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).

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

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

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

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

or $\quad \frac{x^{1/2}}{1/2} = 6t \qquad$ or $\quad x = \frac{b^2t^2}{4}$

Differentiating w. r. t. time, we get

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

or $\quad v = \frac{b^2\tau}{2}$

2. 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

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

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

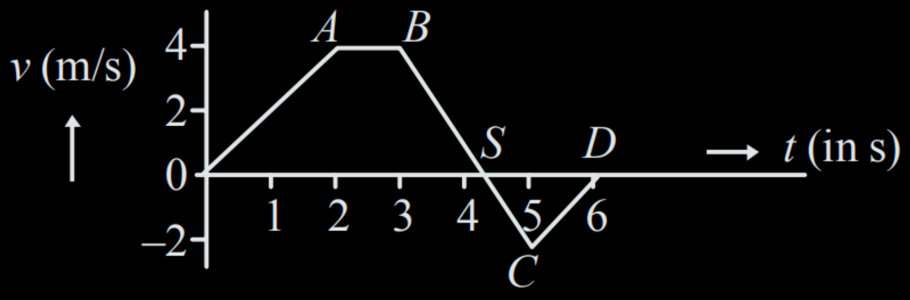
$$\Rightarrow \quad \frac{dx}{dt} = \alpha\sqrt{x} \;\Rightarrow\; \frac{dx}{\sqrt{x}} = \alpha\, dt$$

Integrating both sides,

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

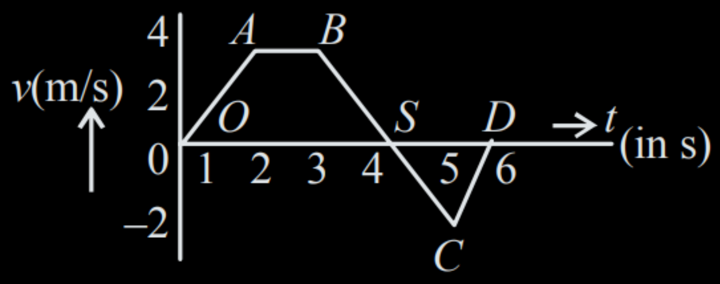
$$\Rightarrow 2\sqrt{x} = \alpha t \;\Rightarrow x = \frac{\alpha^2}{4}t^2$$

3. 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:



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

(a)



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

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

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

$= \text{ar}\,(OABS) + \text{ar}\,(SCD)$

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

4. 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:

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

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

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

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

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

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

5. 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)

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

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

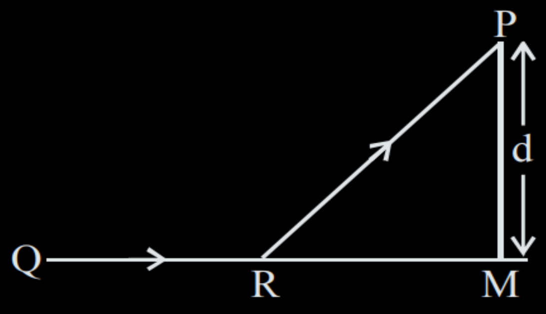
using $v^2 - u^2 = 2as$; $0^2 - 40^2 = 2a \times 40$ ...(i)

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

From eqn. (i) and (ii)

Stopping distance, $s = 160$ m

6. 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?



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

(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,

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

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

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

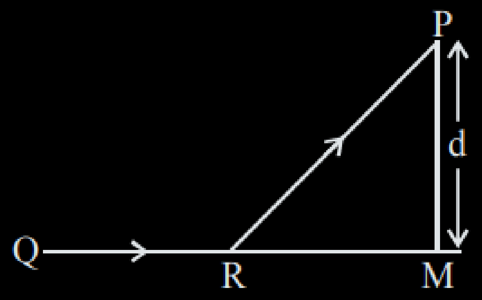
Total time elapsed to move the car from Q to P

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

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

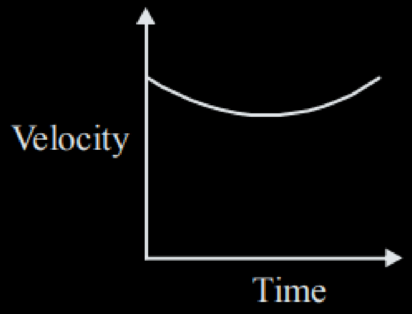
$$\frac{1}{v}\left[-\frac{1}{2} + \frac{x}{\sqrt{d^2 + x^2}}\right] = 0$$

