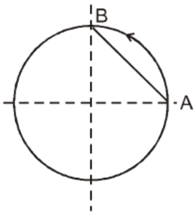
TOPIC : RECTILINEAR MOTION
EXERCISE # 1
PART – I

SECTION (A)

1. Total time = 140 sec time for one round of a circular path = 40 sec. Then after time 140 sec he will complete half of circular path so displacement (D = 2r)

2. Displacement $d_1 = \sqrt{2}\ r$

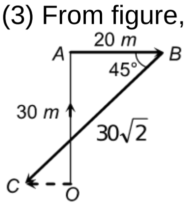
Distance from A to B $d_2 = \left(\frac{\pi r}{2}\right)$



$\frac{d_2}{d_1} = \frac{\frac{\pi r}{2}}{\sqrt{2}\ r} = \left(\frac{\pi}{2\sqrt{2}}\right)$

3. (1) $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$ $\therefore r = \sqrt{x^2 + y^2 + z^2}$ $\Rightarrow$ $r = \sqrt{6^2 + 8^2 + 10^2} = 10\sqrt{2}$ m

4. (3) From figure, $\overrightarrow{OA} = 0\,\vec{i} + 30\,\vec{j}$, $\overrightarrow{AB} = 20\,\vec{i} + 0\,\vec{j}$



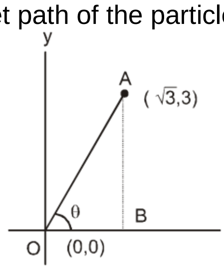
$\overrightarrow{BC} = -30\sqrt{2}\cos 45^\circ\,\vec{i} - 30\sqrt{2}\sin 45^\circ\,\vec{j} = -30\,\vec{i} - 30\,\vec{j}$

$\therefore$ Net displacement, $\overrightarrow{OC} = \overrightarrow{OA} + \overrightarrow{AB} + \overrightarrow{BC} = -10\,\vec{i} + 0\,\vec{j}$ $\Rightarrow$ $|\overrightarrow{OC}| = 10$ m.

5. Dimension of hall, length of any side = 10 m = a (say)

Magnitude of displacement = Length of diagonal = a$\sqrt{3}$ = 10 $\sqrt{3}$ m

6. Slope of the path of the particle gives the measure of angle required. Draw the situation as shown. OA represents the path of the particle starting from origin 0 (0,0), Draw a perpendicular from point A to x-axis. Let path of the particle makes an angle θ with the x-axis, then



tan θ = slope of line OA $= \frac{AB}{OB} = \frac{3}{\sqrt{3}} = \sqrt{3}$ or θ = 60°

SECTION (B)

1. $< v > = \left(\frac{x}{\frac{x}{30} + \frac{x}{60} + \frac{x}{180}}\right) = \left(\frac{1}{\frac{1}{30} + \frac{1}{60} + \frac{1}{180}}\right) = \frac{180}{6+3+1}$ $< v >$ = 18 km / h

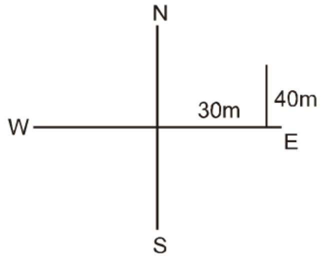
2. $\langle V \rangle = \dfrac{\text{Total distance}}{\text{Total time}}$ ⇒ $V_1 = 48 = \dfrac{2\ \text{km}}{\dfrac{1}{40} + \dfrac{1}{V}}$ ⇒ $48 = \dfrac{2 \times 40V}{V + 40}$

⇒ $V + 40 = \dfrac{80}{48}V$ ⇒ $24V + 960 = 40V$ ⇒ $16V = 960$

$V = 60$ km/hr

3. Distance covered towards east = 2 × 15 = 30 m

Distance covered towards north = 8 × 5 = 40 m



Total displacement = $\sqrt{40^2 + 30^2}$ = 50 m

Average velocity = $\dfrac{\text{Total displacement}}{\text{total time}} = \dfrac{50}{2+8}$ = 5 m/s

5. $\dfrac{|\text{Average velocity}|}{|\text{Average speed}|} = \dfrac{|\text{displacement}|}{|\text{distance}|} \le 1$ because displacement will either be equal or less than distance. It can never be greater than distance.

6. Average speed = $\dfrac{\text{Total distance}}{\text{Total time taken}} = \dfrac{2\pi r}{62.8} = \dfrac{2 \times 3.14 \times 100}{62.8}$ =10m/s

Average velocity = $\dfrac{\text{Total displacement}}{\text{Total time taken}} = \dfrac{0}{62.8}$ = zero

Hence option (2) is correct

7. Average velocity = $\dfrac{\text{Displacement}}{\text{Time taken}}$ & Average speed = $\dfrac{\text{Distance}}{\text{Time taken}}$

Distance can be equal to or greater than displacement magnitude.

When speed is zero throughout an interval, particle does not move at all.

So, average speed is also zero in that interval.

Hence, (3) is incorrect.

When speed is not zero in an interval, particle covers some distance, but displacement can be zero.

So, average velocity can be zero in that interval but average speed will never be zero.

Hence, (4) is incorrect.

8. Average speed of a body in a given time interval is defined as the ratio of distance travelled to the time taken.

Average speed = $\dfrac{\text{Distance travelled}}{\text{Time taken}}$

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, $t_1 + t_2 = \dfrac{XY}{\nu_u} + \dfrac{XY}{\nu_d} = XY\left(\dfrac{\nu_u + \nu d}{\nu_u \nu d}\right)$

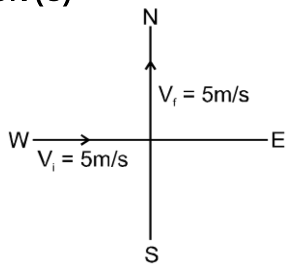
Total distance travelled

= XY + XY = 2XY

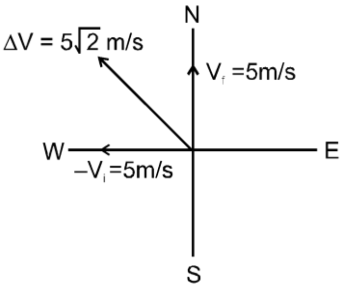
Therefore, average speed of the car for this round trip is

$v_{av} = \dfrac{2XY}{XY\left(\dfrac{\nu_u + \nu_d}{n_u \nu_d}\right)}$ or $v_{av} = \dfrac{2\nu_u \nu_d}{\nu_u + \nu_d}$

SECTION (C)



1. $\vec{a} = \dfrac{\vec{V_f} - \vec{V_i}}{\Delta_t}$ $\Rightarrow$ $\vec{a} = \dfrac{5\hat{j} - 5\hat{i}}{10}$ $\Rightarrow$ $|\vec{a}| = \dfrac{5\sqrt{2}}{10} = \dfrac{1}{\sqrt{2}}$ m/s^2



Direction northwest

2. $x = a_0 + a_1 t + a_2 t^2$

$\dfrac{dx}{dt} = 0 + a_1 + 2a_2 t$ $\Rightarrow$ $a = \dfrac{d^2x}{dt^2} = 0 + 2a_2$

