Motion in a Straight Line

Question1

A ball projected vertically upwards with a velocity ' V ' passes through a point P in its upward journey in a time of ' x ' seconds. From there, the time in which the ball again passes through the same point P is

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Options:

A.

$\frac{v}{2g}$

B.

$\frac{2v}{g} - x$

C.

$\frac{v}{2g} - x$

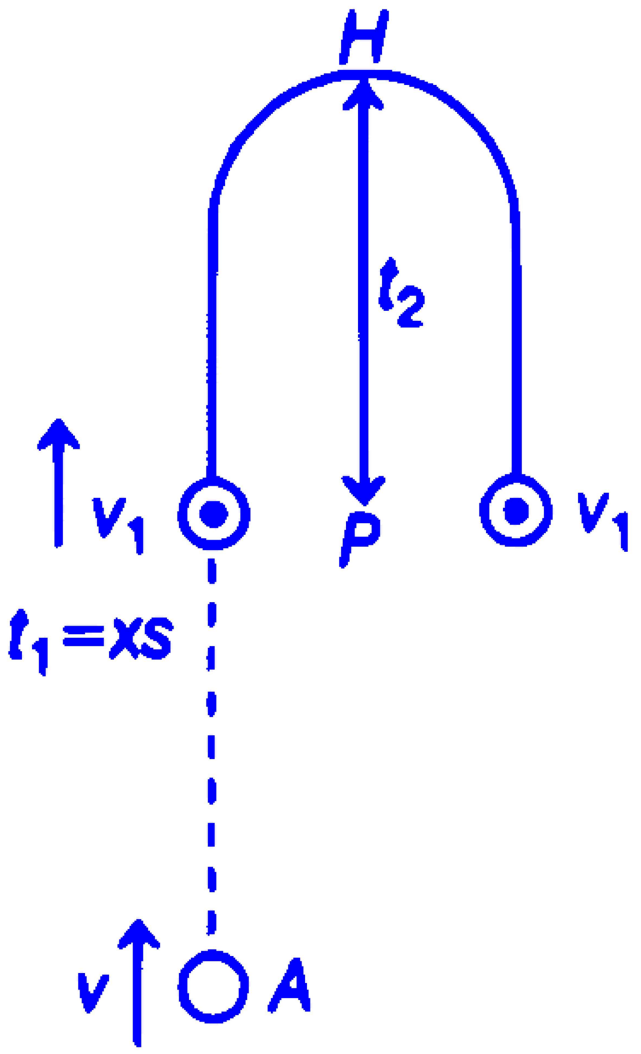
D.

$2\left(\frac{v}{g} - x\right)$

Answer: D

Solution:

The given situation is shown in figure.



Using $v=u-gt$, for motion point A to P,

$$v_1 = v - gt_1$$
$$v_1 = v - gx$$

At highest point $H, v_2 = 0$

$$\therefore \quad v_2 = v_1 - gt_2$$
$$0 = v_1 - gt_2$$
$$\Rightarrow \quad t_2 = \frac{v_1}{g} = \frac{v-gx}{g}$$

$\therefore$ Required time $= 2t_2$

$$= 2\left(\frac{v-gx}{g}\right) = 2\left(\frac{v}{g} - x\right)$$

Question2

Two smooth inclined planes A and B each of height 20 m have angles of inclination 30° and 60° respectively. If t_1 and t_2 are respectively the times taken by two blocks to reach the bottom of the planes A and B from the top, then $t_1 - t_2 =$ (Acceleration due to gravity $= 10 \text{ ms}^{-2}$)

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Options:

A.

$\frac{\sqrt{3}-1}{\sqrt{3}}$ s

B.

$3(\sqrt{3}-1)$s

C.

$4\left(\frac{\sqrt{3}-1}{\sqrt{3}}\right)$s

D.

$(3\sqrt{3}-2)$s

Answer: C

Solution:

The height of both planes is $h = 20$ m.

Finding Length of Each Inclined Plane:

For plane A, the length is $l_1 = \frac{h}{\sin 30^{\circ}}$.

Since $\sin 30^{\circ} = \frac{1}{2}$, we get $l_1 = \frac{20}{0.5} = 40$ m.

For plane B, the length is $l_2 = \frac{h}{\sin 60^{\circ}}$.

Since $\sin 60^{\circ} = \frac{\sqrt{3}}{2}$, we get $l_2 = \frac{20}{\frac{\sqrt{3}}{2}} = \frac{40}{\sqrt{3}}$ m.

Finding Acceleration Along Each Plane:

Acceleration on an incline is $a = g \sin\theta$.