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

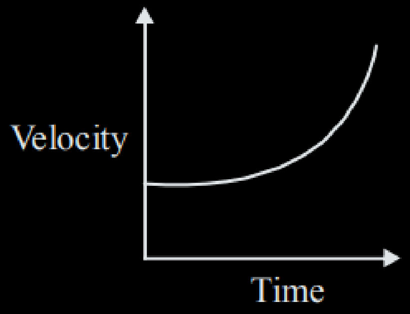


7. Which graph corresponds to an object moving with a constant negative acceleration and a positive velocity ?

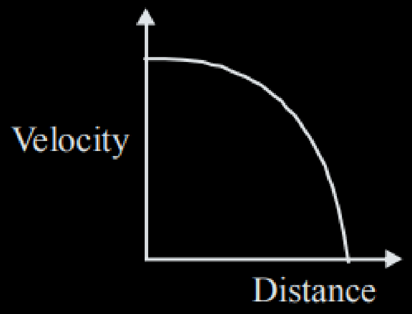
(a)



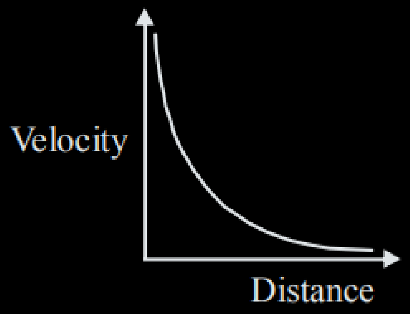
(b)



(c)



(d)



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

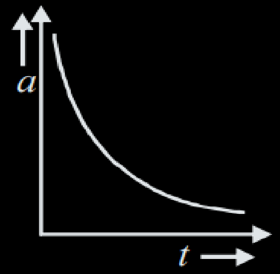
$$\frac{vdv}{dx} = -C$$

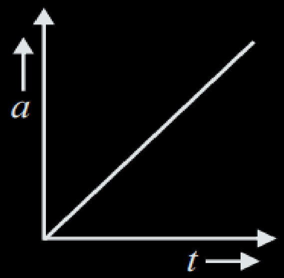
$$vdv = -Cdx$$

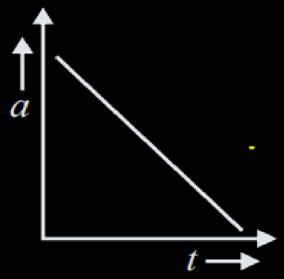
$$\frac{v^2}{2} = -Cx + k \qquad x = -\frac{v^2}{2C} + \frac{k}{C}$$

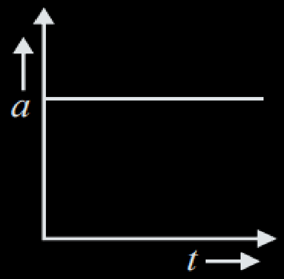
Hence, graph (3) represents correctly.

8. 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

(a)


(b)


(c)


(d)


(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.

