CHAPTER 2

Motion in a Straight Line

1. If a body looses half of its velocity on penetrating 3 cm in a wooden block, then how much will it penetrate more before coming to rest? **[2002]**

(a) 1 cm (b) 2 cm
(c) 3 cm (d) 4 cm.

2. Speeds of two identical cars are u and $4u$ at the specific instant. The ratio of the respective distances in which the two cars are stopped from that instant is **[2002]**

(a) 1 : 1 (b) 1 : 4
(c) 1 : 8 (d) 1 : 16

3. From a building two balls A and B are thrown such that A is thrown upwards and B downwards (both vertically). If v_A and v_B are their respective velocities on reaching the ground, then **[2002]**

(a) $v_B > v_A$
(b) $v_A = v_B$
(c) $v_A > v_B$
(d) their velocities depend on their masses.

4. A car, moving with a speed of 50 km/hr, can be stopped by brakes after at least 6 m. If the same car is moving at a speed of 100 km/hr, the minimum stopping distance is **[2003]**

(a) 12m (b) 18m
(c) 24m (d) 6m

5. A ball is released from the top of a tower of height h meters. It takes T seconds to reach the ground. What is the position of the ball at $\frac{T}{3}$ second **[2004]**

(a) $\frac{8h}{9}$ meters from the ground
(b) $\frac{7h}{9}$ meters from the ground
(c) $\frac{h}{9}$ meters from the ground
(d) $\frac{17h}{18}$ meters from the ground

6. An automobile travelling with a speed of 60 km/h, can brake to stop within a distance of 20m. If the car is going twice as fast i.e., 120 km/h, the stopping distance will be **[2004]**

(a) 60m (b) 40m
(c) 20m (d) 80m

7. A car, starting from rest, accelerates at the rate f through a distance S, then continues at constant speed for time t and then decelerates at the rate $\frac{f}{2}$ to come to rest. If the total distance traversed is 15 S, then **[2005]**

(a) $S = \frac{1}{6}ft^2$ (b) $S = ft$
(c) $S = \frac{1}{4}ft^2$ (d) $S = \frac{1}{72}ft^2$

8. A particle is moving eastwards with a velocity of 5 ms^{-1}. In 10 seconds the velocity changes to 5 ms^{-1} northwards. The average acceleration in this time is **[2005]**

(a) $\frac{1}{2} ms^{-2}$ towards north
(b) $\frac{1}{\sqrt{2}} ms^{-2}$ towards north-east
(c) $\frac{1}{\sqrt{2}} ms^{-2}$ towards north-west
(d) zero

9. The relation between time t and distance x is $t = ax^2 + bx$ where a and b are constants. The acceleration is **[2005]**

(a) $-2bv^3$ (b) $-2abv^2$
(c) $2av^2$ (d) $-2av^3$

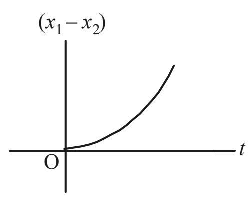
10. A particle located at $x = 0$ at time $t = 0$, starts moving along with the positive x-direction with a velocity 'v' that varies as $v = \alpha\sqrt{x}$. The displacement of the particle varies with time as **[2006]**

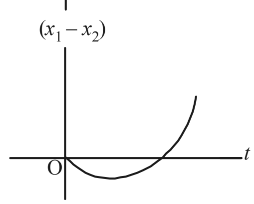
(a) t^2 (b) t
(c) $t^{1/2}$ (d) t^3

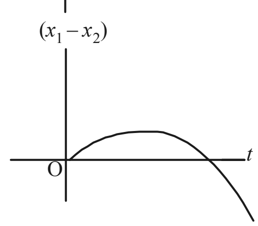
11. The velocity of a particle is $v = v_0 + gt + ft^2$. If its position is $x = 0$ at $t = 0$, then its displacement after unit time ($t = 1$) is **[2007]**

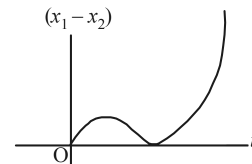
(a) $v_0 + g/2 + f$ (b) $v_0 + 2g + 3f$
(c) $v_0 + g/2 + f/3$ (d) $v_0 + g + f$

