2

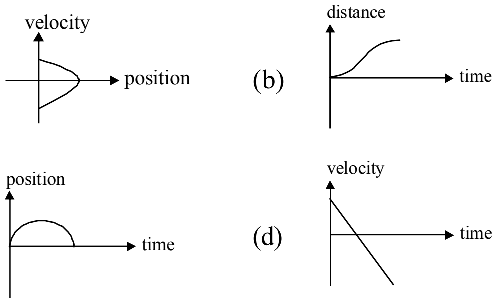
Motion in a Straight Line

TOPIC 1 Distance, Displacement & Uniform Motion

1. A particle is moving with speed $v = b\sqrt{x}$ along positive x-axis. Calculate the speed of the particle at time $t = \tau$ (assume that the particle is at origin at t = 0). **[12 Apr. 2019 II]**

(a) $\frac{b^2\tau}{4}$ (b) $\frac{b^2\tau}{2}$ (c) $b^2\tau$ (d) $\frac{b^2\tau}{\sqrt{2}}$

2. All the graphs below are intended to represent the same motion. One of them does it incorrectly. Pick it up. **[2018]**



3. 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 **[Online May 7, 2012]**

(a) 40 km/h (b) 45 km/h
(c) 48 km/h (d) 60 km/h

4. 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]**

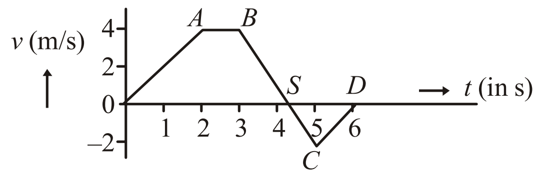
(a) $v_0 + g/2 + f$ (b) $v_0 + 2g + 3f$
(c) $v_0 + g/2 + f/3$ (d) $v_0 + g + f$

5. 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

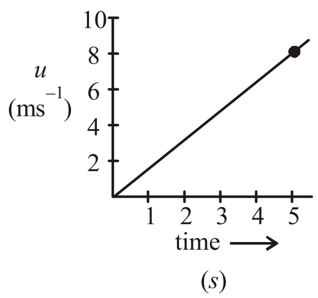
TOPIC 2 Non-uniform Motion

6. The velocity (v) and time (t) graph of a body in a straight line motion is shown in the figure. The point S is at 4.333 seconds. The total distance covered by the body in 6 s is: **[05 Sep. 2020 (II)]**



(a) $\frac{37}{3}$ m (b) 12 m (c) 11 m (d) $\frac{49}{4}$ m

7. The speed verses time graph for a particle is shown in the figure. The distance travelled (in m) by the particle during the time interval $t = 0$ to $t = 5$ s will be __________. **[NA 4 Sep. 2020 (II)]**



8. The distance x covered by a particle in one dimensional motion varies with time t as $x^2 = at^2 + 2bt + c$. If the acceleration of the particle depends on x as x^{-n}, where n is an integer, the value of n is ______. **[NA 9 Jan 2020 I]**

9. A bullet of mass 20g has an initial speed of 1 ms^{-1}, just before it starts penetrating a mud wall of thickness 20 cm. If the wall offers a mean resistance of 2.5×10^{-2} N, the speed of the bullet after emerging from the other side of the wall is close to : **[10 Apr. 2019 II]**

(a) 0.1 ms^{-1} (b) 0.7 ms^{-1}
(c) 0.3 ms^{-1} (d) 0.4 ms^{-1}

10. The position of a particle as a function of time t, is given by

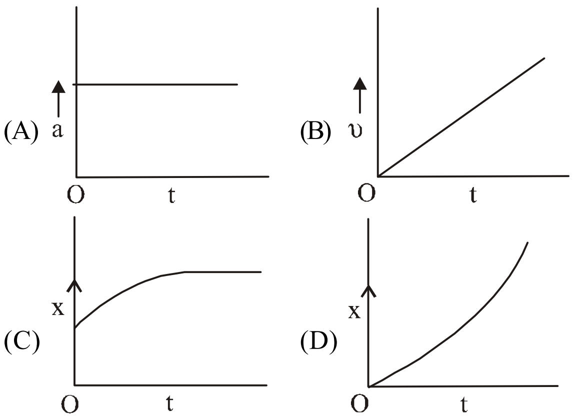
$x(t) = at + bt^2 - ct^3$

where, a, b and c are constants. When the particle attains zero acceleration, then its velocity will be: **[9 Apr. 2019 II]**

(a) $a+\frac{b^2}{4c}$ (b) $a+\frac{b^2}{3c}$

(c) $a+\frac{b^2}{c}$ (d) $a+\frac{b^2}{2c}$

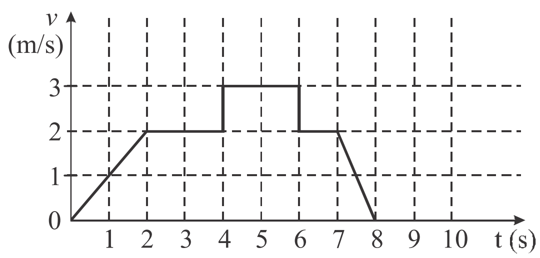
11. A particle starts from origin O from rest and moves with a uniform acceleration along the positive x-axis. Identify all figures that correctly represents the motion qualitatively (a = acceleration, v = velocity, x = displacement, t = time) **[8 Apr. 2019 II]**



(a) (B), (C) (b) (A)

(c) (A), (B), (C) (d) (A), (B), (D)

12. A particle starts from the origin at time t = 0 and moves along the positive x-axis. The graph of velocity with respect to time is shown in figure. What is the position of the particle at time t = 5s? **[10 Jan. 2019 II]**