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

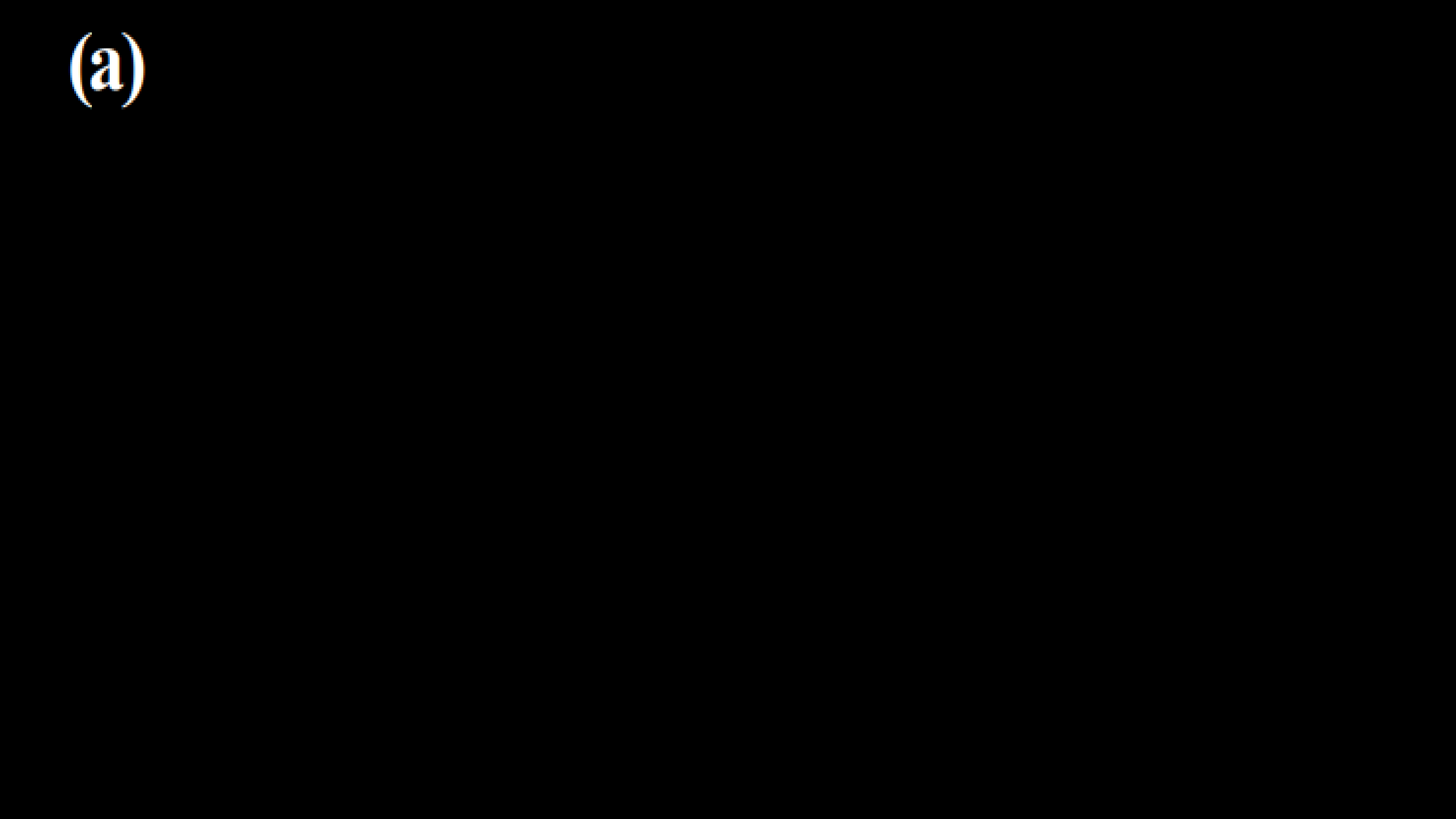
$a = 6t$ or $a \propto t$

Hence graph (b) is correct.

9. 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:

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

(a)

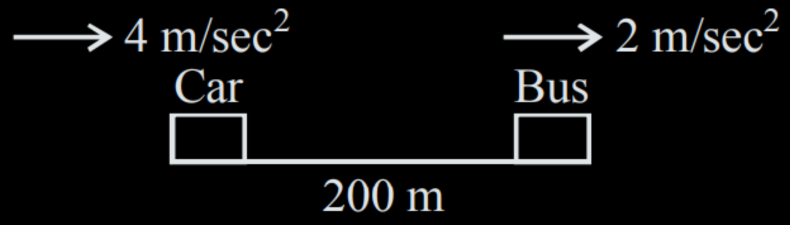


10. A car is standing 200 m behind a bus, which is also at rest. The two start moving at the same instant but with different forward accelerations. The bus has acceleration $2\ m/s^2$ and the car has acceleration $4\ m/s^2$. The car will catch up with the bus after a time of :

(a) $\sqrt{110}$ s (b) $\sqrt{120}$ s

(c) $10\sqrt{2}$ s (d) 15 s

(c)



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

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

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

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

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

$$t = 10\sqrt{2} \text{ second}$$

11. 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] :

(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) $t = \sqrt{\frac{2h}{3g}}$

(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.

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

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

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

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

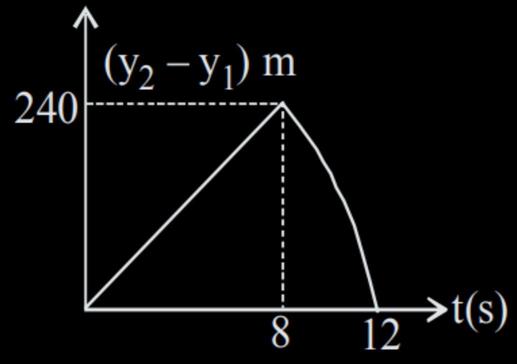
$$\text{or, } t = 3.4\sqrt{\frac{h}{g}}$$

12. 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 ?

