acceleration is equal to the acceleration due to gravity,

$$a_y = g = 10 \text{ m/s}^2$$

The velocity of the ball in the y-direction,

$$v_y = u + a_y t \quad \Rightarrow v_y = 0 + 10 \times 2$$

$$\Rightarrow \quad v_y = 20 \text{ m/s}$$

Thus, the velocity of the ball in y-direction is 20 m/s.

The net velocity at $t = 6$s,

$$v = \sqrt{v_x^2 + v_y^2} \quad \Rightarrow v = \sqrt{(20)^2 + (20)^2}$$

$$\Rightarrow \quad v = 20\sqrt{2} \text{ m/s}$$

Thus, the velocity of the ball at $t = 6$ s is $20\sqrt{2}$ m/s.

and there is no acceleration in the x-direction, $a_x = 0 \text{ ms}^{-2}$

In y-direction, $a_y = 10 \text{ ms}^{-2}$

Now, we shall determine the net acceleration

at $t = 6$ s, $a = \sqrt{a_x^2 + a_y^2}$

$$\Rightarrow a = \sqrt{(0) + (10)^2} \Rightarrow a = 10 \text{ ms}^{-2}$$

24. A small block slides down on a smooth inclined plane, starting from rest at time $t = 0$. Let s_n be the distance travelled by the block in the interval $t = n - 1$ to $t = n$. Then, the ratio $\frac{s_n}{s_{n+1}}$ is **[NEET 2021]**

(a) $\frac{2n-1}{2n}$ (b) $\frac{2n-1}{2n+1}$ (c) $\frac{2n+1}{2n-1}$ (d) $\frac{2n}{2n-1}$

Ans. *(b)*

Distance covered nth seconds is s_n.

Distance covers in $(n+1)$ th seconds is s_{n+1}.

Initial velocity of small block, $u = 0$

Distance cover in nth seconds,

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

$$\Rightarrow \quad s_n = 0 + \frac{a}{2}(2n-1)$$

$$\Rightarrow \quad s_n = \frac{a}{2}(2n-1) \quad \text{...(i)}$$

Distance cover in $(n+1)$th seconds,

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

$$\Rightarrow \quad s_{n+1} = 0 + \frac{a}{2}(2n + 2 - 1)$$

$$\Rightarrow \quad s_{n+1} = \frac{a}{2}(2n+1) \quad \text{...(ii)}$$

On dividing Eq. (i) by Eq. (ii), we get

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

$$\Rightarrow \quad \frac{s_n}{s_{n+1}} = \frac{(2n-1)}{(2n+1)}$$

25. A person sitting in the ground floor of a building notices through the window of height 1.5 m, a ball dropped from the roof of the building crosses the window in 0.1 s. What is the velocity of the ball when it is at the topmost point of the window? ($g = 10 \text{ m/s}^2$) **[NEET (Oct.) 2020]**

(a) 15.5 m/s (b) 14.5 m/s

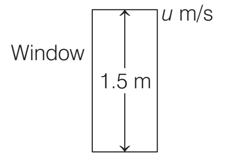
(c) 4.5 m/s (d) 20 m/s

Ans. *(b)*

According to question, time taken by the ball to cross the window,

$$t = 0.1 \text{ s}$$

$$h = 1.5 \text{ m}$$



If u be the velocity at the top most point of the window, then from equation of motion,

$$h = ut + \frac{1}{2}gt^2$$

$$\Rightarrow \quad 1.5 = u \times 0.1 + \frac{1}{2} \times 10 \times (0.1)^2$$

$$\Rightarrow \quad 1.5 = 0.1u + 0.05$$

$$\Rightarrow \quad u = \frac{1.5 - 0.05}{0.1} = \frac{1.45}{0.1} = 14.5 \text{ m/s}$$

26. A ball is thrown vertically downward with a velocity of 20 m/s from the top of a tower. It hits the ground after some time with a velocity of 80 m/s. The height of the tower is ($g = 10 \text{ m/s}^2$) **[NEET (Sep.) 2020]**

(a) 340 m

(b) 320 m

(c) 300 m

(d) 360 m

Ans. *(c)*

Given, $u = 20$ m/s, $v = 80$ m/s and $h = ?$

From kinematic equation of motion,

$$v^2 = u^2 + 2gh$$

$$\Rightarrow \quad h = \frac{v^2 - u^2}{2g}$$

$$= \frac{(80)^2 - (20)^2}{2 \times 10} \quad (\because \text{given, } g = 10 \text{ m/s}^2)$$

$$= 300 \text{ m}$$

Hence, correct option is (c).