(a) 10 m (b) 6 m

(c) 3m (d) 9m

13. In a car race on straight road, car A takes a time t less than car B at the finish and passes finishing point with a speed 'v' more than of car B. Both the cars start from rest and travel with constant acceleration a_1 and a_2 respectively. Then 'v' is equal to: **[9 Jan. 2019 II]**

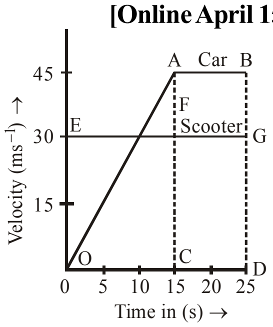
(a) $\frac{2a_1 a_2}{a_1 + a_2}t$ (b) $\sqrt{2a_1 a_2}\, t$

(c) $\sqrt{a_1 a_2}\, t$ (d) $\frac{a_1 + a_2}{2}t$

14. An automobile, travelling at 40 km/h, can be stopped at a distance of 40 m by applying brakes. If the same automobile is travelling at 80 km/h, the minimum stopping distance, in metres, is (assume no skidding) **[Online April 15, 2018]**

(a) 75m (b) 160m (c) 100m (d) 150m

15. The velocity-time graphs of a car and a scooter are shown in the figure. (i) the difference between the distance travelled by the car and the scooter in 15 s and (ii) the time at which the car will catch up with the scooter are, respectively **[Online April 15, 2018]**



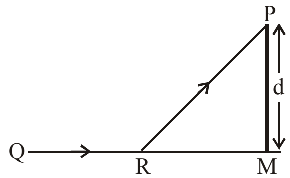
(a) 337.5m and 25s

(b) 225.5m and 10s

(c) 112.5m and 22.5s

(d) 11.2.5m and 15s

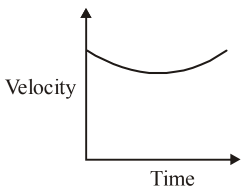
16. A man in a car at location Q on a straight highway is moving with speed v. He decides to reach a point P in a field at a distance d from highway (point M) as shown in the figure. Speed of the car in the field is half to that on the highway. What should be the distance RM, so that the time taken to reach P is minimum? **[Online April 15, 2018]**



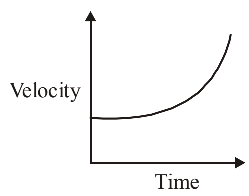
(a) $\frac{d}{\sqrt{3}}$ (b) $\frac{d}{2}$ (c) $\frac{d}{\sqrt{2}}$ (d) d

17. Which graph corresponds to an object moving with a constant negative acceleration and a positive velocity ? **[Online April 8, 2017]**

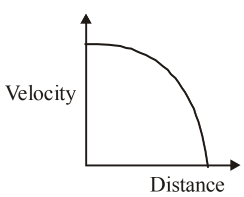
(a)



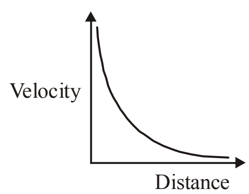
(b)



(c)

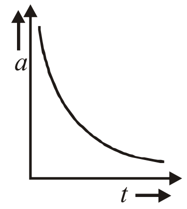


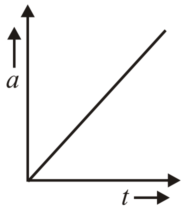
(d)

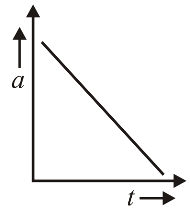


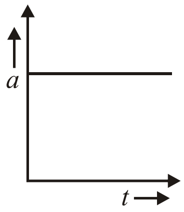
18. The distance travelled by a body moving along a line in time t is proportional to t^3.

The acceleration-time (a, t) graph for the motion of the body will be **[Online May 12, 2012]**

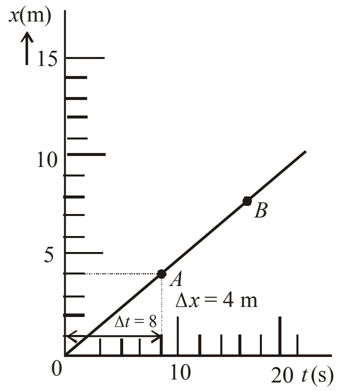
(a) 

(b) 

(c) 

(d) 

19. The graph of an object's motion (along the x-axis) is shown in the figure. The instantaneous velocity of the object at points A and B are v_A and v_B respectively. Then **[Online May 7, 2012]**



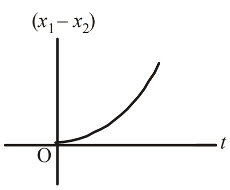
(a) $v_A = v_B = 0.5$ m/s (b) $v_A = 0.5$ m/s $< v_B$
(c) $v_A = 0.5$ m/s $> v_B$ (d) $v_A = v_B = 2$ m/s

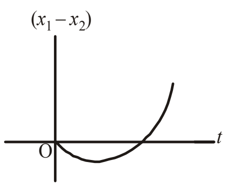
20. An object, moving with a speed of 6.25 m/s, is decelerated at a rate given by

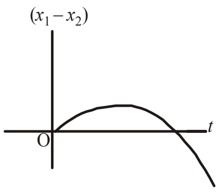
$\frac{dv}{dt} = -2.5\sqrt{v}$ where v is the instantaneous speed. The time taken by the object, to come to rest, would be: **[2011]**

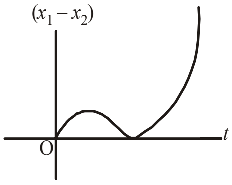
(a) 2 s (b) 4 s (c) 8 s (d) 1 s

21. 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) 

22. 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) $S = \frac{1}{72} ft^2$

23. 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

24. 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) $-2av^3$

25. 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

26. 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

27. 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.