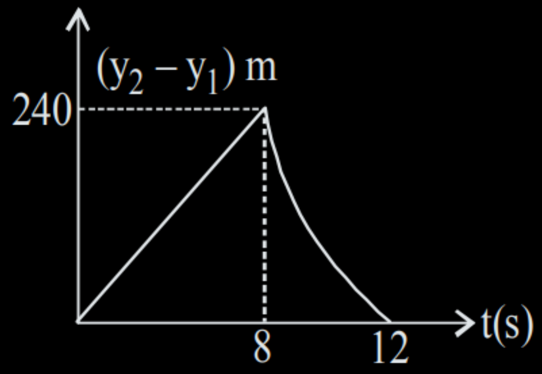
(Assume stones do not rebound after hitting the ground and neglect air resistance, take $g = 10\ m/s^2$)

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

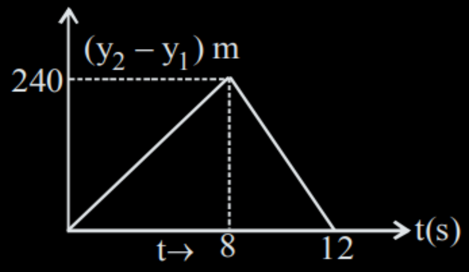
(a)



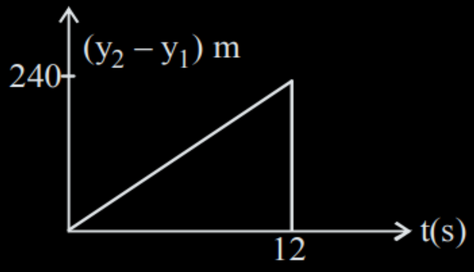
(b)



(c)



(d)



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

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

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

for $t > 8s$,

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

13. A particle is moving with a velocity $\vec{v} = K(y\hat{i} + x\hat{j})$, where K is a constant. The general equation for its path is: + ca

(a) $y = x^2$ + constant (b) $y^2 = x$ + constant

(c) $y^2 = x^2$ + constant (d) xy = constant

(c) From given equation,

$$\vec{V} = K\left(y\hat{i} + x\hat{j}\right)$$

$$\frac{dx}{dt} = ky \text{ and } \frac{dy}{dt} = kx$$

Now $\dfrac{\frac{dy}{dt}}{\frac{dx}{dt}} = \dfrac{x}{y} = \dfrac{dy}{dx}, \Rightarrow ydy = xdx$

Integrating both side

$$y^2 = x^2 + c$$

14. The co-ordinates of a moving particle at any time ‘t’ are given by $x = \alpha t^3$ and $y = \beta t^3$. The speed of the particle at time ‘t’ is given by

(a) $3t\sqrt{\alpha^2 + \beta^2}$

(b) $3t^2\sqrt{\alpha^2 + \beta^2}$

(c) $t^2\sqrt{\alpha^2 + \beta^2}$

(d) $\sqrt{\alpha^2 + \beta^2}$

(b) Coordinates of moving particle at time 't' are

$x = \alpha t^3$ and $y = \beta t^3$

$$v_x = \frac{dx}{dt} = 3\alpha t^2 \text{ and } v_y = \frac{dy}{dt} = 3\beta t^2$$

$$\therefore\ v = \sqrt{v_x^2 + v_y^2} = \sqrt{9\alpha^2 t^4 + 9\beta^2 t^4}$$

$$= 3t^2\sqrt{\alpha^2 + \beta^2}$$

15. The trajectory of a projectile near the surface of the earth is given as $y = 2x - 9x^2$. If it were launched at an angle θ_0 with speed v_0 then ($g = 10\ \text{ms}^{-2}$):

(a) $\theta_0 = \sin^{-1}\frac{1}{\sqrt{5}}$ and $v_0 = \frac{5}{3}\ \text{ms}^{-1}$

(b) $\theta_0 = \cos^{-1}\left(\frac{2}{\sqrt{5}}\right)$ and $v_0 = \frac{3}{5}\ \text{ms}^{-1}$

(c) $\theta_0 = \cos^{-1}\left(\frac{1}{\sqrt{5}}\right)$ and $v_0 = \frac{9}{3}\ \text{ms}^{-1}$

(d) $\theta_0 = \sin^{-1}\left(\frac{2}{\sqrt{5}}\right)$ and $v_0 = \frac{3}{5}\ \text{ms}^{-1}$