12. A body is at rest at $x = 0$. At $t = 0$, it starts moving in the positive x-direction with a constant acceleration. At the same instant another body passes through $x = 0$ moving in the positive x-direction with a constant speed. The position of the first body is given by $x_1(t)$ after time 't'; and that of the second body by $x_2(t)$ after the same time interval. Which of the following graphs correctly describes $(x_1 - x_2)$ as a function of time 't'? **[2008]**

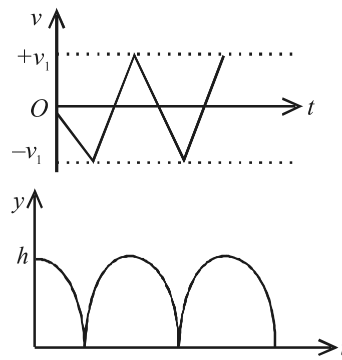
(a) 

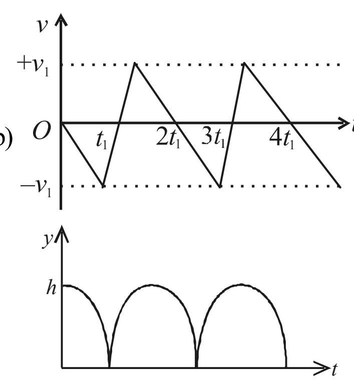
(b) 

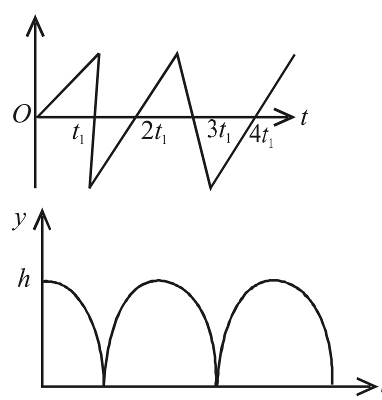
(c) 

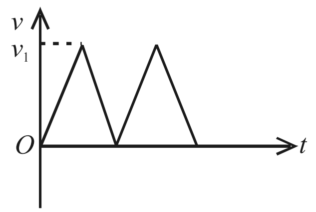
(d) 

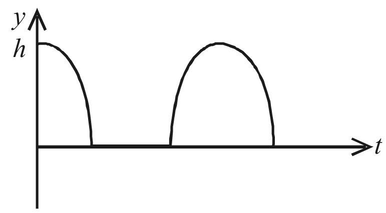
13. Consider a rubber ball freely falling from a height $h = 4.9$ m onto a horizontal elastic plate. Assume that the duration of collision is negligible and the collision with the plate is totally elastic.
Then the velocity as a function of time and the height as a function of time will be : **[2009]**

(a) 

(b) 

(c) 

(d) 



14. An object, moving with a speed of 6.25 m/s, is decelerated at a rate given by

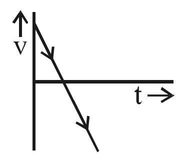
$\frac{dv}{dt} = -2.5\sqrt{v}$ where v is the instantaneous speed. The time taken by the object, to come to rest, would be: **[2011]**

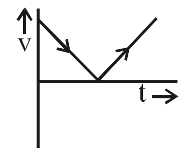
(a) 2 s (b) 4 s
(c) 8 s (d) 1 s

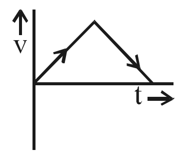
15. From a tower of height H, a particle is thrown vertically upwards with a speed u. The time taken by the particle, to hit the ground, is n times that taken by it to reach the highest point of its path. The relation between H, u and n is: **[2014]**

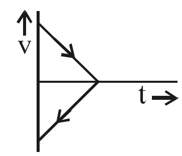
(a) $2gH = n^2u^2$
(b) $gH = (n-2)^2 u^2d$
(c) $2gH = nu^2 (n-2)$
(d) $gH = (n-2)u^2$

16. A body is thrown vertically upwards. Which one of the following graphs correctly represent the velocity vs time? **[2017]**

(a) 

(b) 

(c) 

(d) 