28. 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

TOPIC 3 Relative Velocity

29. Train A and train B are running on parallel tracks in the opposite directions with speeds of 36 km/hour and 72 km/hour, respectively. A person is walking in train A in the direction opposite to its motion with a speed of 1.8

km/hour. Speed (in ms^{-1}) of this person as observed from train B will be close to : (take the distance between the tracks as negligible) **[2 Sep. 2020 (I)]**

(a) $29.5\ ms^{-1}$ (b) $28.5\ ms^{-1}$
(c) $31.5\ ms^{-1q}$ (d) $30.5\ ms^{-1}$

30. A passenger train of length 60 m travels at a speed of 80 km/hr. Another freight train of length 120 m travels at a speed of 30 km/h. The ratio of times taken by the passenger train to completely cross the freight train when: (i) they are moving in same direction, and (ii) in the opposite directions is: **[12 Jan. 2019 II]**

(a) $\frac{11}{5}$ (b) $\frac{5}{2}$ (c) $\frac{3}{2}$ (d) $\frac{25}{11}$

31. A person standing on an open ground hears the sound of a jet aeroplane, coming from north at an angle 60º with ground level. But he finds the aeroplane right vertically above his position. If v is the speed of sound, speed of the plane is: **[12 Jan. 2019 II]**

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

32. A car is standing 200 m behind a bus, which is also at rest. The two start moving at the same instant but with different forward accelerations. The bus has acceleration 2 m/s² and the car has acceleration 4 m/s². The car will catch up with the bus after a time of : **[Online April 9, 2017]**

(a) $\sqrt{110}$ s (b) $\sqrt{120}$ s
(c) $10\sqrt{2}$ s (d) 15 s

33. A person climbs up a stalled escalator in 60 s. If standing on the same but escalator running with constant velocity he takes 40 s. How much time is taken by the person to walk up the moving escalator? **[Online April 12, 2014]**

(a) 37 s (b) 27 s (c) 24 s (d) 45 s

34. A goods train accelerating uniformly on a straight railway track, approaches an electric pole standing on the side of track. Its engine passes the pole with velocity u and the guard's room passes with velocity v. The middle wagon of the train passes the pole with a velocity. **[Online May 19, 2012]**

(a) $\frac{u+v}{2}$ (b) $\frac{1}{2}\sqrt{u^2+v^2}$

(c) $\sqrt{uv}$ (d) $\sqrt{\left(\frac{u^2+v^2}{2}\right)}$

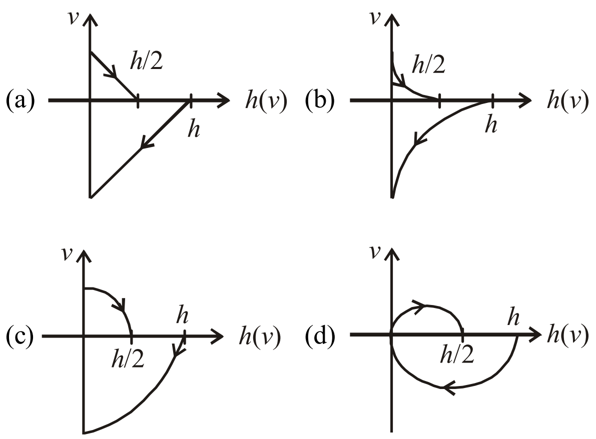
TOPIC 4 Motion Under Gravity

35. A helicopter rises from rest on the ground vertically upwards with a constant acceleration g. A food packet is dropped from the helicopter when it is at a height h. The time taken by the packet to reach the ground is close to [g is the accelertion due to gravity] : **[5 Sep. 2020 (I)]**

(a) $t=\frac{2}{3}\sqrt{\left(\frac{h}{g}\right)}$ (b) $t=1.8\sqrt{\frac{h}{g}}$

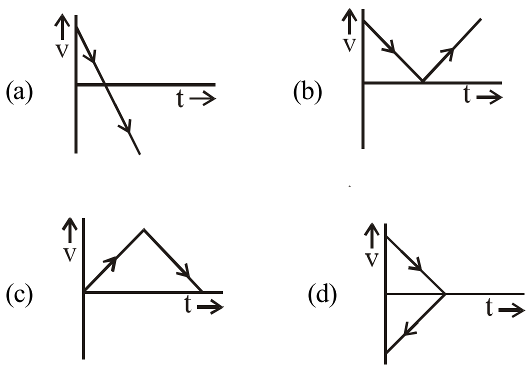
(c) $t=3.4\sqrt{\left(\frac{h}{g}\right)}$ (d) $t=\sqrt{\frac{2h}{3g}}$

36. A Tennis ball is released from a height h and after freely falling on a wooden floor it rebounds and reaches height $\frac{h}{2}$. The velocity versus height of the ball during its motion may be represented graphically by :
(graph are drawn schematically and on not to scale) **[4 Sep. 2020 (I)]**



37. A ball is dropped from the top of a 100 m high tower on a planet. In the last $\frac{1}{2}$ s before hitting the ground, it covers a distance of 19 m. Acceleration due to gravity (in ms^{-2}) near the surface on that planet is _______. **[NA 8 Jan. 2020 II]**

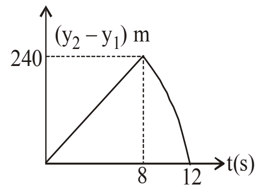
38. A body is thrown vertically upwards. Which one of the following graphs correctly represent the velocity vs time? **[2017]**

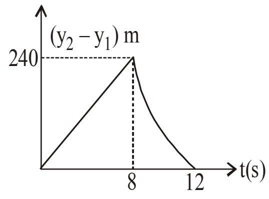


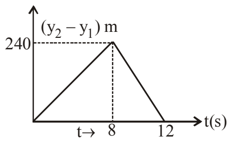
39. Two stones are thrown up simultaneously from the edge of a cliff 240 m high with initial speed of 10 m/s and 40 m/s respectively. Which of the following graph best represents the time variation of relative position of the second stone with respect to the first ?