27. A person standing on the floor of an elevator drops a coin. The coin reaches the floor in time t_1 if the elevator is at rest and in time t_2 if the elevator is moving uniformly. The which of the following option is correct? **[NEET (Odisha) 2019]**

(a) $t_1 < t_2$ or $t_1 > t_2$ depending upon whether the lift is going up or down

(b) $t_1 < t_2$

(c) $t_1 > t_2$

(d) $t_1 = t_2$

Ans. ***(d)***

Let h be the height through which the coin is dropped. Then, according to the equation of motion, it is given as

$$h = ut + \frac{1}{2}gt^2 \Rightarrow t = \sqrt{\frac{2h}{g}} \quad [\because u = 0]$$

$$\Rightarrow t \propto \frac{1}{\sqrt{g}}$$

As the elevator is moving uniformly i.e. its velocity is constant, so the acceleration is zero.

$\therefore$ Relative acceleration of the lift when it is either moving upward or downward is given as, $g' = g \pm a = g \pm 0 = g$

Hence, the time for the coin to reach the floor will remains same i.e. $t_1 = t_2$.

28. A toy car with charge q moves on a frictionless horizontal plane surface under the influence of a uniform electric field **E**. Due to the force q**E**, its velocity increases from 0 to 6 m/s in one second duration. At that instant, the direction of the field is reversed. The car continues to move for two more seconds under the influence of this field. The average velocity and the average speed of the toy car between 0 to 3 seconds are respectively **[NEET 2018]**

(a) 1 m/s, 3.5 m/s
(b) 1 m/s, 3 m/s
(c) 2 m/s, 4 m/s
(d) 1.5 m/s, 3 m/s

Ans. ***(b)***

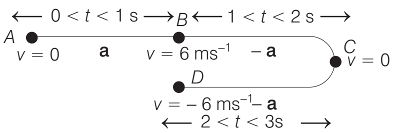
According to the question,

For the time duration $0 < t < 1$ s,

the velocity increase from 0 to 6 ms^{-1}

As the direction of field has been reversed for, $1 < t < 2$ s : the velocity firstly decreases from 6 ms^{-1} to 0.

Then, for $2 < t < 3$ s; as the field strength is same; the magnitude of acceleration would be same, but velocity increases from 0 to $-6 ms^{-1}$.



Acceleration of the car

$$|a| = \left|\frac{v-u}{t}\right| = \frac{6-0}{1} = 6 ms^{-2}$$

The displacement of the particle is given as

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

For $t = 0$ to $t = 1$ s,

$u = 0, a = +6 m/s^2$

$$\Rightarrow s_1 = 0 + \frac{1}{2} \times 6 \times (1)^2 = 3 \text{ m}$$

For $t = 1$ s to $t = 2$ s,

$u = 6 \text{ ms}^{-1}, a = -6 \text{ ms}^{-2}$

$$\Rightarrow s_2 = 6 \times 1 - \frac{1}{2} \times 6 \times (1)^2 = 6 - 3 = 3 \text{m}$$

For $t = 2$ s to $t = 3$ s,

$u = 0, a = -6 ms^{-1}$

$$\Rightarrow s_3 = 0 - \frac{1}{2} \times 6 \times (1)^2 = -3 \text{m}$$

$\therefore$ Net displacement, $s = s_1 + s_2 + s_3$
$= 3 \text{m} + 3 \text{m} - 3 \text{m} = 3 \text{m}$