(c) Given, $y = 2x - 9x^2$

On comparing with,

$$y = x \tan\theta - \frac{gx^2}{2u^2 \cos^2\theta},$$

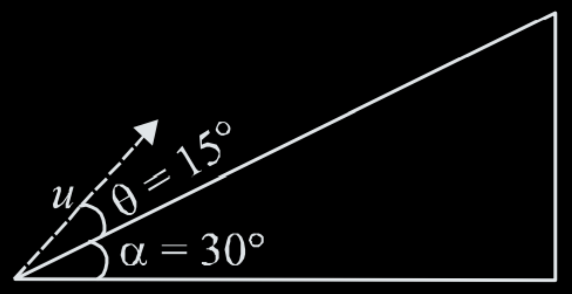
We have,

$$\tan\theta = 2 \text{ or } \cos\theta = \frac{1}{\sqrt{5}}$$

$$\text{and } \frac{g}{2u^2 \cos^2\theta} = 9 \text{ or } \frac{10}{2u^2 (1/\sqrt{5})^2} = 9$$

$$\therefore \quad u = 5/3 \text{ m/s}$$

16. A plane is inclined at an angle $\alpha = 30^{\circ}$ with respect to the horizontal. A particle is projected with a speed $u = 2\ ms^{-1}$, from the base of the plane, as shown in figure. The distance from the base, at which the particle hits the plane is close to : (Take $g = 10\ ms^{-2}$)



(a) 20 cm (b) 18 cm (c) 26 cm (d) 14 cm

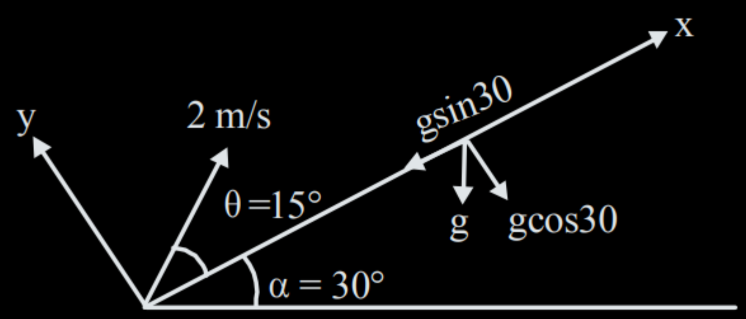
(a) On an inclined plane, time of flight (T) is given by

$$T = \frac{2u\sin\theta}{g\cos\alpha}$$

Substituting the values, we get

$$T = \frac{(2)(2\sin 15°)}{g\cos 30°} = \frac{4\sin 15°}{10\cos 30°}$$

Distance, S $= (2\cos 15°)T - \frac{1}{2}g\sin 30°(T)^2$



$$= (2\cos 15°)\frac{4}{10}\frac{\sin 15°}{10\cos 30°} - \left(\frac{1}{2}\times 10\sin 30°\right)\frac{16\sin^2 15°}{100\cos^2 30°}$$

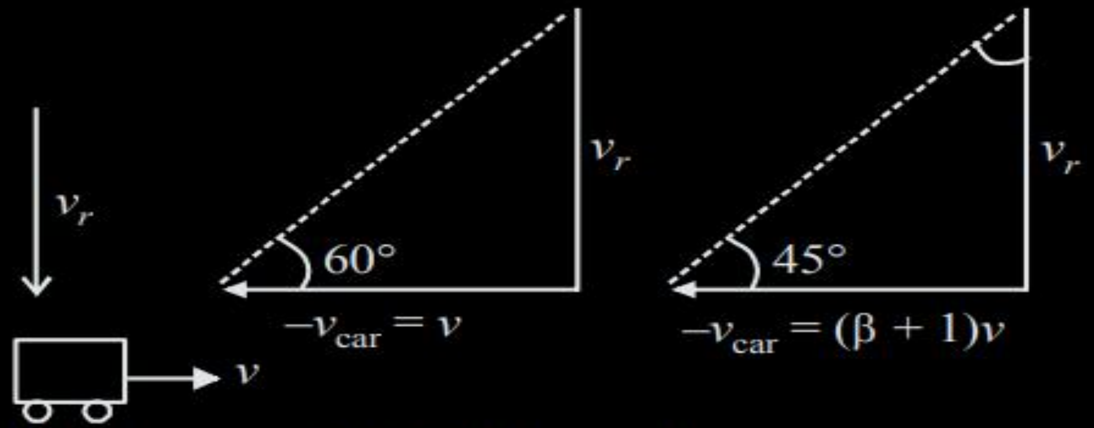
$$= \frac{16\sqrt{3}-16}{60} \simeq 0.1952\text{m} \simeq 20\text{cm}$$

17. When a carsit at rest, its driver sees raindrops falling on it vertically. When driving the car with speed v, he sees that raindrops are coming at an angle 60º from the horizontal. On furter increasing the speed of the car to $(1 + \beta)v$, this angle changes to 45º. The value of β is close to:

(a) 0.50
(b) 0.41
(c) 0.37
(d) 0.73

Hence, average acceleration is of the order of 10^{-3}.