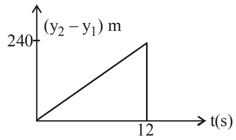
(Assume stones do not rebound after hitting the ground and neglect air resistance, take g = 10 m/ s^2) **[2015]**

(*The figures are schematic and not drawn to scale*)

(a) 

(b) 

(c) 

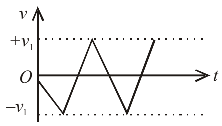
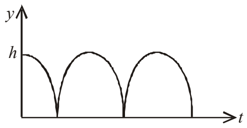
(d) 

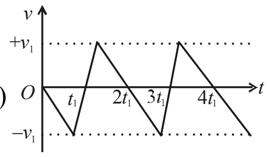
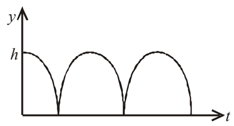
40. From a tower of height H, a particle is thrown vertically upwards with a speed u. The time taken by the particle, to hit the ground, is n times that taken by it to reach the highest point of its path. The relation between H, u and n is: **[2014]**

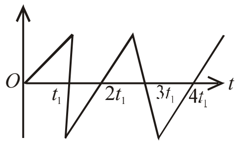
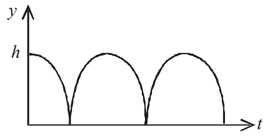
(a) $2gH = n^2u^2$
(b) $gH = (n-2)^2 u^2 d$
(c) $2gH = nu^2 (n-2)$
(d) $gH = (n-2)u^2$

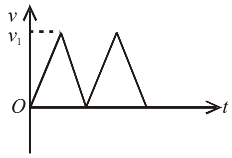
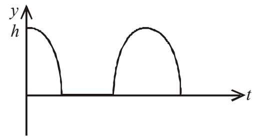
41. Consider a rubber ball freely falling from a height $h = 4.9$ m onto a horizontal elastic plate. Assume that the duration of collision is negligible and the collision with the plate is totally elastic.

Then the velocity as a function of time and the height as a function of time will be : **[2009]**

(a) 


(b) 


(c) 


(d) 


42. A parachutist after bailing out falls 50 m without friction. When parachute opens, it decelerates at 2 m/s^2 . He reaches the ground with a speed of 3 m/s. At what height, did he bail out ? **[2005]**

(a) 182 m
(b) 91 m
(c) 111m
(d) 293m

43. 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

44. 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.

Hints & Solutions

1. (b) Given, $v = b\sqrt{x}$

or $\dfrac{dx}{dt} = b\,x^{1/2}$

or $\int_0^x x^{-1/2}dx = \int_0^t b\,dt$

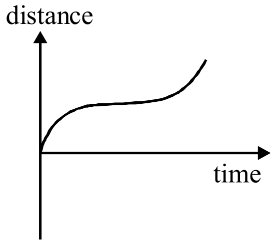
or $\dfrac{x^{1/2}}{1/2} = 6t$ or $x = \dfrac{b^2t^2}{4}$

Differentiating w. r. t. time, we get

$\dfrac{dx}{dt} = \dfrac{b^2 \times 2t}{4}$ $(t = \tau)$

or $v = \dfrac{b^2\tau}{2}$

2. (b) Graphs in option (c) position-time and option (a) velocity-position are corresponding to velocity-time graph option (d) and its distance-time graph is as given below. Hence distance-time graph option (b) is incorrect.



3. (c) Average speed = $\dfrac{\text{Total distance travelled}}{\text{Total time taken}} = \dfrac{x}{T}$

$= \dfrac{x}{\dfrac{x}{2\times 40} + \dfrac{x}{2\times 60}} = 48$ km/h

4. (c) We know that, $v = \dfrac{dx}{dt}$

$\Rightarrow dx = v\,dt$

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

or $x = \int_0^t (v_0 + gt + ft^2)\,dt = \left[v_0t + \dfrac{gt^2}{2} + \dfrac{ft^3}{3}\right]_0^t$

or, $x = v_0t + \dfrac{gt^2}{2} + \dfrac{ft^3}{3}$

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

5. (a) $v = \alpha\sqrt{x}$,

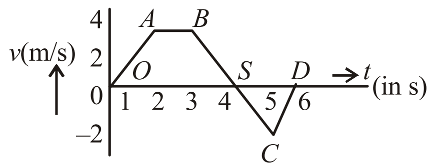
$\Rightarrow \dfrac{dx}{dt} = \alpha\sqrt{x} \Rightarrow \dfrac{dx}{\sqrt{x}} = \alpha\,dt$

Integrating both sides,

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

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

6. (a)



$OS = 4 + \dfrac{1}{3} = \dfrac{13}{3}$

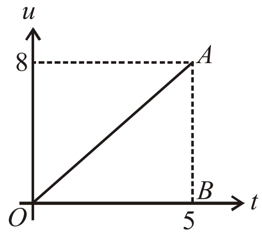
$SD = 2 - \dfrac{1}{3} = \dfrac{5}{3}$

Distance covered by the body = area of v-t graph

= ar $(OABS)$ + ar (SCD)