Hence, average velocity

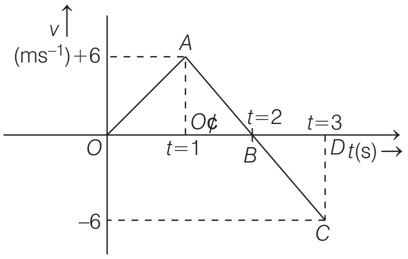
$$= \frac{\text{Net displacement}}{\text{Total time}} = \frac{3}{3} = 1 \text{m s}^{-1}$$

Total distance travelled, $d = 9$ m

$$\text{Hence, average speed} = \frac{\text{Total distance}}{\text{Total time}} = \frac{9}{3} = 3 \text{ m s}^{-1}$$

Alternative Method

Given condition can be represented through graph also as shown below.



$\therefore$ Displacement in three seconds

= Area under the graph

= Area of $\Delta OAO'$ + Area of $\Delta AO'B$ – Area of ΔBCD

$$= \frac{1}{2} \times 1 \times 6 + \frac{1}{2} \times 1 \times 6 - \frac{1}{2} \times 6 \times 1 = 3 \text{m}$$

$$\therefore \text{Average velocity} = \frac{3}{3} = 1 \text{ms}^{-1}.$$

Total distance travelled, $d = 9$ m

$$\therefore \text{Average speed} = \frac{9}{3} = 3 \text{ms}^{-1}$$

29. A stone falls freely under gravity. It covers distances h_1, h_2 and h_3 in the first 5s, the next 5s and the next 5s respectively. The relation between h_1, h_2 and h_3 is **[NEET 2013]**

(a) $h_1 = 2h_2 = 3h_3$
(b) $h_1 = \frac{h_2}{3} = \frac{h_3}{5}$
(c) $h_2 = 3h_1$ and $h_3 = 3h_2$
(d) $h_1 = h_2 = h_3$

Ans. ***(b)***

For free fall from a height, $u = 0$

$\therefore$ Distance covered by stone in first 5 s,

$$h_1 = 0 + \frac{1}{2}g(5)^2 = \frac{25}{2}g \quad \text{...(i)}$$

$\therefore$ Distance covered in first 10 s,

$$s_2 = 0 + \frac{1}{2}g(10)^2 = \frac{100}{2}g$$

$\therefore$ Distance covered in second 5 s

$$h_2 = s_2 - h_1 = \frac{100}{2}g - \frac{25}{2}g = \frac{72}{2}g \quad \text{...(ii)}$$

Distance covered in first 15 s,

$$s_3 = 0 + \frac{1}{2}g(15)^2 = \frac{225}{2}g$$

$\therefore$ Distance covered in last 5 s,

$$h_3 = s_3 - s_2 = \frac{225}{2}g - \frac{100}{2}g = \frac{125}{2}g \quad \text{...(iii)}$$

From Eqs. (i), (ii) and (iii), we get

$$h_1 : h_2 : h_3 = \frac{25}{2}g : \frac{75}{2}g : \frac{125}{2}g = 1 : 3 : 5$$

$$\Rightarrow \quad h_1 = \frac{h_2}{3} = \frac{h_3}{5}$$

30. A boy standing at the top of a tower of 20 m height drops a stone. Assuming, $g = 10 \text{ ms}^{-2}$, the velocity with which it hits the ground is **[CBSE AIPMT 2011]**

(a) 20 m/s (b) 40 m/s
(c) 5 m/s (d) 10 m/s

Ans. ***(a)***

Given, $g = 10 \text{ m/s}^2$ and $h = 20$ m

We have $v = \sqrt{2gh} = \sqrt{2 \times 10 \times 20}$

$= \sqrt{400} = 20 \text{ m/s}$

31. A ball is dropped from a high rise platform at $t = 0$ starting from rest. After 6 s, another ball is thrown downwards from the same platform with a speed v. The two balls meet at $t = 18$ s. What is the value of v?
(Take $g = 10 ms^{-2}$) **[CBSE AIPMT 2010]**