For plane A: $a_1 = 10 \times \sin 30^\circ = 10 \times 0.5 = 5 \text{ m/s}^2$.

For plane B: $a_2 = 10 \times \sin 60^\circ = 10 \times \frac{\sqrt{3}}{2} = 5\sqrt{3} \text{ m/s}^2$.

Finding the Time to Slide Down Each Plane:

The formula for distance with starting speed 0 is $s = \frac{1}{2}at^2$. Solving for t gives $t = \sqrt{\frac{2s}{a}}$.

For plane A: $t_1 = \sqrt{\frac{2l_1}{a_1}} = \sqrt{\frac{2\times40}{5}} = \sqrt{16} = 4$ s.

For plane B: $t_2 = \sqrt{\frac{2l_2}{a_2}} = \sqrt{\frac{2\times\frac{40}{\sqrt{3}}}{5\sqrt{3}}}$.

Let's simplify t_2:$t_2 = \sqrt{\frac{80/\sqrt{3}}{5\sqrt{3}}} = \sqrt{\frac{80}{5(\sqrt{3})^2}} = \sqrt{\frac{80}{5\times3}} = \sqrt{\frac{80}{15}} = \sqrt{\frac{16}{3}} = \frac{4}{\sqrt{3}}$ s

Finding the Difference in Time:

$t_1 - t_2 = 4 - \frac{4}{\sqrt{3}}$

This can also be written as:$4\left(\frac{\sqrt{3}-1}{\sqrt{3}}\right)$ s

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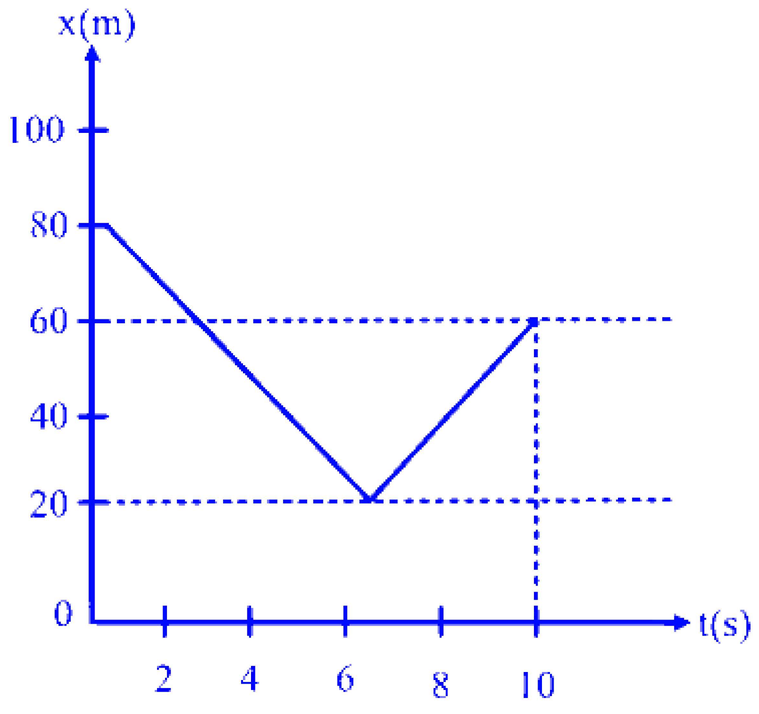
Question3

The displacement (x) and time (t) graph of a particle moving along a straight line is shown in the figure. The average velocity of the particle in the time of 10 s is



Options:

A.

2 ms^{-1}

B.

4 ms^{-1}

C.

6 ms^{-1}

D.

8 ms^{-1}

Answer: A

Solution:

From the given graph,

At time $t = 0$ s, initial displacement

$x_i = 80 \text{ m}$

At time $t = 10$ s, final displacement

$x_f = 60 \text{ m}$

$\therefore$ Average velocity

$$= \frac{x_f - x_i}{\Delta t} = \frac{60 - 80}{10}$$
$$= \frac{-20}{-10} = -2 \text{ m/s}$$

$\therefore$ Magnitude of average velocity $= 2 \text{ m/s}$

Question4

A body starts from rest with uniform acceleration and its velocity at a time of ' n ' seconds is ' v '. The total displacement of the body in the nth and $(n-1)$ th seconds of its motion is

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Options:

A.

$\frac{v(n+1)}{n}$

B.

$\frac{2v(n+1)}{n}$

C.