(d) The given situation is shown in the diagram. Here v_r be the velocity of rain drop.



When car is moving with speed v,

$$\tan 60° = \frac{v_r}{v} \qquad \text{...(i)}$$

When car is moving with speed $(1+\beta)v$,

$$\tan 45° = \frac{v_r}{(\beta+1)v} \qquad \text{...(ii)}$$

Dividing (i) by (ii) we get,

$$\sqrt{3}v = (\beta+1)v \Rightarrow \beta = \sqrt{3} - 1 = 0.732.$$

18. The stream of a river is flowing with a speed of 2 km/h. A swimmer can swim at a speed of 4 km/h. What should be the direction of the swimmer with respect to the flow of the river to cross the river straight?

(a) 90° (b) 150°

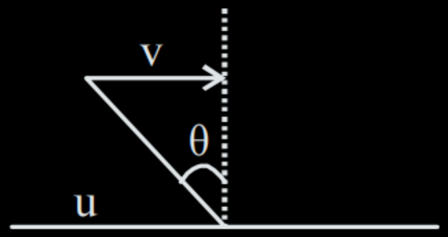
(c) 120° (d) 60°

(c) $\sin\theta = \frac{u}{v} = \frac{2}{4} = \frac{1}{2}$

or $\theta = 30°$

with respect to flow,

$= 90° + 30° = 120°$

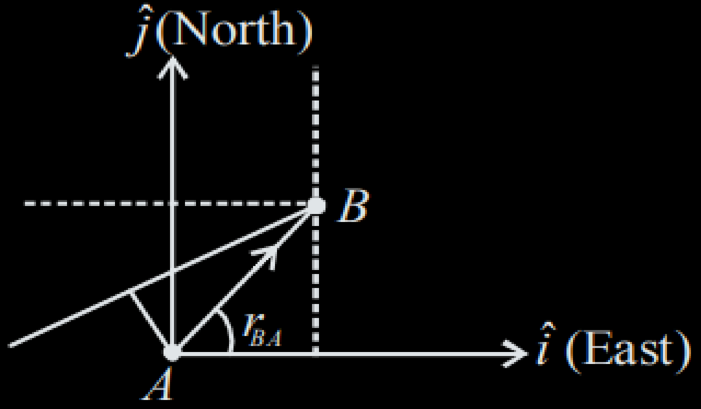


19. Ship A is sailing towards north-east with velocity km/hr where points east and , north. Ship B is at a distance of 80 km east and 150 km north of Ship A and is sailing towards west at 10 km/hr. A will be at minimum distance from B in:

(a) 4.2 hrs. (b) 2.6 hrs.

(c) 3.2 hrs. (d) 2.2 hrs.

(b)



$\vec{v}_A = 30\hat{i} + 50\hat{j}$ km/hr

$\vec{v}_B = (-10\hat{i})$ km/hr

$r_{BA} = (80\hat{i} + 150\hat{j})$ km

$\vec{v}_{BA} = \vec{v}_B - \vec{v}_A = -10\hat{i} - 30\hat{i} - 50\hat{i} = 40\hat{i} - 50\hat{j}$

$$t_{\text{minimum}} = \frac{\left|(\vec{r}_{BA})\cdot(\vec{v}_{BA})\right|}{\left|(\vec{v}_{BA})\right|^2}$$

$$= \frac{\left|(80\hat{i} + 150\hat{j})(-40\hat{i} - 50\hat{j})\right|}{(10\sqrt{41})^2}$$

$$\therefore \; t = \frac{10700}{10\sqrt{41} \times 10\sqrt{41}} = \frac{107}{41} = 2.6 \text{ hrs.}$$

20. A shell is fired from a fixed artillery gun with an initial speed u such that it hits the target on the ground at a distance R from it. If t_1 and t_2 are the values of the time taken by it to hit the target in two possible ways, the product t_1t_2 is :

(a) R/4g (b) R/g (c) R/2g (d) 2R/g

(d) R will be same for θ and $90° - \theta$.