(a) 74 ms^{-1}
(b) 55 ms^{-1}
(c) 40 ms^{-1}
(d) 60 ms^{-1}

Ans. *(a)*

For first ball, $u = 0$

$\therefore \quad s_1 = \frac{1}{2} g t_1^2 = \frac{1}{2} \times g\,(18)^2$

For second ball, initial velocity $= v$

$\therefore \quad s_2 = v t_2 + \frac{1}{2} g t^2$

$t_2 = 18 - 6 = 12\ \text{s}$

$\Rightarrow \quad s_2 = v \times 12 + \frac{1}{2} g\,(12)^2$

Here, $\quad s_1 = s_2$

$\frac{1}{2} g (18)^2 = 12v + \frac{1}{2} g\,(12)^2$

$\Rightarrow \quad v = 74\ \text{ms}^{-1}$

32. A particle starts its motion from rest under the action of a constant force. If the distance covered in first 10 s is s_1 and that covered in the first 20 s is s_2, then **[CBSE AIPMT 2009]**

(a) $s_2 = 2\,s_1$ (b) $s_2 = 3\,s_1$
(c) $s_2 = 4\,s_1$ (d) $s_2 = s_1$

Ans. *(c)*

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

$\therefore \quad s = \frac{1}{2} a t^2$

Now, $\quad s_1 = \frac{1}{2} a\,(10)^2 \quad$ ...(i)

and $\quad s_2 = \frac{1}{2} a\,(20)^2 \quad$ ...(ii)

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

$$\frac{s_1}{s_2} = \frac{(10)^2}{(20)^2}$$

$\Rightarrow \quad s_2 = 4 s_1$

33. A particle moves in a straight line with a constant acceleration. It changes its velocity from $10\ \mathbf{ms}^{-1}$ to $20\ \mathbf{ms}^{-1}$ while passing through a distance 135 m in t sec. The value of t is **[CBSE AIPMT 2008]**

(a) 10 (b) 1.8
(c) 12 (d) 9

Ans. *(d)*

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

$(20)^2 - (10)^2 = 2 \times a \times 135$

$\Rightarrow \quad \frac{300}{270} = a = \frac{10}{9}$

Now, using $v - u = at$

$20 - 10 = \frac{10}{9} \times t$

$\Rightarrow \quad t = 9\ \text{s}$

34. The distance travelled by a particle starting from rest and moving with an acceleration $\frac{4}{3}\ \mathbf{ms}^{-2}$, in the third-second is **[CBSE AIPMT 2008]**

(a) 6 m (b) 4 m
(c) $\frac{10}{3}$ m (d) $\frac{19}{3}$ m

Ans. *(c)*

Distance travelled in n^{th} second is given by

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

Here, $\quad u = 0, \ a = \frac{4}{3}$

$\therefore \quad s_3 = 0 + \frac{1}{2} \times \frac{4}{3} \times (6 - 1) = \frac{10}{3}\ \text{m}$

35. Two bodies A (of mass 1 kg) and B (of mass 3 kg) are dropped from heights of 16 m and 25 m, respectively. The ratio of the time taken by them to reach the ground is **[CBSE AIPMT 2006]**

(a) –5/4 (b) 12/5
(c) 5/12 (d) 4/5

Ans. *(d)*

For free fall from a height, $u = 0$ (initial velocity).

From second equation of motion

$$h = ut + \frac{1}{2} g t^2$$

or $\quad h = 0 + \frac{1}{2} g t^2$

$\therefore \quad \frac{h_1}{h_2} = \left(\frac{t_1}{t_2}\right)^2$

Given, $\quad h_1 = 16\ \text{m}, h_2 = 25\ \text{m}$

$\therefore \quad \frac{t_1}{t_2} = \sqrt{\frac{h_1}{h_2}} = \sqrt{\frac{16}{25}} = \frac{4}{5}$

36. A man throws balls with the same speed vertically upwards one after the other at an interval of 2 s. What should be the speed of the throw so that more than two balls are in the sky at any time? (Take $g = \mathbf{9.8}\ \text{m/s}^2$) **[CBSE AIPMT 2003]**