3. $V = 20 + 0.1 t^2$

$a = \dfrac{dv}{dt} = 0 + 0.2 t$

acceleration of particle is changing with time, acceleration is nonuniform

4. Displacement $x = 2t2 + t + 5$

Velocity $V = \dfrac{dx}{dt} = 4t + 1$ Acceleration $a = \dfrac{dv}{dt} = 4$

5. $S = t^3 - 6t^2 + 3t + 4$

$V = \dfrac{ds}{dt} = 3t^2 - 12t + 3$ $\Rightarrow$ $a = \dfrac{dv}{dt} = 6t - 12 = 0 \therefore t = 2$ sec

$v = 3(2)^2 - 12 \times 2 + 3 = 2 - 24 + 3 = -9$m/s

6. $V = 10 + 2t^2$ $V_2 = 10 + 2(2)^2 = 10 + 8 = 18$

$a = 4t$ $V_5 = 10 + 2(5)^2 = 60$

$\langle \vec{a} \rangle = \dfrac{V_2 - V_1}{t_2 - t_1} = \dfrac{60 - 18}{3} = \dfrac{42}{3} = 14$

7. $\sqrt{x} = t + 7$

$x = (t + 7)^2 = t^2 + 49 + 14t$

$V = \dfrac{dx}{dt} = 2t + 14$

$a = 2$

8. $x \propto S \propto t^2$

$V = \frac{dx}{dt} = 2\,Kt$

$a = \frac{dv}{dt} = 2\,k$ (constant)

10. $s = a + bt + ct^2 \Rightarrow v = \frac{ds}{dt} = b + 2\,ct$

Initial velocity = $\left|\frac{ds}{dt}\right|_{t=0} = b$ and $a = \frac{dv}{dt} = 2c \Rightarrow$ Initial acceleration = $\left|\frac{dv}{dt}\right|_{t=0} = 2c$

11. $a = t$

$\therefore v = \frac{t^2}{2} \Rightarrow S_1 = \frac{t^3}{6}$

$S_2 = 6t \Rightarrow S_1 = S_2$

$\frac{t^3}{6} = 6t \Rightarrow t = 6$ sec

$S = 6 \times 6 = 36$ m

12. $h_1 = \frac{1}{2} g\,(3)^2$

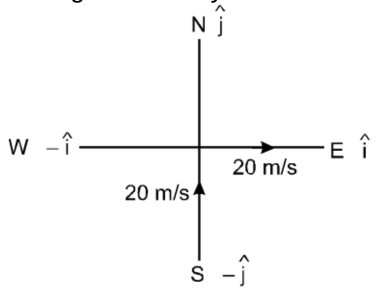
$h_2 = \frac{1}{2} g\,(3 - 1)^2$

$h_1 - h_2 = \frac{1}{2} g\,(9 - 4) = 25$ m

13. $\vec{V}_1 = 20\,\hat{j}$

$\vec{V}_2 = 20\,\hat{i}$

Change in velocity



$\Delta\vec{V} = \vec{V}_2 - \vec{V}_1 \Rightarrow \vec{V} = +20\,\hat{i} - 20\hat{j} \Rightarrow |\vec{V}| = 20\sqrt{2}$

Direction south - east

14. As given

$v = 4t$

$\Rightarrow \frac{dx}{dt} = 4t \quad \therefore \int_0^x dx = \int_2^4 4t\,dt$

$\Rightarrow X = 4\left[\frac{t^2}{2}\right]_2^4 \Rightarrow x = 2\,[(4)^2 - (2)^2] \Rightarrow x = 2\,(16 - 4)$

So, $x = 24$ m

15. Velocity is rate of change of distance or displacement
Distance travelled by the particle is

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

we know that, velocity is rate of change of displacement, e.,m $v = \frac{dx}{dt}$.

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

but final velocity $v = 0$

$\therefore \quad 12 - 3t^2 = 0 \quad \text{or} \quad t^2 = \frac{12}{3} = 4 \quad \text{or} \quad t = 2\ s$

Hence, position of the particle at t = 2 sec.

$x = 40 + 12\,(2) - (2)^3 = 40 + 24 - 8 = 64 - 8 = 56$ m position of particle at t = 0 sec.

$x = 40$ m distance travelled by particle in 2 sec. = 56 – 40 = 16m

16. At the instant when speed is maximum, its acceleration is zero.
Given, the position x of a particle with respect to time t along x-axis

$x = 9t^2 - t^3$ …(i)

Differentiating Eq. (i), with respect to time, we get speed, i.e.,

$v = \frac{dx}{dt} = \frac{d}{dt}(9t^2 - t^3)$ …(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 $v = 18 - 6t$ …(iii)

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

$a = 0$

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

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

$x = 9\,(3)^2 - (3) = 9\,(9) - 27$

17. $x \propto t^3$

$x = kt^3$

$V = \frac{dx}{dt} = 3\,kt^2$

$a = \frac{dv}{dt} = 6kt \Rightarrow a \propto t$

18. $\vec{V} \,||\, \vec{a} \Rightarrow$ straight line

19. Given $t = ax^2 + bx$
Differentiating w.r.t. 't'

$\frac{dt}{dt} = 2ax\frac{dt}{dt} + \frac{dx}{dt}$

$\upsilon = \frac{dx}{dt} = \frac{1}{(2ax+b)}$

Again differentiating. w.r.t. 't'

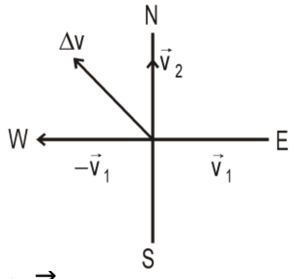
$\frac{d^2x}{dt^2} = \frac{d(2ax+b)^{-1}}{d(2ax+b)}.2a\frac{dx}{dt} \qquad \therefore \quad f = \frac{d^2x}{dt^2} = \frac{-1}{(2ax+b)^2}.\frac{2a}{(2ax+b)}$

or $f = \frac{-2a}{(2ax+b)^3} \qquad \therefore \quad f = -2a\upsilon^3$

20. $\vec{v}_1 = -5\hat{i}$

$\vec{v}_2 = 5\hat{j}$

$\Delta\vec{v}_2 = 5\hat{j} - 5\hat{i}$



$|\Delta\vec{v}| = 5\sqrt{2}$

a = $\frac{|\vec{v}|}{t} = \frac{5\sqrt{2}}{10} = \frac{1}{\sqrt{2}}$ ms^{-2}

For direction,

tan θ = – $\frac{5}{5}$ = – 1 ∴ Average acceleration is $\frac{1}{\sqrt{2}}$ ms^{-2} towards north-west.