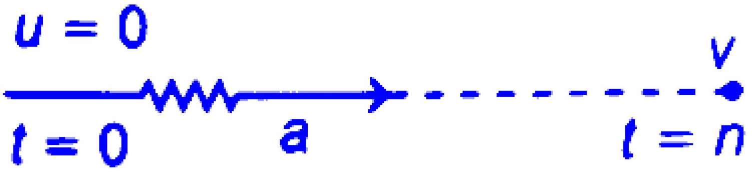
$\frac{2v(n-1)}{n}$

D.

$\frac{v(n-1)}{n}$

Answer: C

Solution:



Step 1: Find acceleration a.

We use the formula for velocity with uniform acceleration: $v=u+at$. Here, $u=0$ (because the body starts from rest), and after n seconds, the velocity is v. So:

$v=an \implies a=\frac{v}{n}$

Step 2: Find displacement in the nth second (S_n).

The formula for how far an object moves during the nth second is:

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

Since $u = 0 : S_n = \frac{a}{2}(2n-1)$

Step 3: Find displacement in the $(n-1)$th second (S_{n-1}).

Plug $(n-1)$ instead of n into the formula:

$$S_{n-1} = \frac{a}{2}(2(n-1)-1)$$
$$= \frac{a}{2}(2n-3)$$

Step 4: Add the displacements for the nth and $(n-1)$th seconds.

$S_n + S_{n-1} = \frac{a}{2}(2n-1) + \frac{a}{2}(2n-3)$

Combine the numbers in the brackets:

$S_n + S_{n-1} = \frac{a}{2}[(2n-1)+(2n-3)] = \frac{a}{2}(4n-4)$

Step 5: Substitute $a = \frac{v}{n}$ from Step 1.

$S_n + S_{n-1} = \frac{1}{2} \cdot \frac{v}{n} \cdot (4n-4) = \frac{v}{2n}(4n-4)$

Simplify:

$S_n + S_{n-1} = \frac{v}{2n} \cdot 4(n-1) = \frac{2v}{n}(n-1)$

Question5

If a stone thrown vertically upwards from a bridge with an initial velocity of 5 ms^{-1}, strikes the water below the bridge in a time of 3 s , then the height of the bridge above the water surface is(Acceleration due to gravity $= 10 \text{ ms}^{-2}$)

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Options:

A.

10 m

B.

26 m

C.

30 m

D.

18 m

Answer: C

Solution:

If h be the height of the bridge above the water surface, then

$$\begin{aligned} h &= -ut + \frac{1}{2} g t^2 \\ &= -5 \times 3 + \frac{1}{2} \times 10 \times 3^2 \\ &= -15 + 45 = 30 \text{ m} \end{aligned}$$

Question6

A particle moving along a straight line covers the first half of the distance with a speed of 3 ms^{-1}, the other half of the distance is covered in two equal time intervals with speeds of 4.5 ms^{-1} and 7.5 ms^{-1} respectively, then the average speed of particle during the motion is

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Options:

A.

4.0 ms^{-1}

B.

5.0 ms^{-1}

C.

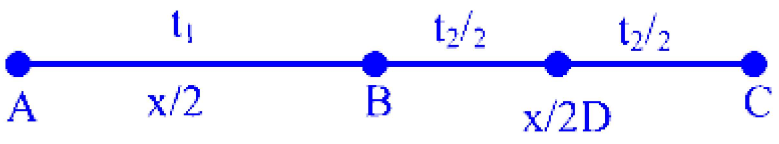
5.5 ms^{-1}

D.

4.8 ms^{-1}

Answer: A

Solution:



$\frac{x}{2} = 3t_1$

$$\Rightarrow \quad t_1 = \frac{x}{6}$$
$$BC = \frac{x}{2} = BD + DC$$
$$= 4.5 \times \frac{t_2}{2} + 7.5 \times \frac{t_2}{2}$$
$$\frac{x}{2} = 6t_2 \Rightarrow t_2 = \frac{x}{12}$$

$\therefore$ Average speed

$$V_{\text{avg}} = \frac{\text{total distance travelled}}{\text{total time taken}}$$
$$= \frac{x}{t_1 + t_2} = \frac{x}{\frac{x}{6} + \frac{x}{12}}$$
$$= \frac{x}{\frac{3x}{12}} = 4 \text{ m/s}$$

Question7

If the distance travelled by a freely falling body in the last but one second of its motion is 5 m , then the last second is

(Acceleration due to gravity $= 10 \text{ ms}^{-2}$)

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Options:

A.

1 st

B.

2nd

C.

3rd

D.