(a) Any speed less than 19.6 m/s
(b) Only with speed 19.6 m/s
(c) More than 19.6 m/s
(d) At least 9.8 m/s

Ans. *(c)*

From equation of motion time taken by ball to reach maximum height $\quad v = u - gt$

At maximum height, final speed is zero i.e. $v = 0$

So, $\quad u = gt$ or $t = \frac{u}{g}$

In 2 s, $u = 2 \times 9.8 = 19.6\ \text{m/s}$

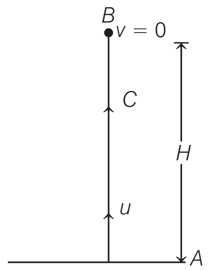
If man throws the ball with velocity of 19.6 m/s then after 2 s it will reach the maximum height. When he throws 2nd ball, 1st is at top. When he throws third ball, 1st will come to ground and 2nd will be at the top. Therefore, only 2 balls are in air. If he wants to keep more than 2 balls in air he should throw the ball with a speed greater than 19.6 m/s.

37. If a ball is thrown vertically upwards with speed u, the distance covered during the last t sec of its ascent is **[CBSE AIPMT 2003]**

(a) $ut - \frac{1}{2} g t^2$ (b) $(u + gt)\,t$
(c) ut (d) $\frac{1}{2} g t^2$

Ans. *(d)*

Let the ball takes T second to reach maximum height H. $\quad v = u - gT$



put $v = 0$

(at height H)

$\therefore \quad u = gT$

or $\quad T = \frac{u}{g} \quad$ ...(i)

Velocity attained by the ball in $(T - t)$ s is,

$$v' = u - g\,(T - t) = u - gT + gt$$

$$= u - g\frac{u}{g} + gt = u - u + gt$$

$v' = gt \quad$ ...(ii)

Hence, distance travelled in last t sec of its ascent

$CB = v't - \frac{1}{2} g t^2 = (gt)\,t - \frac{1}{2} g t^2$

$= g t^2 - \frac{1}{2} g t^2 \quad$ [From Eq. (ii)]

$= \frac{1}{2} g t^2$

38. A stone is thrown vertically upwards. When stone is at a height half of its maximum height, its speed is 10 m/s, then the maximum height attained by the stone is $(g = 10\,\mathbf{m/s^2})$ **[CBSE AIPMT 2001]**

(a) 8 m (b) 10 m
(c) 15 m (d) 20 m

Ans. *(b)*

Let u be the initial velocity and H be the maximum height attained.

At height $h = \frac{H}{2}$, we have $v = v_1 = 10$ m/s

From third equation of motion,

$$v_1^2 = u^2 - 2gh$$

$$\left(\begin{array}{l}\text{Negative sign indicates that velocity and}\\ \text{acceleration are in opposite direction}\end{array}\right)$$

or $\quad (10)^2 = u^2 - 2g\frac{H}{2} \quad$ ...(i)

At height H, $\quad v_2 = 0$

$$v_2^2 = u^2 - 2gH \quad \text{or} \quad 0 = u^2 - 2gH \quad \text{...(ii)}$$

Subtract Eq. (ii) from Eq. (i), we get

$$(10)^2 = 2g\frac{H}{2} \quad \text{or} \quad H = \frac{(10)^2}{g}$$

or $\quad H = \frac{(10)^2}{10} = 10$ m

Alternative

Maximum height attained by the stone

$$H = \frac{u^2}{2g}$$

When, $\quad H = \frac{H}{2}, u = 10$ m / s

$$\frac{H}{2} = \frac{(10)^2}{2g} \quad \text{or} \, H = \frac{100}{10} = 10 \text{ m}$$

39. A car moving with a speed of 40 km/h can be stopped after 2 m by applying brakes. If the same car is moving with a speed of 80 km/h, what is the minimum stopping distance? **[CBSE AIPMT 1998]**

(a) 8 m (b) 2 m
(c) 4 m (d) 6 m

Ans. *(a)*

According to conservation of energy, the kinetic energy of car = work done in stopping the car

i.e. $\quad \frac{1}{2}mv^2 = Fs$

where, F is the retarding force and s is the stopping distance.