SECTION (D)

1. For constant acceleration acceleration does not depend on any quantity

2. $V^2 = u^2 + 2ax$

$0 = u^2 - 2 \times 32 \times 64$

$u^2 = (64)^2$

(u = 64 ft /sec)

3. $t_1 = \sqrt{\frac{2a}{g}}$ $t_2 = \sqrt{\frac{2b}{g}}$ $t_1 : t_2 = \sqrt{a} : \sqrt{b}$

4. $S = ut + \frac{1}{2}at^2$

$0 = u(4) - \frac{1}{2} \times 10\,(4)^2$

$u(4) = 5(4)^2$

u = 20 m/sec

5. At maximum height velocity is zero and acceleration is g

6. f = at ⇒ $\frac{dv}{dt}$ = at

$\int_u^v dv = \int_0^t at\ dt$ ⇒ $V = u + \frac{at^2}{2}$

$[\,V = u + \frac{at^2}{2}\,]$

7. $S = u + \frac{1}{2}a(2n - 1)$

$S = 0 + \frac{1}{2} \times 8\,(2 \times 5 - 1)$

S = 4 (9) = 36 m

8. Distance travelled by the body during 3rd second

$S_1 = U + \frac{a}{2}(2n - 1) = \frac{a}{2}(6 - 1) = \frac{a}{2}(5)$

Distance travelled by the body during 4th second $S_2 = U + \frac{a}{2}(2n - 1) = \frac{a}{2}(8 - 1) = \frac{a}{2}(7)$

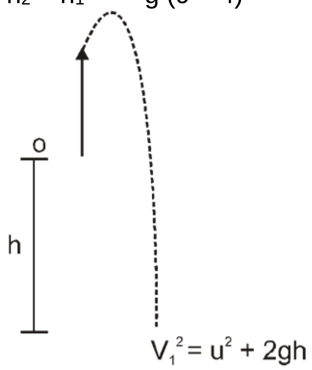
$\frac{S_1}{S_2} = \frac{5}{7}$

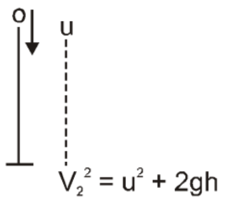
9. $S_n = U + \frac{a}{2}(2n - 1) = 10 - \frac{2}{2}(2 \times 5 - 1) = 10 - 9 = 1$ m

10. $h_1 = \frac{1}{2} g (3)^2$ distance travelled by 1st object

$h_2 = \frac{1}{2} g (2)^2$ distance travelled by 2nd object

$h_2 - h_1 = \frac{1}{2} g (9 - 4) = \frac{5}{2} \times 9.8 = 24.5$

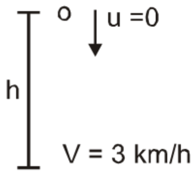




11.

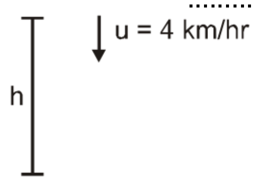
$V_1 = V_2$ So, $\frac{V_1}{V_2} = 1 : 1$

12. $x = \frac{1}{2} gt^2 = \frac{1}{2} \times 9.8 \times (4)^2 = 4 \times 9.8 \times 2 = 9.8 \times 8 = 78.4$ m



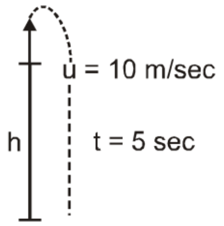
13. **Case-I**

V2 = u2 + 2gh (3)2 = (0)2 + 2gh
2gh = 9 ....(1)



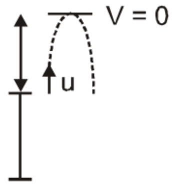
Case - II

V2 = 42 + 2gh = (4)2 + 9 V2 = 25 V = 5 km/hr

14. 

$h = S = 4t - \frac{1}{2}$ gt2 $\Rightarrow$ $-h = 10 \times 5 - \frac{1}{2} \times 10$ (5)2

$-h = 50 - 125$ $\Rightarrow$ $h = 75$ m

15. 

V2 = u2 – 2 gh $\Rightarrow$ 0 = (10)2 – 2 × 10 × 4 $\Rightarrow$ $H = \frac{100}{20} = 5$ m

16. Total distance = 2H + h = 10 + 75 = 85 m

17. Maximum height V = 0 $\Rightarrow$ u – gt = 0 $\Rightarrow$ 10 – 10

t = 0 $\Rightarrow$ t = 1 sec

18. V2 = u2 + 2 gh = (10)2 + 2 × 10 × 75 = 100 + 1500

V = 40 m/s

19. $Sn = U + \frac{a}{2}(2n - 1)$

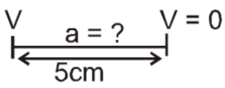
$1.2 = 0 + \frac{a}{2}(2 \times 8 - 1)$

$1.2 = \frac{a}{2}(15) \Rightarrow a = \frac{2.4}{15} \Rightarrow 0.16\ m/s^2$

20. $S = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2} \times 20\,(8)^2 = 10 \times 64$ $\Rightarrow$ S = 640 cm

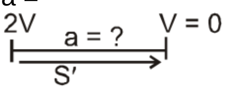
21. Distance coverd by the body in the 5th second

$S_n = u + \frac{a}{2}(2n - 1) = 7 + \frac{4}{2}(2 \times 5 - 1) = 7 + 2\,(10 - 1) = 7 + 18 = 25$ M

22. **Case- I** 

$V^2 = u^2 - 2as$

$a = \frac{v^2}{2 \times 50}$

Case- I 

$0 = (2v)^2 - 2aS'$

$S' = \frac{4v^2}{2a} = \frac{4v^2 \times 2 \times 50}{2v^2}$ $\Rightarrow S' = 200$ m

23. In 20 seconds, total distance travelled

$s = \frac{1}{2} a (20)^2 = \frac{1}{2} a \times 400$
$= 200\ a$

In first 10 seconds, the distance s_1 travelled

$s_1 = \frac{1}{2} a \times (10)^2$
$= 50a$

So, in other 10 seconds, the distance s_2 travelled

$s_2 = s - s_1$

or $s_2 = 200a - 50a$ or $= 150a$ or $= 3 \times (50a)$

Hence $s_2 = 3s_1$

24. From relation

$h = ut + \frac{1}{2} gt^2$ (with u = 0)

we have $h = \frac{1}{2} gt^2$

$\Rightarrow$ $t = \sqrt{\left(\frac{2h}{g}\right)} \propto \sqrt{h}$ $\therefore$ $\frac{t_1}{t_2} = \sqrt{\frac{h_1}{h_2}}\sqrt{\left(\frac{h}{2h}\right)} = \frac{1}{\sqrt{2}}$

25. Here : Initial velocity = 200 m/s
Final velocity (υ) = 100 m/s
distance s = 10 cm = 0.1 m
Using the relation of equation of motion

$\upsilon^2 = u^2 + 2as$

$a = \frac{\upsilon^2 - u^2}{2s} = \frac{(100)^2 - (200)^2}{2 \times 0.1} = \frac{10000 - 40000}{2 \times 0.1} = \frac{-300000}{2} = -150000\ m/s^2$

$= -15 \times 10^4\ m/s^2$ (–) minus sign denotes retardation

26. Using the relation

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

As the body is falling from rest, u = 0

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

Suppose the distance travelled in

t = 2 s, t = 4s, t = 6s

are s_2, s_4 and s_6 respectively.