4 th

Answer: A

Solution:

Step 1: Write the formula for distance in the n-th second

The distance a freely falling object travels during the n-th second is given by: $S_n = u + \frac{1}{2}g(2n - 1)$Here, u is the starting speed (which is 0 if just falling), g is gravity, and n is the second we are looking at.

Step 2: Substitute the values

We know the speed at start $u = 0$ and $g = 10\ \mathrm{ms}^{-2}$. The distance in the last but one second is 5 m, so: $5 = 0 + \frac{1}{2} \times 10(2n - 1)$

Step 3: Solve for n

Simplify the equation:$5 = 5(2n - 1) \Rightarrow \frac{5}{5} = 2n - 1 \Rightarrow 1 = 2n - 1 \Rightarrow 2n = 2 \Rightarrow n = 1$

This means the last but one second is the 1st second of the fall.

Question8

The ratio of the displacements of a freely falling body during second and fifth seconds of its motion is

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Options:

A.

1 : 1

B.

2 : 5

C.

4 : 25

D.

1 : 3

Answer: D

Solution:

$$\begin{aligned} \frac{h_2}{h_5} &= \frac{u+\frac{1}{2}g\left(2n_1-1\right)}{u+\frac{1}{2}g\left(2n_2-1\right)} \\ &= \frac{\frac{1}{2}g(2\times 2-1)}{\frac{1}{2}g(2\times 5-1)} = \frac{3}{9} = \frac{1}{3} \end{aligned}$$

$\therefore h_2 : h_5 = 1 : 3$

Question9

If a car travels 40% of the total distance with a speed v_1 and the remaining distance with a speed v_2, then average speed of the car is

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Options:

A.

$\frac{1}{2}\sqrt{v_1 v_2}$

B.

$\frac{v_1+v_2}{2}$

C.

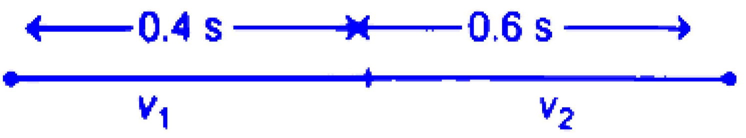
$\frac{2v_1 v_2}{v_1+v_2}$

D.

$\frac{5v_1 v_2}{3v_1+2v_2}$

Answer: D

Solution:



$$\begin{aligned} V_{\text{avg}} & =\frac{\text{total distance}}{\text{total time taken}} \\ & =\frac{0.4 \text{ s}+0.6 \text{ s}}{\frac{0.4 \text{ s}}{v_1}+\frac{0.6 \text{ s}}{v_2}} \\ & =\frac{\text{s}}{\frac{2 \text{ s}}{5} v_2+\frac{3 \text{ s}}{5} v_1} \\ & =\frac{5 v_1 v_2}{3 v_1+2 v_2} \end{aligned}$$

Question10

A diving board is at at height of h from the water surface. A swimmer standing on this board thrown a stone vertically upward with a velocity 16 ms^{-1}. It reaches the water surface in a time of 5 s . In the next 0.2 s the diver can hear the sound from water surface. The speed of sound is (acceleration due to gravity $g=10 \text{ ms}^{-2}$)

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Options:

A. 450 ms^{-1}

B. 225 ms^{-1}

C. 200 ms^{-1}

D. 275 ms^{-1}

Answer: B

Solution:

To solve the problem of finding the speed of sound, we begin by using the given data:

Initial velocity of the stone, $u = 16\,\text{m/s}$

Time taken for the stone to reach the water, $t = 5\,\text{s}$

Acceleration due to gravity, $g = 10\,\text{m/s}^2$

Now, using the equation of motion:

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

Substituting the known values:

$h = 16 \times 5 + \frac{1}{2} \times 10 \times (5)^2$

This simplifies to:

$h = 80 - 125$

$h = -45\,\text{m}$

The negative sign indicates that the stone has dropped 45 meters below its initial point on the diving board, reaching the water.

Next, to determine the speed of sound, we use the information that the diver hears the sound 0.2 seconds after the stone reaches the water. Thus, the sound covers a distance of 45 meters in 0.2 seconds.

Calculating the speed of sound:

$v = \frac{\text{distance}}{\text{time}} = \frac{45\text{ m}}{0.2\text{ s}} = 225\,\text{m/s}$

Thus, the speed of sound is $225\,\text{m/s}$.