For same retarding force,

$$s \propto v^2$$

$\therefore \quad \frac{s_2}{s_1} = \left(\frac{v_2}{v_1}\right)^2 = \left(\frac{80}{40}\right)^2 = 4$

$\therefore \quad s_2 = 4s_1 = 4 \times 2$

$$= 8 \text{ m}$$

Alternative

Initial speed of car $u = 40$ km/ h

$$= 40 \times \frac{5}{18} \text{ m / s} = \frac{100}{9} \text{ m / s}$$

From 3rd equation of motion,

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

$\Rightarrow \quad 0 = \left(\frac{100}{9}\right)^2 - 2 \times a \times 2$

$$4a = \frac{100 \times 100}{81}$$

$\Rightarrow \quad a = \frac{2500}{81}$ m / s^2

Final speed of car = 80 km/h

$$= 80 \times \frac{5}{18} = \frac{200}{9} \text{ m/s}$$

Suppose car stops for a distance s'.
Then

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

$$0 = \left(\frac{200}{9}\right)^2 - 2 \times \frac{2500}{81} s'$$

$\Rightarrow \quad s' = \frac{200 \times 200 \times 81}{9 \times 9 \times 2 \times 2500} = 8$ m

40. If a car at rest, accelerates uniformly to a speed of 144 **km/h** in 20s, it covers a distance of **[CBSE AIPMT 1997]**

(a) 2880 m (b) 1440 m
(c) 400 m (d) 20 m

Ans. *(c)*

Concept First of all find acceleration from the given values and then using equation of motion calculate distance travelled.

Given,

Initial velocity $u = 0$, time $t = 20$s

Final velocity $v = 144$ km/h $= 40$ m/s

From 1st equation of motion,

$$v = u + at$$

$\Rightarrow \quad a = \frac{v - u}{t} = \frac{40 - 0}{20} = 2$ m/s^2

Now, from 2nd equation of motion,

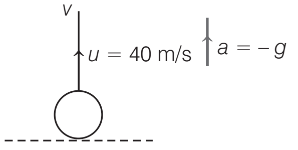
distance covered, $s = ut + \frac{1}{2}at^2$

$$= 0 + \frac{1}{2} \times 2 \times (20)^2 = 400 \text{ m}$$

41. If a ball is thrown vertically upwards with a velocity of 40 **m/s**, then velocity of the ball after 2s will be $(g = 10 \text{ m / s}^2)$ **[CBSE AIPMT 1996]**

(a) 15 m/s (b) 20 m/s
(c) 25 m/s (d) 28 m/s

Ans. *(b)*



Here, initial velocity of ball $u = 40$ m/s

Acceleration of ball $a = -g$ m/s^2

$$= -10 \text{ m/s}^2$$

Time = 2 s

From first equation of motion,

$$v = u + at = 40 - 10 \times 2$$

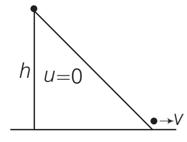
$\Rightarrow \quad v = 20$ m/s

42. Three different objects of masses m_1, m_2 and m_3 are allowed to fall from rest and from the same point O along three different frictionless paths. The speeds of the three objects on reaching the ground will be in the ratio of **[CBSE AIPMT 1995]**

(a) $m_1 : m_2 : m_3$
(b) $m_1 : 2m_2 : 3m_3$
(c) 1:1:1
(d) $\frac{1}{m_1} : \frac{1}{m_2} : \frac{1}{m_3}$

Ans. *(c)*

When an object falls freely under gravity, then its speed depends only on its height of fall and is independent of the mass of the object. As all objects are falling through the same height, therefore their speeds on reaching the ground will be in the ratio of 1 : 1 : 1.