Answer Key

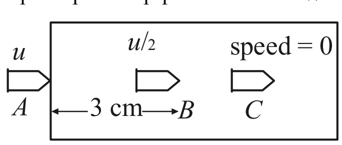
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
(a)	(d)	(b)	(c)	(a)	(d)	(d)	(c)	(d)	(a)	(c)	(b)	(b)	(a)	(c)
16														
(a)														

SOLUTIONS

1. **(a)** **Activity *A* to *B***

$u_1 = u\,;\, v_1 = \frac{u}{2}\,,\, s_1 = 0.03 \text{ m},\, a_1 = ?$

$v_1^2 - u_1^2 = 2a_1s_1$ ...(i)



$\therefore \left(\frac{u}{2}\right)^2 - u^2 = 2 \times a \times 0.03$

$\Rightarrow \frac{u^2}{4} - u^2 = 0.06a \Rightarrow -\frac{3}{4}u^2 = 0.06a$

$\Rightarrow a = \frac{-3}{4 \times 0.06}u^2$

Activity *B* to *C*: Assuming the same retardation

$u_2 = u/2\,;\, v_2 = 0\,;\, s_2 = ?\,;\; a_2 = \frac{-3}{4 \times 0.06}u^2$

$v_2^2 - u_2^2 = 2a_2 \times s_2$ ...(ii)

$\therefore\ 0 - \frac{u^2}{4} = 2\left(\frac{-3}{4 \times 0.06}\frac{u^2}{}\right) \times s_2$

$\Rightarrow\ s_2 = \frac{1}{100} m = 1 cm$

Alternatively, dividing (i) and (ii),

$$\frac{v_1^2 - u_1^2}{v_2^2 - u_2^2} = \frac{2a \times s_1}{2a \times s_2}$$

$$\Rightarrow \frac{\left(\frac{u}{2}\right)^2 - u^2}{0 - \left(\frac{u}{2}\right)^2} = \frac{0.03}{s_2} \Rightarrow s_2 = 1\ cm.$$

2. (d) **For car 1**

$u_1 = u, v_1 = 0, a_1 = -a, s_1 = s_1$

$\therefore \quad v_1^2 - u_1^2 = 2a_1 s_1 \Rightarrow -u^2 = -2as_1$

$\Rightarrow \quad u^2 = 2as_1$ ...(i)

For car 2

$u_2 = 4u, v_1 = 0, a_2 = -a, s_2 = s_2$

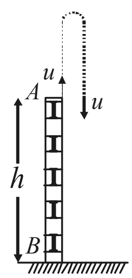
$\therefore \quad v_2^2 - u_2^2 = 2a_2 s_2 \Rightarrow -(4u)^2 = 2(-a)s_2$

$\Rightarrow \quad 16u^2 = 2as_2$ ...(ii)

Dividing (i) and (ii),

$$\frac{u^2}{16u^2} = \frac{2as_1}{2as_2} \Rightarrow \frac{1}{16} = \frac{s_1}{s_2}$$

3. (b) Ball A is thrown upwards from the building. During its downward journey when it comes back to the point of throw, its speed is equal to the speed of throw. So, for the journey of both the balls from point A to B.



We can apply $v^2 - u^2 = 2gh$.

As u, g, h are same for both the balls, $v_A = v_B$

4. (c) **Case-1 :** $u = 50 \times \frac{5}{18}$ m/s,

$v = 0, s = 6\text{m}, a = a$

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

$$\Rightarrow 0^2 - \left(50 \times \frac{5}{18}\right)^2 = 2 \times a \times 6$$

$$\Rightarrow -\left(50 \times \frac{5}{18}\right)^2 = 2 \times a \times 6 \ ....(i)$$

Case-2 : $u = 100$ km/hr $= 100 \times \frac{5}{18}$ m/sec

$v = 0, s = s, a = a \qquad \therefore v^2 - u^2 = 2as$

$$\Rightarrow 0^2 - \left(100 \times \frac{5}{18}\right)^2 = 2\text{as}$$

$$\Rightarrow -\left(100 \times \frac{5}{18}\right)^2 = 2as \quad \ldots\text{(ii)}$$

Dividing (i) and (ii) we get

$$\frac{100 \times 100}{50 \times 50} = \frac{2 \times a \times s}{2 \times a \times 6} \Rightarrow \text{s} = 24\text{m}$$