Time of flights:

$$t_1 = \frac{2u\sin\theta}{g} \text{ and}$$

$$t_2 = \frac{2u\sin(90° - \theta)}{g} = \frac{2u\cos\theta}{g}$$

$$\text{Now, } t_1 t_2 = \left(\frac{2u\sin\theta}{g}\right)\left(\frac{2u\cos\theta}{g}\right)$$

$$= \frac{2}{g}\left(\frac{u^2\sin 2\theta}{g}\right) = \frac{2R}{g}$$

21. The position of a projectile launched from the origin at $t = 0$ is given by $\vec{r} = \left(40\hat{i} + 50\hat{j}\right)$ m at $t = 2$s. If the projectile was launched at an angle θ from the horizontal, then θ is (take $g = 10\ ms^{-2}$)

(a) $\tan^{-1}\frac{2}{3}$

(b) $\tan^{-1}\frac{3}{2}$

(c) $\tan^{-1}\frac{7}{4}$

(d) $\tan^{-1}\frac{4}{5}$

(c) From question,

Horizontal velocity (initial),

$$u_x = \frac{40}{2} = 20\,\text{m/s}$$

Vertical velocity (initial), $50 = u_y t + \frac{1}{2} g t^2$

$$\Rightarrow \quad u_y \times 2 + \frac{1}{2}(-10) \times 4$$

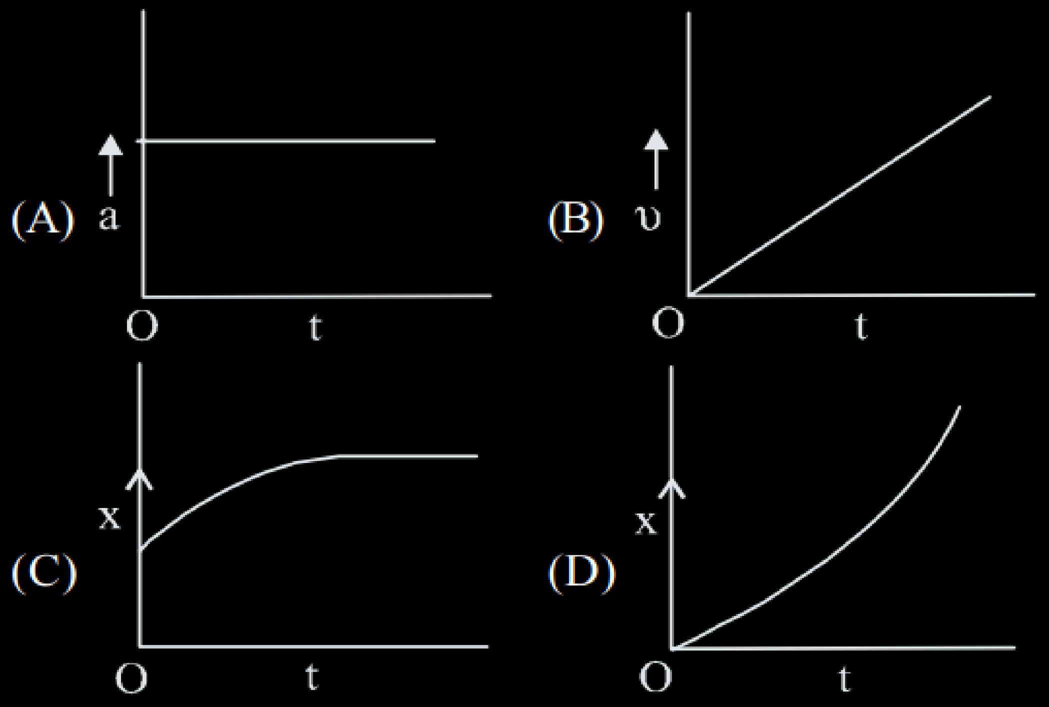
or, $50 = 2u_y - 20$

or, $u_y = \frac{70}{2} = 35\,\text{m/s}$

$$\therefore \quad \tan\theta = \frac{u_y}{u_x} = \frac{35}{20} = \frac{7}{4}$$

$$\Rightarrow \quad \text{Angle } \theta = \tan^{-1}\frac{7}{4}$$

22. 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)



(a) (B), (C)

(b) (A)

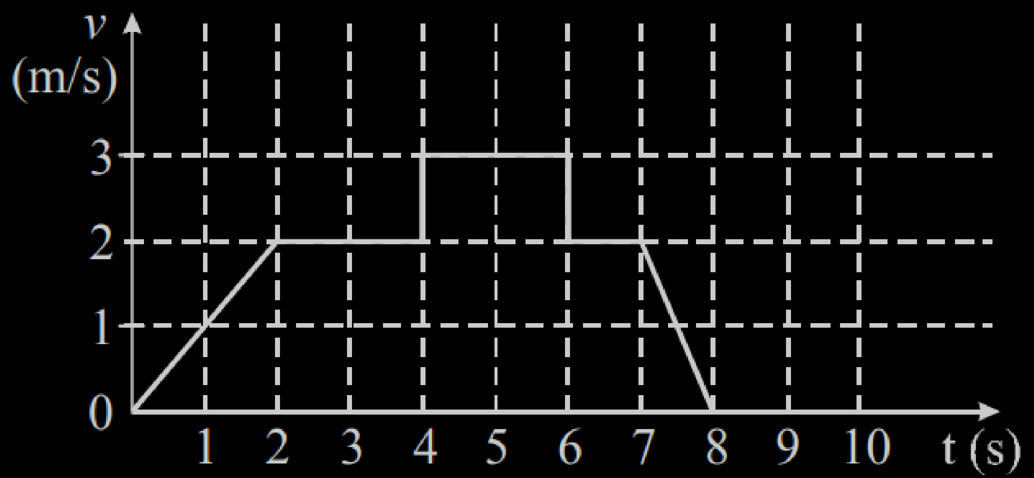
(c) (A), (B), (C)