Alternative

The vertical displacement for all the three is same and paths are frictionless. So, by conservation of mechanical energy,

$$\frac{1}{2}mv^2 = mgl$$

$\Rightarrow \quad v = \sqrt{2gl}$

So, $v_1 : v_2 : v_3 = 1 : 1 : 1$

43. The water drops fall at regular intervals from a tap 5 m above the ground. The third drop is leaving the tap at an instant when the first drop touches the ground. How far above the ground is the second drop at that instant ? (Take $g = 10\,m/s^2$) **[CBSE AIPMT 1995]**

(a) 1.25 m
(b) 2.50 m
(c) 3.75 m
(d) 5.00 m

Ans. *(c)*

Let t be the time interval of two drops. For third drop to fall

$$5 = \frac{1}{2} g (2t)^2 \qquad [\text{As } u = 0]$$

or $$\frac{1}{2} gt^2 = \frac{5}{4} \qquad \text{...(i)}$$

Let x be the distance through which second drop falls for time t, then

$$x = \frac{1}{2} gt^2 = \frac{5}{4}\,\text{m} \qquad [\text{from Eq. (i)}]$$

Thus, height of second drop from ground

$$= 5 - \frac{5}{4} = \frac{15}{4} = 3.75\,\text{m}$$

44. A body is thrown vertically upwards from the ground. It reaches a maximum height of 20 m in 5 s. After what time it will reach the ground from its maximum height position ? **[CBSE AIPMT 1995]**

(a) 2.5 s (b) 5 s
(c) 10 s (d) 25 s

Ans. *(b)*

Time taken by the body to reach the ground from some height is the same as taken to reach that height. Hence, time to reach the ground from its maximum height is 5 s.

45. A stone released with zero velocity from the top of a tower, reaches the ground in 4 s. The height of the tower is $(g = 10\,\mathbf{m/s^2})$ **[CBSE AIPMT 1995]**

(a) 20 m (b) 40 m
(c) 80 m (d) 160 m

Ans. *(c)*

Initial velocity of stone $u = 0$
Time to reach at ground $t = 4$ s
Acceleration $a = +\,g = 10\,m/s^2$

$$\left(\begin{array}{l}\text{As motion of body is along}\\ \text{the acceleration due to gravity}\end{array}\right)$$

$\therefore$ Height of tower

$$h = ut + \frac{1}{2} gt^2 = (0 \times 4) + \frac{1}{2} \times 10 \times 4^2$$
$$= 80\,\text{m}$$

46. A body starts from rest, what is the ratio of the distance travelled by the body during the 4th and 3rd s? **[CBSE AIPMT 1993]**

(a) $\frac{7}{5}$ (b) $\frac{5}{7}$ (c) $\frac{7}{3}$ (d) $\frac{3}{7}$

Ans. *(a)*

Distance travelled by the body in nth second is given by

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

Here, $u = 0$

$\therefore$ For 4th s, $s_4 = \frac{a}{2}(2 \times 4 - 1)$

and For 3th s, $s_3 = \frac{a}{2}(2 \times 3 - 1)$

Hence, $$\frac{s_4}{s_3} = \frac{(2 \times 4 - 1)}{(2 \times 3 - 1)} = \frac{7}{5}$$

47. A body dropped from top of a tower fall through 40 m during the last two seconds of its fall. The height of tower is $(g = 10\,\mathbf{m/s^2})$ **[CBSE AIPMT 1991]**

(a) 60 m (b) 45 m
(c) 80 m (d) 50 m

Ans. *(b)*

Let the body falls through the height of tower in t seconds.

From $s_n = u + \frac{a}{2}(2n - 1)$, we have

Total distance travelled in last 2 s of fall is

$$s = s_t + s_{(t-1)}$$
$$= \left[0 + \frac{g}{2}(2t - 1)\right] + \left[0 + \frac{g}{2}(2(t - 1) - 1)\right]$$
$$= \frac{g}{2}(2t - 1) + \frac{g}{2}(2t - 3)$$
$$= \frac{g}{2}(4t - 4) = \frac{10}{2} \times 4(t - 1)$$

or $40 = 20(t - 1)$ or $t = 2 + 1 = 3$ s

Distance travelled in t sec is

$$s = ut + \frac{1}{2} at^2$$
$$= 0 + \frac{1}{2} \times 10 \times 3^2 = 45\,\text{m}$$