$= \dfrac{1}{2}\left(\dfrac{13}{3} + 1\right)\times 4 + \dfrac{1}{2}\times\dfrac{5}{3}\times 2 = \dfrac{32}{3} + \dfrac{5}{3} = \dfrac{37}{3}$ m

7. (20)



Distance travelled = Area of speed-time graph

$= \dfrac{1}{2}\times 5\times 8 = 20$ m

8. (3) Distance X varies with time t as $x^2 = at^2 + 2bt + c$

$\Rightarrow 2x\dfrac{dx}{dt} = 2at + 2b$

$\Rightarrow x\dfrac{dx}{dt} = at + b \Rightarrow \dfrac{dx}{dt} = \dfrac{(at+b)}{x}$

$\Rightarrow x\dfrac{d^2x}{dt^2} + \left(\dfrac{dx}{dt}\right)^2 = a$

$\Rightarrow \dfrac{d^2x}{dt^2} = \dfrac{a - \left(\dfrac{dx}{dt}\right)^2}{x} = \dfrac{a - \left(\dfrac{at+b}{x}\right)^2}{x}$

$= \dfrac{ax^2 - (at+b)^2}{x^3} = \dfrac{ac - b^2}{x^3}$

$\Rightarrow$ $a \propto x^{-3}$ Hence, n = 3

9. **(b)** From the third equation of motion

$v^2 - u^2 = 2aS$

But, $a = \frac{F}{m}$

$\therefore v^2 = u^2 - 2\left(\frac{F}{m}\right)S$

$\Rightarrow v^2 = (1)^2 - (2)\left[\frac{2.5\times10^{-2}}{20\times10^{-3}}\right]\frac{20}{100}$

$\Rightarrow v^2 = 1 - \frac{1}{2}$

$\Rightarrow v = \frac{1}{\sqrt{2}}$ m/s = 0.7m/s

10. **(b)** $x = at + bt^2 - ct^3$

Velocity, $v = \frac{dx}{dt} = \frac{d}{dt}(at + bt^2 + ct^3)$

$= a + 2bt - 3ct^2$

Acceleration, $\frac{dv}{dt} = \frac{d}{dt}(a + 2bt - 3ct^2)$

or $0 = 2b - 3c \times 2t \quad \therefore t = \left(\frac{b}{3c}\right)$

and $v = a + 2b\left(\frac{b}{3c}\right) - 3c\left(\frac{b}{3c}\right)^2 = \left(a + \frac{b^2}{3c}\right)$

11. **(d)** For constant acceleration, there is straight line parallel to t-axis on $\vec{a} - t$.

Inclined straight line on $\vec{v} - t$, and parabola on $\vec{x} - t$.

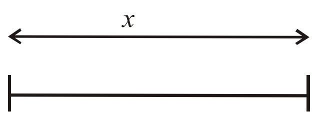
12. **(d)** Position of the particle,

S = area under graph (time t = 0 to 5s)

$= \frac{1}{2}\times2\times2 + 2\times2 + 3\times1 = 9\,\text{m}$

13. **(c)** Let time taken by A to reach finishing point is t_0

$\therefore$ Time taken by B to reach finishing point = $t_0 + t$



u = 0 $\quad v_A = a_1 t_0$

$v_B = a_2(t_0 + t)$

$v_A - v_B = v$

$\Rightarrow v = a_1 t_0 - a_2(t_0 + t) = (a_1 - a_2)t_0 - a_2 t$ ...(i)

$x_B = x_A = \frac{1}{2}a_1 t_0^2 = \frac{1}{2}a_2(t_0 + t)^2$

$\Rightarrow \sqrt{a_1}t_0 = \sqrt{a_2}(t_0 + t)$

$\Rightarrow \left(\sqrt{a_1} - \sqrt{a_2}\right)t_0 = \sqrt{a_2}t$

$\Rightarrow t_0 = \frac{\sqrt{a_2}t}{\sqrt{a_1} - \sqrt{a_2}}$

Putting this value of t_0 in equation (i)

$v = (a_1 - a_2)\frac{\sqrt{a_2}t}{\sqrt{a_1} - \sqrt{a_2}} - a_2 t$

$= \left(\sqrt{a_1} + \sqrt{a_2}\right)\sqrt{a_2}t - a_2 t = \sqrt{a_1 a_2}t + a_2 t - a_2 t$

or, $v = \sqrt{a_1 a_2}\,t$

14. **(b)** According to question, $u_1 = 40$ km/h, $v_1 = 0$ and $s_1 = 40$ m

using $v^2 - u^2 = 2as$; $0^2 - 40^2 = 2a \times 40$ ...(i)

Again, $0^2 - 80^2 = 2as$ ...(ii)

From eqn. (i) and (ii)

Stopping distance, $s = 160$ m

15. **(c)** Using equation, $a = \frac{v - u}{t}$ and $S = ut + \frac{1}{2}at^2$

Distance travelled by car in 15 sec = $\frac{1}{2}\frac{(45)}{15}(15)^2$

$= \frac{675}{2}$ m

Distance travelled by scooter in 15 seconds = 30 × 15 = 450

($\because$ distance = speed × time)

Difference between distance travelled by car and scooter in 15 sec, 450 – 337.5 = 112.5 m

Let car catches scooter in time t;