Now, $s_2 = \frac{1}{2} g (2)^2 = 2g$

$s_4 = \frac{1}{2} g (4)^2 = 8\ g$

$s_6 = \frac{1}{2} g (6)^2 = 18\ g$

Hence, the distance travelled in first two seconds

$(s_i)_2 = s_2 - s_0 = 2\ g$
$(s_m)_2 = s_4 - s_2$
$= 8\ g - 2\ g$
$= 6\ g$
$(s_f)_2 = s_6 - s_4$
$= 18\ g - 8\ g$
$= 10\ g$

Now, the ratio becomes

$= 2\ g : 6\ g : 10\ g$
$= 1 : 3 : 5$

27. $v^2 = u^2 + 2a\,s$

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

$a = -16\ m/s^2$ (a = retardation)

Again $v^2 = u^2 + 2as$

$0 = \left(100 \times \frac{5}{18}\right)^2 \times 16 \times 2 \times s \Rightarrow s = \frac{(100 \times 5)^2}{18 \times 10 \times 32} = 24m$

28. For first car,

$u_1 = u,\ v_1 = 0,\ t_1 = t$

$\therefore\ v_1 = u_1 + a_1t$

$0 = u - a_1t$

$\therefore\ u = a_1t$ ....(i)

Now, $v_1^2 = u_1^2 + 2a_1s_1$

$0 = u^2 - 2\,a_1s_1$

$u^2 = 2a_1s_1$

$\Rightarrow\ u^2 = 2 \times \frac{u}{t} \times s_1$

$\therefore\ s_1 = \frac{ut}{2}$ ....(ii)

For second car,

$u_1 = 4u,\quad v_2 = 0$

$\therefore\ v_2 = u_2 + at$

$0 = 4u - a_2t$

$a_2 = \frac{4u}{t}$ ....(iii)

Now, $v_2^2 = u_2^2 + 2a_2s_2$

$0 = u_2^2 - 2a_2s_2$

$(4u)^2 = 2 \times \frac{4u}{t} \times s_2$

$\therefore\ s_2 = \frac{4ut}{2}$ ....(iv)

$\therefore\ \frac{s_1}{s_2} = \frac{ut/2}{4ut/2} = \frac{1}{4}$

29. Time of flight – $T = \frac{2u}{g}$

maximum height $H = \frac{u^2}{2g} = 20m$

$u = 20\ m/s\quad T = 4\ sec$

Time gap between each ball = 1 sec

$h_1 = ut_1 - \frac{1}{2}gt_1^2 = 20 \times 1 - \frac{1}{2} \times 10\,(1)^2 = 20 - 5 = 15m$

$h_2 = ut_2 - \frac{1}{2}gt_2^2$

$= 20 \times 2 - \frac{1}{2} \times 10(2)^2 = 40 - 20 = 20m$

$h_3 = ut_3 - \frac{1}{2}gt_3^2$

$= 20 \times 3 - \frac{1}{2} \times 10(3)^2 = 60 - 45 = 15\ m$

30. Let a be the retardation produced by resistive force, t_a and t_d be the time of ascent and time of descent respectively.
If the particle rises upto a height h

then $h = \frac{1}{2}(g + a)t_a^2$ and $h = \frac{1}{2}(g - a)t_d^2$ $\therefore \frac{t_a}{t_d} = \sqrt{\frac{g-a}{g+a}} = \sqrt{\frac{10-2}{10+2}} = \sqrt{\frac{2}{3}}$ **Ans.** $\sqrt{\frac{2}{3}}$

31. Distance travelled in t^{th} second is,

$s_t = u + at - \frac{1}{2}a$

Given : u = 0 $\therefore$ $\frac{s_n}{s_{n+1}} = \frac{an - \frac{1}{2}a}{a(n+1) - \frac{1}{2}a} = \frac{2n-1}{2n+1}$ Hence, the correct option is (B).

32. $v^2 = u^2 + 2as \Rightarrow (9000)^2 - (1000)^2 = 2 \times a \times 4$

$\Rightarrow a = 10^7 m/s^2$ Now $t = \frac{v-u}{a}$ $\Rightarrow t = \frac{9000-1000}{10^7} = 8 \times 10^{-4}$ *sec*

33. Let student will catch the bus after t sec. So it will cover distance ut.

Similarly distance travelled by the bus will be $\frac{1}{2}at^2$ for the given condition

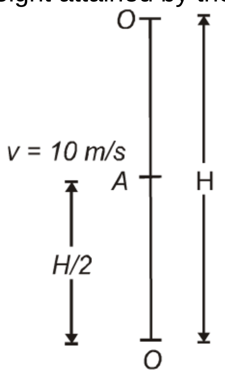
$ut = 50 + \frac{1}{2}at^2 = 50 + \frac{t^2}{2}$ $[a = 1 m/s^2]$ $\Rightarrow$ $u = \frac{50}{t} + \frac{t}{2}$

To find the minimum value of u

$\frac{du}{dt} = 0$, so we get $t = 10 sec$, then $u = 10 m/s$

34. Time taken by all to reach maximum hight
v = u – gT
at maximum height, final speed is zero i. e., v = 0. So, u = gT or T = u/g
In 2 s, u = 2 × 9.8 = 19.6 m/s
If man throw's the ball with veocity of 19.6 m/s then after 2 sec it will reach trhe maximum height. When he throws 2nd ball, 1 st is at top. When he throws third ball, 1 st will come to ground and 2nd will 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 then 19.6 m/s.

35. The problem can be solved using third equation of motion at A and O'.
Let maximum height attained by the ball be H. Third equation of motion gives



$v^2 = u^2 - 2gh$

At A, $(10)^2 = u^2 - 2 \times 10 \times \frac{H}{2}$

$\Rightarrow$ $u^2 = 100 + 10H$ … (i)

At O', $(0)^2 = u^2 - 2 \times 10 \times H$

$\Rightarrow$ $u^2 = 20H$ Thus, from Eqs. (i) and (ii), we get

$20H = 100 + 10H$ $\Rightarrow$ $10H = 100 \therefore H = 10$ m

36. As bodies are dropped from a certain height, their initial velocities are zereo i. e., u = 0.
For free fall from a height u = 0 (initial velocity). From second equation of motion

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

or $h = 0 + \frac{1}{2}gt^2$ $\therefore$ $\frac{h_1}{h_2} = \left(\frac{t_1}{t_2}\right)^2$

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

NOTE : Time taken by the object in falling does not depend on mass of object.

37. Distance travelled by the particle in n^{th} second is

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

where u is initial speed and a is acceleration of the particle.

Here $m = 3,\ u = 0,\ a = \frac{4}{3}$ m/s^2

$\therefore$ $S_{3rd} = 0 + \frac{1}{2} \times \frac{4}{3} \times (2 \times 3 - 1) = \frac{4}{6} \times 5 = \frac{10}{3}$ m

Alternative : Distance travelled in the 3rd second
= distane travelled in 3 n s
As, u = 0,

$S_{(3rd\ s)} = \frac{1}{2}a.3^2 - \frac{1}{2}a.2^2 = \frac{1}{2}.a.5$ Given $a = \frac{4}{3}$ ms^{-2} $\therefore$ $S_{(3rd)} = \frac{1}{2}$ j $\frac{4}{3} \times 5 = \frac{10}{3}$ m

38. V = u – gt
V = 40 – 10 × 2
V = 20m/s

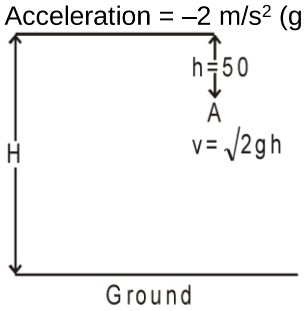
39. $S_4 = 0 + \frac{a_1}{2}(2 \times 5 - 1) = \frac{9a_1}{2}$

$S_8 = 0 + \frac{a_2}{2}(2 \times 3 - 1) = \frac{5a_2}{2}$ $\Rightarrow$ $\frac{9a_1}{2} = \frac{5a_2}{2}$ $\therefore$ $\frac{a_1}{a_2} = \frac{5}{9}$

40. Parachute bailing out at A.
Velocity at A,

$\upsilon = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 50} = \sqrt{980}$ m/s