48. What will be the ratio of the distance moved by a freely falling body from rest in 4th and 5th second of journey? **[CBSE AIPMT 1989]**

(a) 4 : 5 (b) 7 : 9
(c) 16 : 25 (d) 1 : 1

Ans. *(b)*

As distance travelled in n^{th} sec is given by

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

Here, $u = 0$, acceleration due to gravity

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

$\therefore$ For 4^{th} s, $s_4 = \frac{1}{2} \times 9.8 (2 \times 4 - 1)$

and for 5^{th} s, $s_5 = \frac{1}{2} \times 9.8 (2 \times 5 - 1)$

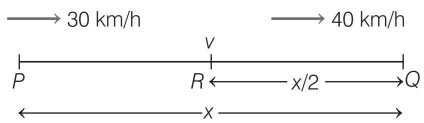
$\therefore$ $$\frac{s_4}{s_5} = \frac{7}{9}$$

49. A car is moving along a straight road with a uniform acceleration. It passes through two points P and Q separated by a distance with velocity 30 km/h and 40 km/h respectively. The velocity of the car midway between P and Q is **[CBSE AIPMT 1988]**

(a) 33.3 km/h (b) $20\sqrt{2}$ km/h
(c) $25\sqrt{2}$ km/h (d) 0.35 km/h

Ans. *(c)*

Let x be the total distance between points P and Q and v be the velocity of car while passing a certain middle point of PQ. If a is the acceleration of the car, then



For part PQ,

$$40^2 - 30^2 = 2ax$$

or $$a = \frac{350}{x} \qquad \text{...(i)}$$

For part RQ,

$$40^2 - v^2 = \frac{2ax}{2} \qquad \text{...(ii)}$$

Putting value of a from Eq. (i) in Eq. (ii), we have

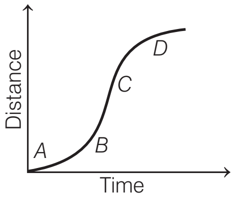
$$40^2 - v^2 = 2\left(\frac{350}{x}\right)\frac{x}{2}$$

or $40^2 - v^2 = 350$ or
$v^2 = 1250$

$\Rightarrow$ $v = 25\sqrt{2}$ km/h

TOPIC 3
Graphs in Motion

50. A particle shows distance-time curve as given in this figure. The maximum instantaneous velocity of the particle is around the point **[CBSE AIPMT 2008]**



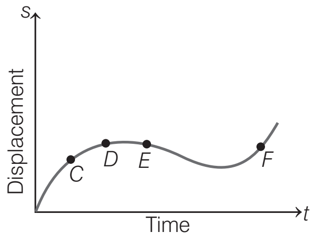
(a) B (b) C
(c) D (d) A

Ans. ***(b)***

Maximum velocity point means, the point at which $\frac{dx}{dt}$ i.e. the slope of the graph is maximum.

At point C, slope is maximum.

51. The displacement-time graph of moving particle is shown below.



The instantaneous velocity of the particle is negative at the point **[CBSE AIPMT 1994]**

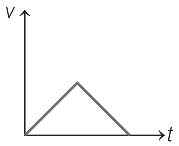
(a) D
(b) F
(c) C
(d) E

Ans. ***(d)***

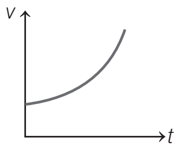
Instantaneous velocity is the slope of displacement-time graph. At point E, the slope is negative so instantaneous velocity of the particle is negative. At points C and F, the slope is positive and at D, the slope is zero.

52. Which of the following curves does not represent motion in one dimension? **[CBSE AIPMT 1992]**

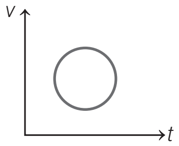
(a)



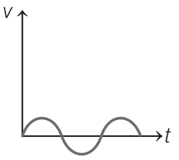
(b)



(c)



(d)



Ans. ***(c)***

In option (c), particle have two velocities at a particular instant of time, which is impossible.