5. (a) We have $s = ut + \frac{1}{2}gt^2$,

or $h = \frac{1}{2}gT^2 \qquad (\because \text{u} = 0)$

now for $T/3$ second, vertical distance moved is given by

$$h' = \frac{1}{2}g\left(\frac{T}{3}\right)^2 \Rightarrow h' = \frac{1}{2} \times \frac{gT^2}{9} = \frac{h}{9}$$

$\therefore$ position of ball from ground $= h - \frac{h}{9}$

$$= \frac{8h}{9}$$

6. (d) Speed, $u = 60 \times \frac{5}{18}\text{m/s} = \frac{50}{3}\text{m/s}$

$d = 20\text{m}, u' = 120 \times \frac{5}{18} = \frac{100}{3}\text{m/s}$

Let declaration be a then $(0)^2 - u^2 = -2ad$

or $\quad u^2 = 2ad$ ...(1)

and $(0)^2 - u'^2 = -2ad'$

or $\quad u'^2 = 2ad'$ ...(2)

(2) divided by (1) gives,

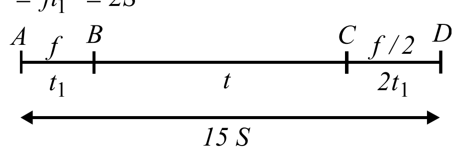
$$4 = \frac{d'}{d} \Rightarrow d' = 4 \times 20 = 80\text{m}$$

7. (d) Distance from A to $B = S = \frac{1}{2}ft_1^2$

Distance from B to $C = (ft_1)t$

Distance from C to $D = \frac{u^2}{2a} = \frac{(ft_1)^2}{2(f/2)}$

$= ft_1^2 = 2S$



$\Rightarrow \quad S + f\,t_1 t + 2S = 15S$

$\Rightarrow \quad f\,t_1 t = 12S$ .... (i)

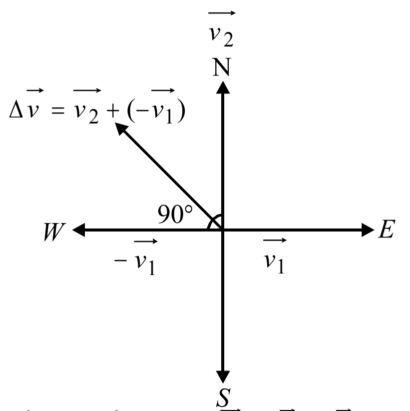
$\frac{1}{2} f\,t_1^2 = S$ .... (ii)

Dividing (i) by (ii), we get $t_1 = \frac{t}{6}$

$\Rightarrow \quad S = \frac{1}{2} f \left(\frac{t}{6}\right)^2 = \frac{f\,t^2}{72}$

8. **(c)** Average acceleration

$= \frac{\text{change in velocity}}{\text{time interval}} = \frac{\Delta \vec{v}}{t}$



$\vec{v}_1 = 5\hat{i}, \vec{v}_2 = 5\hat{j}$, $\Delta\vec{v} = (\vec{v}_2 - \vec{v}_1)$

$= \sqrt{v_1^2 + v_2^2 + 2v_1 v_2 \cos 90}$

$= \sqrt{5^2 + 5^2 + 0}$

[As $|v_1| = |v_2| = 5$ m/s]

$= 5\sqrt{2}$ m/s

Avg. acc. $= \frac{\Delta\vec{v}}{t} = \frac{5\sqrt{2}}{10} = \frac{1}{\sqrt{2}}\,\text{m/s}^2$

$\tan\theta = \frac{5}{-5} = -1$

which means θ is in the second quadrant. (towards north-west)

9. **(d)** $t = ax^2 + bx$; Diff. with respect to time (t)

$\frac{d}{dt}(t) = a\frac{d}{dt}(x^2) + b\frac{dx}{dt} = a.2x\frac{dx}{dt} + \text{b.v.}$

$1 = 2axv + bv = v(2ax + b)(v = \text{velocity})$

$2ax + b = \frac{1}{v}$.