$\frac{675}{2} + 45(t - 15) = 30t$

337.5 + 45t – 675 = 30t $\Rightarrow$ 15t = 337.5

$\Rightarrow$ t = 22.5 sec

16. **(a)** Let the car turn of the highway at a distance 'x' from the point M. So, RM = x

And if speed of car in field is v, then time taken by the car to cover the distance $QR = QM - x$ on the highway,

$t_1 = \frac{QM - x}{2v}$ .....(i)

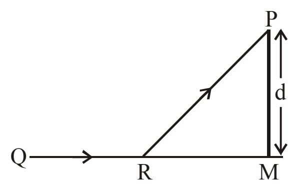
Time taken to travel the distance 'RP' in the field

$t_2 = \frac{\sqrt{d^2 + x^2}}{v}$ ..... (ii)

Total time elapsed to move the car from Q to P

$t = t_1 + t_2 = \frac{QM - x}{2v} + \frac{\sqrt{d^2 + x^2}}{v}$

For 't' to be minimum $\frac{dt}{dx} = 0$



$\frac{1}{v}\left[-\frac{1}{2} + \frac{x}{\sqrt{d^2 + x^2}}\right] = 0$

or $x = \frac{d}{\sqrt{2^2 - 1}} = \frac{d}{\sqrt{3}}$

17. **(c)** According to question, object is moving with constant negative acceleration i.e., a = – constant (C)

$$\frac{vdv}{dx} = -C$$

$$vdv = -Cdx$$

$$\frac{v^2}{2} = -Cx + k \qquad x = -\frac{v^2}{2C} + \frac{k}{C}$$

Hence, graph (3) represents correctly.

18. **(b)** Distance along a line i.e., displacement (s) $= t^3$ ($\because s \propto t^3$ given)

By double differentiation of displacement, we get acceleration.

$$V = \frac{ds}{dt} = \frac{dt^3}{dt} = 3t^2 \text{ and } a = \frac{dv}{dt} = \frac{d3t^2}{dt} = 6t$$

$a = 6t$ or $a \propto t$

Hence graph (b) is correct.

19. **(a)** Instantaneous velocity $v = \frac{\Delta x}{\Delta t}$

From graph, $v_A = \frac{\Delta x_A}{\Delta t_A} = \frac{4m}{8s} = 0.5$ m/s

and $v_B = \frac{\Delta x_B}{\Delta t_B} = \frac{8m}{16s} = 0.5$ m/s

i.e., $v_A = v_B = 0.5$ m/s

20. **(a)** Given, $\frac{dv}{dt} = -2.5\sqrt{v}$

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

Integrating,

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

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

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

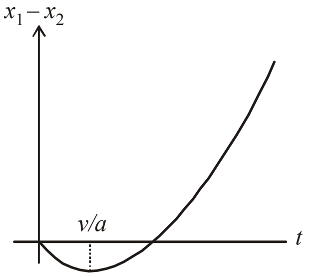
$$\Rightarrow -2 \times 2.5 = -2.5t$$

$$\Rightarrow t = 25$$

21. **(b)** **For the body starting from rest, distance travelled (x_1) is given by**

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

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



For the body moving with constant speed

$x_2 = vt$

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

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

This equation is of parabola.

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

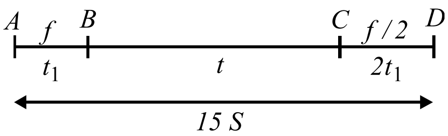
These characteristics are represented by graph (b).

22. **(d)** Let car starts from A from rest and moves up to point B with acceleration f.

Distance, $AB = S = \frac{1}{2}ft_1^2$

Distance, $BC = (ft_1)t$

Distance, $CD = \frac{u^2}{2a} = \frac{(ft_1)^2}{2(f/2)} = ft_1^2 = 2S$



Total distance, $AD = AB + BC + CD = 15S$

$AD = S + BC + 2S$

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

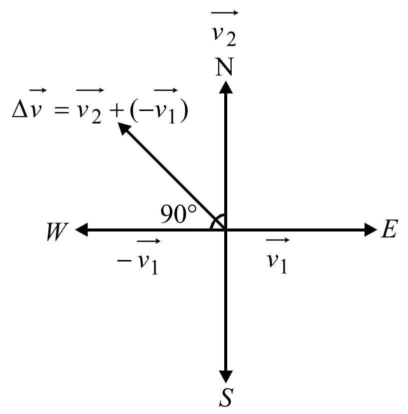
$$\Rightarrow f t_1 t = 12S \qquad \text{............ (i)}$$

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

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

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

23. **(c)**



Initial velocity, $\vec{v_1} = 5\hat{i}$, Final velocity, $\vec{v_2} = 5\hat{j}$,

Change in velocity $\Delta\vec{v} = (\vec{v}_2 - \vec{v}_1)$

$= \sqrt{v_1^2 + v_2^2 + 2v_1v_2\cos 90}$

$= \sqrt{5^2 + 5^2 + 0} = 5\sqrt{2}$m/s

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

Avg. acceleration $= \dfrac{\Delta\vec{v}}{t}$

$= \dfrac{5\sqrt{2}}{10} = \dfrac{1}{\sqrt{2}}\,\text{m/s}^2$

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

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

24. **(d)** Given, $t = ax^2 + bx$;

Diff. with respect to time (t)

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

$\Rightarrow 1 = 2axv + bv = v(2ax + b)$ (v = velocity)

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

Again differentiating, we get

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

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

25. **(d)** In first case speed,

$u = 60 \times \dfrac{5}{18}\text{m/s} = \dfrac{50}{3}\text{m/s}$

$d = 20$m,

Let retardation be a then

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

or $u^2 = 2ad$ ...(i)