The velocity at ground $\upsilon_1 = 3$ m/s (given)
Acceleration = –2 m/s^2 (given)



$\therefore$ $H - h = \frac{\upsilon^2 - \upsilon_1^2}{2 \times 2} = \frac{980 - 9}{4} = \frac{971}{4} = 242.75$ $\therefore$ H = 242.75 + h = 242.75 + 50 = 293 m

41. $v^2 = u^2 + 2as$
$0 = (50 \times 5/18)^2 + 2a \times 6$
$a = -16$m/s^2 (a = retardation) $\therefore$ Again $v^2 = u^2 + 2as$

$0 = (100 \times 5/18^2) - 16 \times 2 \times s$ $\Rightarrow$ $S = (100 \times 5)^2$ $\Rightarrow$ $S = \frac{(100 \times 5)^2}{18 \times 18 \times 32} = 24.1 = 24$m

42. Second law of motion gives

$s = ut + \frac{1}{2}gt^2$ **or** $h = 0 + \frac{1}{2}gt^2$ $(\because u = 0)$ $\therefore$ $T = \sqrt{\left(\frac{2h}{g}\right)}$

At $t = \frac{T}{3}$ sec,

$s = 0 + \frac{1}{2}g\left(\frac{T}{3}\right)^2$ $\Rightarrow$ $s = \frac{1}{2}g.\frac{T^2}{9}$ $\Rightarrow$ $s = \frac{g}{18} \times \frac{2h}{g}\left(\because T = \sqrt{\frac{2h}{g}}\right)$ $\therefore$ $s = \frac{h}{9}$ m

Hence, the position of ball from the ground = $h - \frac{h}{9} = \frac{8h}{9}$ m

43. The braking retardation will remain same and assumed to be constant, let it be a From 3rd equation of motion,

$v^2 = u^2 + 2as$

Ist case $0 = \left(60 \times \frac{5}{18}\right)^2 - 2a \times s_1$ $\Rightarrow$ $s_1 = \frac{(60 \times 5/18)^2}{2a}$

2nd case $0 = \left(120 \times \frac{5}{18}\right)^2 - 2a \times s_2$ $\Rightarrow$ $s_2 = \frac{(120 \times 5/18)^2}{2a}$

$\therefore$ $\frac{s_1}{s_2} = \frac{1}{4}$ $\Rightarrow$ $s_2 = 4s_1 = 4 \times 20 = 80$ m.

44. $u = 48$ m/sec $a = -10$ m/s^2 so, by $v = u + at$ $0 = 48 - 10t$ so, $t = 4.8$ s
this means that the particle comes to rest at t = 4.8 s and turns back covering some distance backwards for rest of the motion.
for the forward journey distance travelled in last 0.8 second before stopping and returning will be $(s_{4.8} - s_4)$ where, $s_{4.8}$ and s_4 are distances travelled in 4.8 seconds and 4 seconds respectively.

$s_{4.8} = 48 \times 4.8 + \frac{1}{2} \times -10 \times 4.8^2 = 48 \times 2.4$

$s_4 = 48 \times 4 + \frac{1}{2} \times -10 \times 4^2 = 16 \times 7$

$(s_{4.8} - s_4) = (48 \times 2.4) - (16 \times 7)$

Distance travelled 0.2 s during backward journey = $s_{0.2} = \frac{1}{2} \times 10 \times 0.2^2 = 0.2$ m

So, total distance travelled = $(48 \times 2.4) - (16 \times 7) + 0.2 = \frac{17}{5}$ m. **Ans.**

SECTION (E)

1. $V_A = \tan 30^o$
$V_B = \tan 60^o$

$\frac{V_A}{V_B} = \frac{\tan 30^o}{\tan 60^o} = \frac{1}{\sqrt{3} \,.\, \sqrt{3}} = 1:3$

2. distance travelled by the body in 4 sec. = area under v – t graph

$= \frac{1}{2} \times 1 \times 20 + 1 \times 20 + 2 \times 10 + \frac{1}{2} \times 1 \times 10 = 10 + 20 + 20 + 5 = 55$ m

3. $\vec{a}_{oA} = \frac{d\vec{V}}{dt} = \frac{10}{10} = 1$

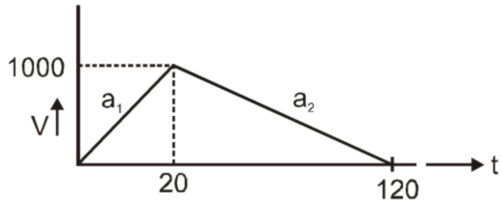
$\vec{a}_{AB} = 0$

$\vec{a}_{BC} = \frac{-10}{20} = \frac{-1}{2} = -0.5$

4. Displacement = Net area under the velocity time graph = $\frac{1}{2}$ × 4 (2 + 4) – $\frac{1}{2}$ × 2 (2 + 4) = 6m

5. Velocity can't change its value suddenly

6.



$a_1 = \frac{1000}{20} = 50$ m/sec2

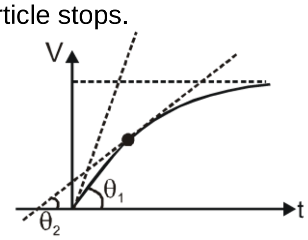
$a_2 = -\frac{1000}{100} = -10$ m/sec2

Maximum height

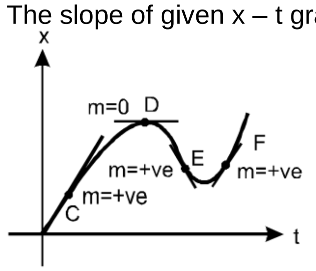
$H = S_1 + S_2$

$$= \left[ut + \frac{1}{2}a_1 t^2\right] + \left[Vt + \frac{1}{2}a_2 t^2\right] = \left[0 + \frac{1}{2} \times 50 \times (20)^2\right] + \left[1000 \times 100 - \frac{1}{2} \times 10(100)^2\right] = 60 \text{ km}$$

7. As the slope of tangent decreases, velocity also decreases with time. After time distance becomes constant i.e particle stops.



10. The slope of position–time (x–t) graph at any point shows the instantaneous velocity at that point. The slope of given x – t graph at different point can be shown as



Obviously the slope is negative at the point E as the angle made by tangent with +ve X–axis is obtuse, hence the instantaneous velocity of the particle is negative at the point E i.e.,

Aliter : As Instantaneous velocity is negative where slope of x–t curve is negative .

At. point C = slope is positive

At. point D = slope is zero

At. point E = slope is negative

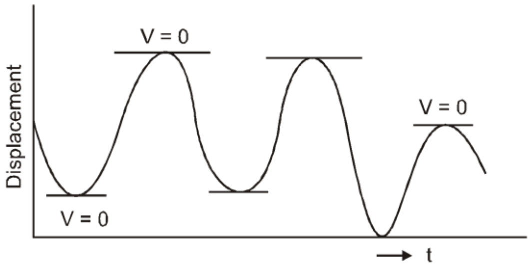
At. point F = slope is positive

Hence , option (3) is correct

11. (1) The slope of displacement-time graph goes on decreasing, it means the velocity is decreasing i.e. It's motion is retarded and finally slope becomes zero i.e. particle stops.

12. (3) From acceleration time graph, acceleration is constant for first part of motion so, for this part velocity of body increases uniformly with time and as a = 0 then the velocity becomes constant. Then again increased because of constant acceleration.

13.