Again differentiating,

$2a\frac{dx}{dt} + 0 = -\frac{1}{v^2}\frac{dv}{dt}$

$\Rightarrow \quad \frac{dv}{dt} = f = -2av^3 \quad \left(\because \frac{dx}{dt} = v\right)$

10. **(a)** $v = \alpha\sqrt{x}$, $\quad \frac{dx}{dt} = \alpha\sqrt{x} \Rightarrow \frac{dx}{\sqrt{x}} = \alpha\,dt$

$\int_0^x \frac{dx}{\sqrt{x}} = \alpha\int_0^t dt$; $\left[\frac{2\sqrt{x}}{1}\right]_0^x = \alpha[t]_0^t$

$\Rightarrow 2\sqrt{x} = \alpha t \quad \Rightarrow x = \frac{\alpha^2}{4}t^2$

11. **(c)** We know that, $v = \frac{dx}{dt} \Rightarrow dx = v\,dt$

Integrating, $\int_0^x dx = \int_0^t v\,dt$

or $\quad x = \int_0^t (v_0 + gt + ft^2)\,dt$

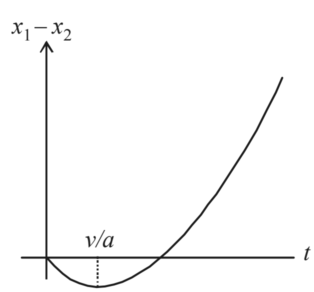
$= \left[v_0 t + \frac{gt^2}{2} + \frac{ft^3}{3}\right]_0^t$

or, $\quad x = v_0 t + \frac{gt^2}{2} + \frac{ft^3}{3}$

At $t = 1$, $\quad x = v_0 + \frac{g}{2} + \frac{f}{3}$.

12. **(b)** **For the body starting from rest**

$x_1 = 0 + \frac{1}{2}at^2 \quad \Rightarrow x_1 = \frac{1}{2}at^2$



For the body moving with constant speed

$x_2 = vt$

$\therefore \quad x_1 - x_2 = \frac{1}{2}at^2 - vt$

at $t = 0, x_1 - x_2 = 0$

For $t < \frac{v}{a}$; the slope is negative

For $t = \frac{v}{a}$; the slope is zero

For $t > \frac{v}{a}$; the slope is positive

These characteristics are represented by graph (b).

13. (b) For downward motion $v = -gt$

The velocity of the rubber ball increases in downward direction and we get a straight line between v and t with a negative slope.

Also applying $y - y_0 = ut + \frac{1}{2}at^2$

We get $y - h = -\frac{1}{2}gt^2 \Rightarrow y = h - \frac{1}{2}gt^2$

The graph between y and t is a parabola with $y = h$ at $t = 0$. As time increases y decreases.

For upward motion.

The ball suffer elastic collision with the horizontal elastic plate therefore the direction of velocity is reversed and the magnitude remains the same.

Here $v = u - gt$ where u is the velocity just after collision.

As t increases, v decreases. We get a straight line between v and t with negative slope.

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

All these characteristics are represented by graph (b).

14. (a) $\frac{dv}{dt} = -2.5\sqrt{v}$

$\Rightarrow \frac{dv}{\sqrt{v}} = -2.5\,dt$

Integrating,

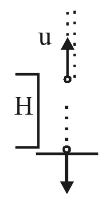
$\int_{6.25}^{0} v^{-1/2} dv = -2.5\int_0^t dt$

$\Rightarrow \left[\frac{v^{+1/2}}{(1/2)}\right]_{6.25}^{0} = -2.5[t]_0^t$

$\Rightarrow -2(6.25)^{1/2} = -2.5t$

$\Rightarrow t = 2$ sec

15. (c) Speed on reaching ground



$v = \sqrt{u^2 + 2gh}$

Now, $v = u + at$

$\Rightarrow \quad \sqrt{u^2 + 2gh} = -u + gt$

Time taken to reach highest point is

$t = \frac{u}{g}$,

$\Rightarrow \quad t = \frac{u + \sqrt{u^2 + 2gH}}{g} = \frac{nu}{g}$ (from question)

$\Rightarrow \quad 2gH = n(n-2)u^2$

16. (a) For a body thrown vertically upwards acceleration remains constant ($a = -g$) and velocity at anytime t is given by $V = u - gt$

During rise velocity decreases linearly and during fall velocity increases linearly and direction is opposite to each other.

Hence graph (a) correctly depicts velocity versus time.