In second case speed, $u' = 120 \times \dfrac{5}{18}$

$= \dfrac{100}{3}$m/s

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

or $u'^2 = 2ad'$ ...(ii)

(ii) divided by (i) gives,

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

26. **(c)** **Fir first case :** Initial velocity,

$u = 50 \times \dfrac{5}{18}\text{m/s}$,

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

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

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

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

$$a = -\frac{250 \times 250}{324 \times 2 \times 6} \approx = -16\ \text{ms}^{-2}.$$

Case-2 : Initial velocity, $u = 100$ km/hr

$= 100 \times \dfrac{5}{18}$ m/sec

$v = 0, s = s, a = a$

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

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

$$\Rightarrow -\left(100 \times \frac{5}{18}\right)^2 = 2 \times (-16) \times 5$$

$$s = \frac{500 \times 500}{324 \times 32} = 24\text{m}$$

27. **(a)** In first case

$u_1 = u$; $v_1 = \dfrac{u}{2}$, $s_1 = 3$ cm, $a_1 = ?$

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

$\left(\dfrac{u}{2}\right)^2 - u^2 = 2 \times a \times 3$

$\Rightarrow a = \dfrac{-u^2}{8}$

In second case: Assuming the same retardation

$u_2 = u/2$; $v_2 = 0$; $s_2 = ?$; $a_2 = \dfrac{-u^2}{8}$

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

$\therefore 0 - \dfrac{u^2}{4} = 2\left(\dfrac{-u^2}{8}\right) \times s_2$

$\Rightarrow s_2 = 1$ cm

28. **(d)** **For first car**

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

As $v_1^2 - u_1^2 = 2a_1s_1$

$\Rightarrow -u^2 = -2as_1$

$\Rightarrow u^2 = 2as_1$

$\Rightarrow s_1 = \dfrac{u^2}{2a}$ ...(i)

For second car

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

$\therefore v_2^2 - u_2^2 = 2a_2s_2$

$\Rightarrow -(4u)^2 = 2(-a)s_2$

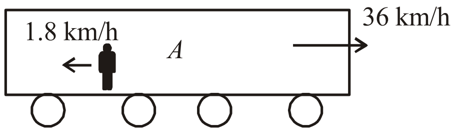
$\Rightarrow \quad 16u^2 = 2as_2$

$\Rightarrow \quad s_2 = \dfrac{8u^2}{a}$ ...(ii)

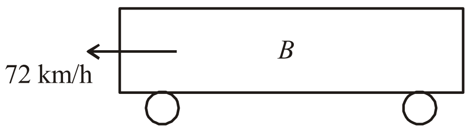
Dividing (i) and (ii),

$\dfrac{s_1}{s_2} = \dfrac{u^2}{2a} \cdot \dfrac{a}{8u^2} = \dfrac{1}{16}$

29. **(a)** According to question, train *A* and *B* are running on parallel tracks in the opposite direction.



$V_A = 36 \text{ km/h} = 10 \text{ m/s}$



$V_B = -72 \text{ km/h} = -20 \text{ m/s}$

$V_{MA} = -1.8 \text{ km/h} = -0.5 \text{ m/s}$

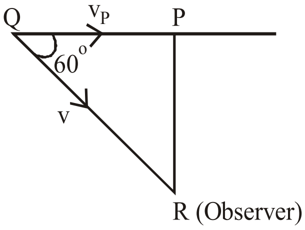
$V_{\text{man}, B} = V_{\text{man}, A} + V_{A, B}$

$= V_{\text{man}, A} + V_A - V_B = -0.5 + 10 - (-20)$

$= -0.5 + 30 = 29.5 \text{ m/s}.$

30. **(a)**

31. **(d)**



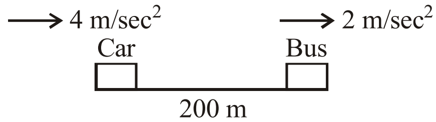
Distance, PQ = $v_p \times t$ (Distance = speed × time)

Distance, QR = V.t

$\cos 60° = \dfrac{PQ}{QR}$

$\dfrac{1}{2} = \dfrac{v_P \times t}{V.t} \Rightarrow v_P = \dfrac{v}{2}$

32. **(c)**



Given, $u_C = u_B = 0$, $a_C = 4 \text{ m/s}^2$, $a_B = 2 \text{ m/s}^2$

hence relative acceleration, $a_{CB} = 2 \text{ m/sec}^2$

Now, we know, $s = ut + \dfrac{1}{2}at^2$

$200 = \dfrac{1}{2} \times 2t^2 \quad \because u = 0$

Hence, the car will catch up with the bus after time

$t = 10\sqrt{2}$ second

33. **(c)** Person's speed walking only is $\dfrac{1}{60} \dfrac{\text{"escalator"}}{\text{second}}$

Standing the escalator without walking the speed is $\dfrac{1}{40} \dfrac{\text{"escalator"}}{\text{second}}$

Walking with the escalator going, the speed add.

So, the person's speed is $\dfrac{1}{60} + \dfrac{1}{40} = \dfrac{15}{120} \dfrac{\text{"escalator"}}{\text{second}}$

So, the time to go up the escalator $t = \dfrac{120}{5} = 24$ second.

34 **(d)** Let '*S*' be the distance between two ends '*a*' be the constant acceleration

As we know $v^2 - u^2 = 2aS$

or, $aS = \dfrac{v^2 - u^2}{2}$

Let *v* be velocity at mid point.