From this x – t graph, slope of particle is zero for six times it means velocity is zero for six times

14. Area under acceleration-time graph gives the change in velocity.

Hence, $v_{max} = \frac{1}{2} \times 10 \times 11 = 55$ m/s

Therefore, the correct option is (C)

15. $v^2 = u^2 + 2\,as$

$v^2 = 2\,as$

$y^2 = kx$

17. (1) time can't be const.

(3) time can't decrease

(4) time can't decrease

18. $v_0^2 = 2\,gh$

$v^2 = 2g\,(3h)$

$v = \sqrt{3}v_0$

19. $v = u - gt$

$v = -gt + u$

20. When particle is thrown vertically upwards, its acceleration is constant downwards.

so, velocity initially decreases linearly to become zero at highest point and then again speed increases linearly. So, graph is (C).

21. $|\text{Average velocity}| = \frac{|\text{displacement}|}{\text{time}} = \frac{AB}{\text{time}} = \frac{2}{1} = 2$ m/s

EXERCISE # 2

1. $V = u + at$

$60 = O + a \times t \Rightarrow at = 60$

$S_1 = \frac{1}{2}at^2 = \frac{1}{2} \times 60 \times t = 30t$

$S_2 = V \times 8t = 8\,at^2 = 8 \times 60 \times t = 480t$

$S_3 = Vt - \frac{1}{2}at^2 = at^2 - \frac{1}{2}at^2 = \frac{1}{2}at^2 = 30t$

$V_{avg} = \frac{S_1 + S_2 + S_3}{t_1 + t_2 + t_3} = \frac{540 \times t}{10t} = 54$ km/hr

2. Time of flight $= \frac{2 \times u}{g} = 6$ sec

$S_n = u - \frac{1}{2}g\,(2n - 1) = 30 - \frac{1}{2} \times 10\,(2 \times 6 - 1) = 30 - 55 = -25$m

(25m downwards)

3. $h_1 = \frac{1}{2}g\,(3)^2 \quad \Rightarrow \quad h_2 = \frac{1}{2}g\,(3 - 2)^2$

$h_1 - h_2 = \frac{1}{2}g\,(9 - 1) = 4 \times 9.8 = 39.2$ m

4. o $\uparrow u = 98$ m/s   o $\uparrow$ (t + 4) t

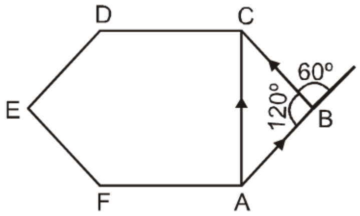
$S_1 = S_2$

$\Rightarrow \quad ut - \frac{1}{2}gt^2 = u(t+4) - \frac{1}{2}g(t+4)^2 \quad \Rightarrow \quad ut - \frac{1}{2}gt^2 = ut + 4u - \frac{1}{2}g[t^2 + 16 + 8t]$

$\Rightarrow \quad 4u - \frac{9.8}{2}[16 + 8t] = 0 \quad \Rightarrow \quad t = 8$

Time of meeting = t + 4 = 12 sec

5.



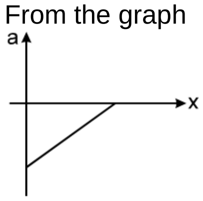
$<\vec{V}> = \frac{\vec{V_1} + \vec{V_2}}{2} = \frac{1}{2}\sqrt{V_1^2 + V_2^2 + 2V_1V_2\cos 60} \quad \Rightarrow \quad <\vec{V}> = \frac{1}{2}\sqrt{3}V$

6. $V_1 = \sqrt{2gh} = \sqrt{2 \times 10 \times 20} = 20$ m/sec

$V_2 = \frac{3}{4} \times 20 = 15$ m/sec

$t_2 = \frac{V_2}{g} = \frac{15}{10} = 1.5$ sec   total time = 2 × 1.5 = 3 sec

7. From the graph



$V = v_0 - mx \quad \therefore$ acceleration $a = \frac{dv}{dt} = -m\frac{dx}{dt} = -mv = -m(v_0 - mx) = -mv_0 + m^2x$

i1e slope $\Rightarrow$ positive   y axis intercept y $\Rightarrow$ negative

8. (1) $S = \int_0^3 v\,dt = \int_0^3 kt\,dt = \left[\frac{1}{2}kt^2\right]_0^3 = \frac{1}{2} \times 2 \times 9 = 9m$

9. (1) From $S = ut + \frac{1}{2}at^2$

$S_1 = \frac{1}{2}a(P-1)^2$ and $S_2 = \frac{1}{2}aP^2$ [As $u = 0$]

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

$S_{(P^2-P+1)^{th}} = \frac{a}{2}\left[2(P^2 - P + 1) - 1\right] = \frac{a}{2}\left[2P^2 - 2P + 1\right]$

It is clear that $S_{(P^2-P+1)^{th}} = S_1 + S_2$

10. (3) Initial relative velocity $= v_1 - v_2$, Final relative velocity = 0

From $v^2 = u^2 - 2as \Rightarrow 0 = (v_1 - v_2)^2 - 2 \times a \times s \Rightarrow s = \frac{(v_1 - v_2)^2}{2a}$

If the distance between two cars is 's' then collision will take place. To avoid collision $d > s \quad \therefore$

$d > \frac{(v_1 - v_2)^2}{2a}$ Where d = actual initial distance between two cars.

11. (1) If a body starts from rest with acceleration α and then retards with retardation β and comes to rest. The total time taken for this journey is t and distance covered is S then

$S = \frac{1}{2}\frac{\alpha\beta t^2}{(\alpha+\beta)} = \frac{1}{2}\frac{5\times10}{(5+10)}\times t^2$ ⇒ $1500 = \frac{1}{2}\frac{5\times10}{(5+10)}\times t^2$ ⇒ $t = 30\,\text{sec}$.

12. (3) Acceleration of body along AB is $g\cos\theta$

Distance travelled in time t sec = $AB = \frac{1}{2}(g\cos\theta)t^2$

From $\Delta ABC,\ AB = 2R\cos\theta;\ 2R\cos\theta = \frac{1}{2}g\cos\theta t^2$ ⇒ $t^2 = \frac{4R}{g}$ or $t = 2\sqrt{\frac{R}{g}}$

13. (3) $\frac{dv}{dt} = bt \Rightarrow dv = bt\,dt \Rightarrow v = \frac{bt^2}{2} + K_1$

At $t = 0, v = v_0 \Rightarrow K_1 = v_0$ We get $v = \frac{1}{2}bt^2 + v_0$

Again $\frac{dx}{dt} = \frac{1}{2}bt^2 + v_0 \Rightarrow x = \frac{1}{2}\frac{bt^2}{3} + v_0t + K_2$

At $t = 0, x = 0 \Rightarrow K_2 = 0$ ∴ $x = \frac{1}{6}bt^3 + v_0t$

14. V = $\alpha\sqrt{x}$ ⇒ $\frac{dx}{dt} = \alpha\cdot\sqrt{x}$ or $\frac{dx}{\sqrt{x}} = \alpha.\,dt$

Perform integration

$\int_0^x \frac{dx}{\sqrt{x}} = \int_0^t \alpha\cdot dt$ [∵ at t = 0, x = 0 and let at any time t, particle is at x]

⇒ $\left.\frac{x^{1/2}}{1/2}\right|_0^x = \alpha t$ or $x^{1/2} = \frac{\alpha}{2}t$ or $x = \frac{\alpha^2}{4}\times t^2$ or $x \propto t^2$