(d) (A), (B), (D)

(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 $\vec{x}-t$.

23. 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?



(a) 10 m (b) 6 m

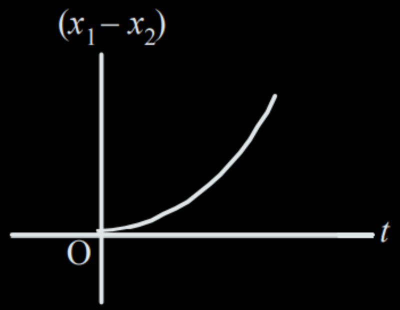
(c) 3m (d) 9m

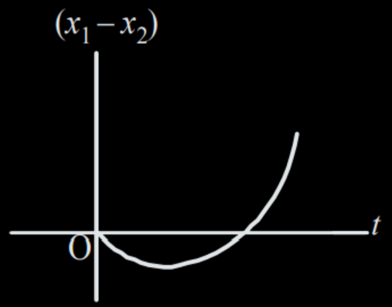
(d) Position of the particle,

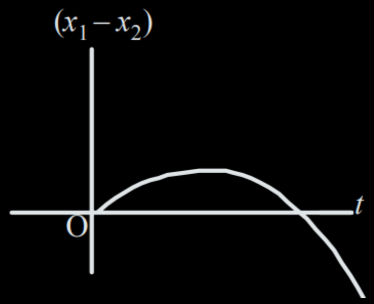
S = area under graph (time t = 0 to 5s)

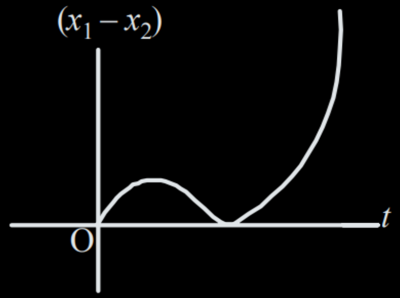
$$= \frac{1}{2} \times 2 \times 2 + 2 \times 2 + 3 \times 1 = 9\,\text{m}$$

24. 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'?

(a) 

(b) 

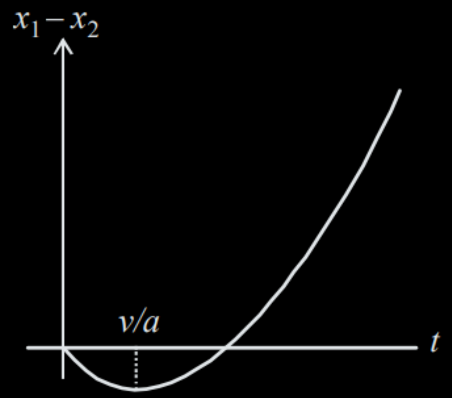
(c) 

(d) 

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

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

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



For the body moving with constant speed

$$x_2 = vt$$

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

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

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).

25. The relation between time t and distance x is $t = ax^2 + bx$ where a and b are constants. The acceleration is

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

An automobile travelling with a speed of 60 km/h, can

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

Diff. with respect to time (t)

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

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

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

Again differentiating, we get

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

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

26 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?

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

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

Standing the escalator without walking the speed is

$\frac{1}{40}\frac{\text{"escalator"}}{\text{second}}$

Walking with the escalator going, the speed add.

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

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

27 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:

(a) $2gH = n^2u^2$

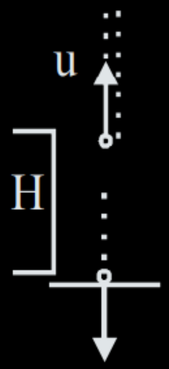
(b) $gH = (n-2)^2 u^2d$

(c) $2gH = nu^2 (n-2)$

(d) $gH = (n-2)u^2$

(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 $t = \dfrac{u}{g}$,

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

(from question)

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

28. 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

(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

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