Therefore, $v_c^2 - u^2 = 2a\dfrac{S}{2}$

$v_c^2 = u^2 + aS$

$v_c^2 = u^2 + \dfrac{v^2 - u^2}{2}$

$v_c = \sqrt{\dfrac{u^2 + v^2}{2}}$

35. **(c)** For upward motion of helicopter,

$v^2 = u^2 + 2gh \Rightarrow v^2 = 0 + 2gh \Rightarrow v = \sqrt{2gh}$

Now, packet will start moving under gravity.

Let '*t*' be the time taken by the food packet to reach the ground.

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

$\Rightarrow -h = \sqrt{2gh}\,t - \dfrac{1}{2}gt^2 \Rightarrow \dfrac{1}{2}gt^2 - \sqrt{2gh}\,t - h = 0$

or, $t = \dfrac{\sqrt{2gh} \pm \sqrt{2gh + 4 \times \dfrac{g}{2} \times h}}{2 \times \dfrac{g}{2}}$

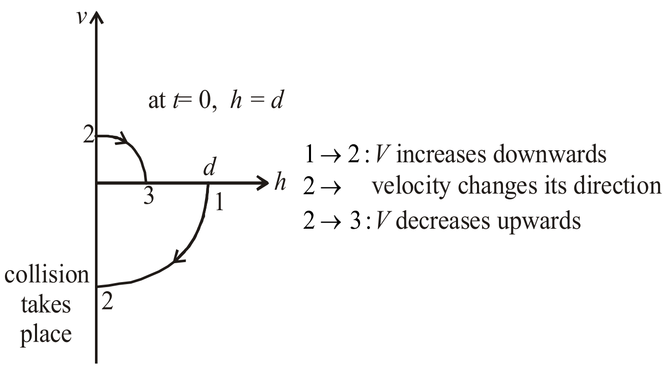
or, $t = \sqrt{\dfrac{2gh}{g}}(1 + \sqrt{2}) \Rightarrow t = \sqrt{\dfrac{2h}{g}}(1 + \sqrt{2})$

or, $t = 3.4\sqrt{\dfrac{h}{g}}$

36. **(c)** For uniformly accelerated/ deaccelerated motion :

$v^2 = u^2 \pm 2gh$

As equation is quadratic, so, *v*-*h* graph will be a parabola



Initially velocity is downwards (–ve) and then after collision it reverses its direction with lesser magnitude, i.e. velocity is upwards (+ve).

Note that time $t = 0$ corresponds to the point on the graph where $h = d$.

Next time collision takes place at 3.

37. **(08.00)** Let the ball takes time t to reach the ground

Using, $S = ut + \frac{1}{2}gt^2$

$\Rightarrow S = 0 \times t + \frac{1}{2}gt^2$

$\Rightarrow \quad 200 = gt^2 \qquad [\because 2S = 100m]$

$\Rightarrow t = \sqrt{\frac{200}{g}} \qquad \ldots(i)$

In last $\frac{1}{2}s$, body travels a distance of 19 m, so in $\left(t - \frac{1}{2}\right)$ distance travelled = 81

Now, $\frac{1}{2}g\left(t - \frac{1}{2}\right)^2 = 81$

$\therefore \; g\left(t - \frac{1}{2}\right)^2 = 81 \times 2$

$\Rightarrow \left(t - \frac{1}{2}\right) = \sqrt{\frac{81 \times 2}{g}}$

$\therefore \; \frac{1}{2} = \frac{1}{\sqrt{g}}(\sqrt{200} - \sqrt{81 \times 2}) \qquad$ using (i)

$\Rightarrow \sqrt{g} = 2(10\sqrt{2} - 9\sqrt{2})$

$\Rightarrow \sqrt{g} = 2\sqrt{2}$

$\therefore$ g = 8 m/s^2

38. **(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.

39. **(b)** $y_1 = 10t - 5t^2$; $y_2 = 40t - 5t^2$

for $y_1 = -240m, t = 8s$

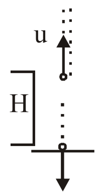
$\therefore \quad y_2 - y_1 = 30t$ for $t \le 8s$.

for $t > 8s$,

$y_2 - y_1 = 240 - 40t - \frac{1}{2}gt^2$

40. **(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 $t = \frac{u}{g}$,

$\Rightarrow t = \frac{u + \sqrt{u^2 + 2gH}}{g} = \frac{nu}{g}$

(from question)

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

41. **(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.

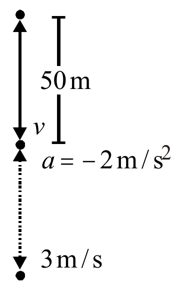
Also $y = ut - \frac{1}{2}gt^2$

All these characteristics are represented by graph (b).

42. **(d)** Initial velocity of parachute after bailing out,

$u = \sqrt{2gh}$

$u = \sqrt{2 \times 9.8 \times 50} = 14\sqrt{5}$



The velocity at ground,

$v = 3m/s$

$S = \frac{v^2 - u^2}{2 \times 2} = \frac{3^2 - 980}{4} \approx 243$ m

Initially he has fallen 50 m.

$\therefore$ Total height from where he bailed out = 243 + 50 = 293 m

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

$\Rightarrow \quad h = 0 \times T + \frac{1}{2}gT^2$

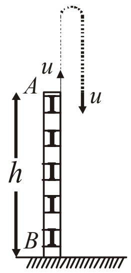
$\Rightarrow \quad h = \frac{1}{2}gT^2$

Vertical distance moved in time $\frac{T}{3}$ is

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

$\therefore$ Position of ball from ground $= h - \frac{h}{9} = \frac{8h}{9}$

44. **(b)** Ball A is thrown upwards with velocity u 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 (u). 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, $v_A = v_B$