15. $v = v_0 + gt + ft^2$

or $\frac{dx}{dt} = v_0 + gt + ft^2$ ⇒ $dx = (v_0 + gt + ft^2)\,dt$

So, $\int_0^x dx = \int_0^1 (v_0 + gt + ft^2)dt$ ⇒ $x = v_0 + \frac{g}{2} + \frac{f}{3}$

16. $t = 2x^2 + 3x$

$\frac{dt}{dt} = 1 = 4x + 3\left(\frac{dx}{dt}\right)$ So, $\frac{1}{v} = 4x + 3$

$v = \frac{1}{(4x + 3)}$ so $a = v\frac{dv}{dx} = -\frac{4}{(4x+3)^3}$

$\frac{dv}{dx} = -\frac{1}{(4x + 3)^2}.4$ $= -4V^3$

17. Acceleration

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

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

Integrating Eq. (i) on both sides,

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

∴ $v = f_0\,t - \frac{f_0}{T}.\frac{t^2}{2} + C$ … (ii)

where C is constant of integration.

Now, when t = 0, v = 0.

similarly from Eq.(ii), we get C = 0

∴ $v = f_0\,t - \frac{f_0}{T}.\frac{t^2}{2}$ …(iii)

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

Substituting, t = T in Eq. (iii), then velocity

$$v_x = f_0T - \frac{f_0}{T}.\frac{t^2}{2} = f_0T - \frac{f_0\mathbf{T}}{2} = \frac{1}{2}f_0T$$

18. Given, $a = \frac{dv}{dt} = 6t + 5$

or $dv = (6t + 5)\,dt$

Integrating, we get

$\int_0^v dv = \int_0^t (6t+5)dt$ or $v = \left(\frac{6t^2}{2}+5t\right)$ Again $v = \frac{ds}{dt}$ ∴ $ds = \left(\frac{6t^2}{2}+5t\right)$

Integrating again, we get

$\int_0^s ds = \int_0^t \left(\frac{6t^2}{2}+5t\right) dt$ ∴ $s = \frac{3t^3}{3}+\frac{5t^2}{2}$

When, t = 2s, $s = 3 \times \frac{2^3}{3}+\frac{5\times 2^2}{2} = 3 \times \frac{8}{3}+\frac{5\times 4}{2} = 8 + 10 = 18m$

19. Given,

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

So, velocity $v = \frac{dx}{dt} = -a\alpha e^{-at} + b\beta e^{\beta t} = A + B$ where, $A = -a\alpha e^{-at}$, $B = b\beta e^{\beta t}$

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

20. $x = \alpha t^3$, $y = \beta t^3$

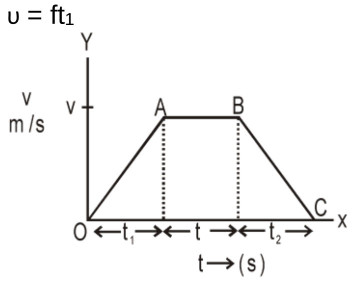
$V_x = \frac{dx}{dt} = 3\alpha t^2$

$V_y = \frac{dy}{dt} = 3\beta t^2$

Resultant velocity

$$V = \sqrt{v_x^2+v_y^2} = \sqrt{9\alpha^2t^4+9\beta^2t^4} = 3t^2\sqrt{a^2+\beta^2}$$

21. $\upsilon = ft_1$



and the final velocity of OA = intial velocity of BC

$ft_1 = \frac{f}{2}t_2$ ∴ $t_2 = 2t_1$

In graph

$S_1 = \frac{1}{2} f t_1^2$ ..... (i) Given, $S_1 = S$

$S_2 = (ft_1)t$

$S_3 = \frac{1}{2} . \frac{f}{2} (2t_1)^2$ Thus, $S_1+S_2+S_3 = 15\ S$

$S + (ft_1)t + 2S = 15S \left(S = \frac{1}{2} f t_1^2\right)$

$(tf_1)\ t = 125$ ..... (ii)

From eq. (i) and (ii) and (iii), we have $\frac{12S}{S} = \frac{(ft_1)t}{\frac{1}{2}(ft_1)t_1}$ ∴ $t_1 = \frac{1}{6}$

From Eq. (i), we get ∴ $S = \frac{1}{2} f(t_1)^2$ ∴ $S = \frac{1}{2} f(t/6)^2 = \frac{1}{72} ft^2$

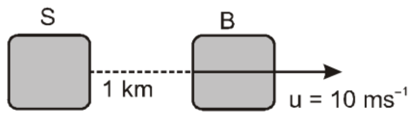
22. Since direction of v is opposite to the direction of g and h so from equation of motion

$h = -vt + \frac{1}{2}gt^2 \Rightarrow gt^2 - 2vt - 2h = 0 \quad \Rightarrow t = \frac{2v \pm \sqrt{4v^2 + 8gh}}{2g} \quad \Rightarrow t = \frac{v}{g}\left[1 + \sqrt{1 + \frac{2gh}{v^2}}\right]$

EXERCISE # 3
PART - I

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

$v = v_S - v_B$



∴ $v_S = v + v_B$ ....(i)

Relative velocity = dispalcement/ time

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

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

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

2. If the particle is moving in a straight line under the action of a constant force then distance covered

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

Since the body starts from rest u = 0 ∴ $s = \frac{1}{2} at^2$

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

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

Dividing Eq (i) and Eq (ii) we get $\frac{s_1}{s_2} = \frac{(10)^2}{(20)^2}$ ⇒ $s_2 = 4s_1$

3. $d_1 = (1/2)\ g\ (18)^2$ & $d_2 = \{ (v \times 12) + (1/2) . g. (12)^2\}$ & $d_1 = d_2$

4. $\langle a \rangle = \frac{\text{Change in velocity}}{\text{Total Time}}$

$\langle a \rangle = \dfrac{|40\hat{j} - 30\hat{i}|}{10-0}$

$\langle a \rangle = 5$ m/sec^2

5. $X = 8 + 12t - t^3$

$V = 0 + 12 - 3t^2 = 0$

$3t^2 = 12$

$t = 2$sec

$a = \dfrac{dv}{dt} = 0 - 6t$

$a\,[t = 2] = -12$ m/s^2 retardation $= 12$ m/s^2

6. $h_1 = \dfrac{1}{2}g(5)^2 = 125$

$h_1 + h_2 = \dfrac{1}{2}g(10)^2 = 500$

$h_2 = 375$

$h_1 + h_2 + h_3 = \dfrac{1}{2}g(5)^2 = 1125$

$h_3 = 625$

$h_2 = 3h_1$

$h_5 = 5h_1$

7. $\vec{r}_\ell = 2\hat{i} + 3\hat{j}$

$\vec{r}_f = 13\hat{i} + 14\hat{j}$

$\vec{s} = 11\hat{i} + 11\hat{j}$

$\langle \vec{v} \rangle = \dfrac{11\hat{i} + 11\hat{j}}{5}$

8. $V(x) = bx^{-2n}$

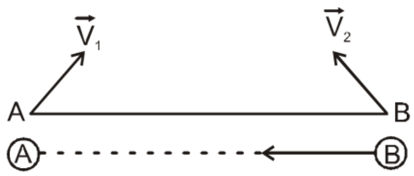
$a = \dfrac{dv}{dx}\ v = bx^{-2n}\ \{b(-2n)x^{-2n-1}\} = -2b^2 n\, x^{-4n-1}$

9. $x = 45$ m $2\pi t$, $y = 4\cos(2\pi t)$

Squiring and adding $x^2 + y^2 = 4^2$ $\Rightarrow$ $R = 4$ $\Rightarrow$ Circular motion

$V = \omega R = (2\pi)(4) = 8\pi$ So, Ans. is (2)

10.



For collision $\vec{V}_{B/A}$ should be along $\overrightarrow{B \to A}$ ($\vec{r}_{A/B}$) So, $\dfrac{\vec{V}_2 - \vec{V}_1}{|V_2 - V_1|} = \dfrac{\vec{r}_1 - \vec{r}_2}{|r_1 - r_2|}$

11. $x = 5t - 2t^2$ $V_x = \dfrac{dx}{dt} = 5 - 4t$ $a_x = -4$

$y = 10t$ $V_y = 10$ $a_y = 0$ So, $\vec{a} = -4\hat{i}$

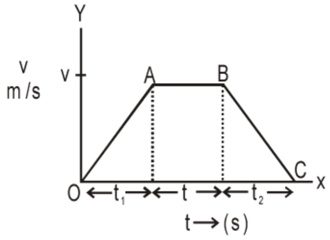
12. In both the cases acceleration of the elevator is zero, so there will be free fall of the coin and it will take same time to reach the floor.

PART - II

1. $v = \frac{ds}{dt} = 12\,t - 3t^2 = 0$
$t\,(12 - 3t) = 0$
$t = 0, 4$

PART - III

1. $\upsilon = ft_1$



and the final velocity of OA = intial velocity of BC

$ft_1 = \frac{f}{2} t_2 \quad \therefore \quad t_2 = 2t_1$

In graph $S_1 = \frac{1}{2} ft_1^2$ ..... (i)
Given, $S_1 = S$
$S_2 = (ft_1)t$
$S_3 = \frac{1}{2} . \frac{f}{2} (2t_1)^2$

Thus, $S_1+S_2+S_3 = 15\,S$

$S + (ft_1)t + 2S = 15S \quad \left(S = \frac{1}{2}ft_1^2\right)$
$(tf_1)\,t = 125$ ..... (ii)

From eq. (i) and (ii) and (iii) , we have

$$\frac{12S}{S} = \frac{(ft_1)t}{\frac{1}{2}(ft_1)t_1} \quad \therefore \quad t_1 = \frac{1}{6}$$

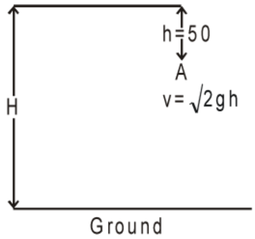
From Eq. (i), we get

$\therefore \quad S = \frac{1}{2} f(t_1)^2 \quad \therefore \quad S = \frac{1}{2} f(t/6)^2 = \frac{1}{72} ft^2$

2. Parachute bailing out at A.
Velocity at A,

$\upsilon = \sqrt{2gh} = \sqrt{2\times 9.8\times 50} = \sqrt{980}$ m/s

The velocity at ground $\upsilon_1 = 3$ m/s (given)
Acceleration = -2 m/s^2 (given)



$\therefore \quad H - h = \frac{\upsilon^2 - \upsilon_1^2}{2\times 2} = \frac{980-9}{4} = \frac{971}{4} = 242.75 \;\therefore\; H = 242.75 + h = 242.75 + 50 = 50\;293$ m

3. $\int_{6.25}^{0} \frac{dv}{\sqrt{v}} = -2.5\int_0^t dt$

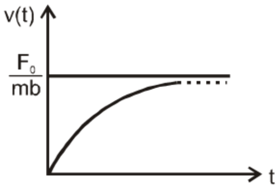
$\left|2\sqrt{\upsilon}\right|_{6.25}^{0} = -2.5\,t$

$2.\sqrt{6.25} = 2.5\ t$

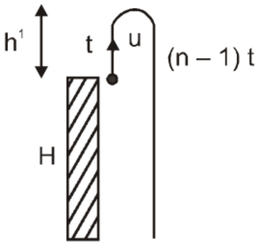
t = 2 sec. **Ans.**

4. $F = ma = F_0\ e^{-bt}$ $\Rightarrow$ $\frac{dv}{dt} = \frac{F_0}{m} e^{-bt}$

$\int_0^v dv = \frac{F_0}{m}\int_0^t e^{-bt}dt$ $\Rightarrow$ $v = \frac{F_0}{m}\left[\frac{e^{-bt}}{-b}\right]_0^t$



$v = \frac{F_0}{mb}\left(1 - e^{-bt}\right)$



5.

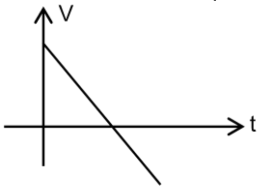
$t = u/g$ .....(1)

$h^1 = \frac{u^2}{2g}$ .....(2)

$h^1 + H = \frac{1}{2} g\ (n-1)^2 t^2$ $\Rightarrow$ $\frac{u^2}{2g} + H = \frac{1}{2} g\ (n-1)^2 \frac{u^2}{g^2}$ $\Rightarrow H = \frac{(n-1)^2 u^2}{2g} - \frac{u^2}{2g}$ $\Rightarrow H = \frac{u^2}{2g}[n^2 - 2n]$

6. $a = -g$ = constant

$\frac{dv}{dt}$ = constant slop of V – t curve is constant & –ve



7. As in distance vs time graph slope is equal to speed In the given graph slope increase initially which is incorrect

8. $\vec{r} = A \cos \omega t\,\hat{i} + A \sin \omega t\,\hat{j} + A\,\omega t\,\hat{k}$

$\vec{v} = -A\omega \sin \omega t\,\hat{i} + A\omega \cos \omega t\,\hat{j} + A\,\omega\,\hat{k}$

$|\vec{v}| = \omega A\sqrt{(-\sin\omega t)^2 + (\cos\omega t)^2 + (1)^2} = \sqrt{2}\omega A$

9. $S = \frac{1}{2} a_1\ t_0^2 = \frac{1}{2}a_2(t_0 + t)^2$ $\Rightarrow$ $\left(\sqrt{a_1} - \sqrt{a_2}\right)\times\sqrt{2s} = v$

$\left(\frac{1}{\sqrt{a_2}} - \frac{1}{\sqrt{a_1}}\right)\times\sqrt{2s} = t$ $=$ $\sqrt{2s} = \frac{\sqrt{a_1}\sqrt{a_2}t}{\sqrt{a_1} - \sqrt{a_2}}$ $\Rightarrow$ $\frac{v}{\sqrt{a_1} - \sqrt{a_2}} = \frac{\sqrt{a_1}\sqrt{a_2}t}{\sqrt{a_1} - \sqrt{a_2}}$ $\Rightarrow$ $v = \sqrt{a_1 a_2}\,t$

10. Area = $\left(\frac{1}{2}\times 2\times 2\right)$ + (2 × 2) + (1 × 3)

Displacement = 2 + 4 + 3 = 9m

11. $t_1 = \frac{x}{v-u} = \frac{x}{50}$ (here total length of two trains is x)

$$t_2 = \frac{x}{v+u} = \frac{x}{110}$$

$$\frac{t_1}{t_2} = \frac{11}{5}$$