Question11

A person walks up a stalled escalator in 90 s. When standing on the same moving escalator, he reached in 60s. The time it would take him to walk up the moving escalator will be

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Options:

A. 36 s

B. 72 s

C. 18 s

D. 27 s

Answer: A

Solution:

To determine the time it would take for a person to walk up a moving escalator, consider the following:

t_s is the time taken to walk up the stalled escalator: 90 seconds.

t_e is the time taken to reach the top while standing still on the moving escalator: 60 seconds.

When walking up the moving escalator, the combined speed of the person and the escalator must be considered:

$t_m = \frac{d}{v_p+v_e}$

Given that:

$v_p = \frac{d}{t_s} \quad \text{and} \quad v_e = \frac{d}{t_e}$

The formula becomes:

$t_m = \frac{d}{\left(\frac{d}{t_s}\right)+\left(\frac{d}{t_e}\right)} = \frac{1}{\frac{1}{t_s}+\frac{1}{t_e}}$

By substituting the given times:

$t_m = \frac{1}{\frac{1}{90}+\frac{1}{60}}$

Calculate the combined rate:

$t_m = \frac{1}{\frac{2}{180}+\frac{3}{180}} = \frac{1}{\frac{5}{180}} = \frac{180}{5}$

Finally:

$t_m = 36$ seconds

Therefore, the person would take 36 seconds to walk up the moving escalator.

Question12

A particle starts from rest and moves in a straight line. It travels a distance $2L$ with uniform acceleration and then moves with a constant velocity a further distance of L. Finally, it comes to rest after moving a distance of $3L$ under uniform retardation. Then, the ratio of average speed to the maximum speed $\left(\frac{v}{v_m}\right)$ of the particle is

Options:

A. $\frac{6}{11}$

B. $\frac{7}{11}$

C. $\frac{5}{11}$

D. $\frac{2}{11}$

Answer: A

Solution:

To find the ratio of the average speed to the maximum speed of the particle, let's break down the particle's motion into three phases:

Uniform Acceleration (Distance $2L$):

Initial velocity, $u_1 = 0$

Distance, $s_1 = 2L$

Final velocity, $v_1 = v_{\max}$

Using the equation of motion:

$$v_{\max}^2 = 0^2 + 2a_1 \times 2L \implies v_{\max} = 2\sqrt{a_1 L}$$

Time taken to travel $2L$:

$$v_{\max} = u_1 + a_1 t_1 \implies t_1 = \frac{v_{\max}}{a_1} = \frac{2\sqrt{a_1 L}}{a_1}$$

Constant Velocity (Distance L):

Velocity, $v_2 = v_{\max} = 2\sqrt{a_1 L}$

Distance, $s_2 = L$

Time taken to travel L:

$$t_2 = \frac{L}{v_{\max}} = \frac{L}{2\sqrt{a_1 L}}$$

Uniform Retardation (Distance $3L$):

Initial velocity, $u_3 = v_{\max} = 2\sqrt{a_1 L}$

Distance, $s_3 = 3L$

Final velocity, $v_3 = 0$

Using the equation of motion:

$v_3^2 = u_3^2 + 2a_3 s_3 \implies 0 = v_{\max}^2 - 2a_3 \times 3L$

$\Rightarrow v_{\max}^2 = 6a_3 L \implies 4a_1 L = 6a_3 L \implies a_3 = \frac{2}{3}a_1$

Time taken to travel $3L$:

$v_3 = u_3 + a_3 t_3 \implies 0 = v_{\max} - a_3 t_3 \implies t_3 = \frac{2\sqrt{a_1 L}}{\frac{2}{3}a_1} = \frac{3\sqrt{a_1 L}}{a_1}$

Total Time:

$T = t_1 + t_2 + t_3 = \frac{2\sqrt{a_1 L}}{a_1} + \frac{L}{2\sqrt{a_1 L}} + \frac{3\sqrt{a_1 L}}{a_1}$

$= \sqrt{L}\left(\frac{2}{\sqrt{a_1}} + \frac{1}{2\sqrt{a_1}} + \frac{3}{\sqrt{a_1}}\right)$

$= \sqrt{\frac{L}{a_1}}\left(2 + \frac{1}{2} + 3\right) = \frac{11}{2}\frac{\sqrt{L}}{\sqrt{a_1}}$

Total Distance:

$s_{\text{total}} = 2L + L + 3L = 6L$

Average Speed:

$v_{\text{avg}} = \frac{s_{\text{total}}}{T} = \frac{6L}{\frac{11}{2}\frac{\sqrt{L}}{\sqrt{a_1}}}$

$= \frac{12\sqrt{a_1 L}}{11}$

Ratio of Average Speed to Maximum Speed:

$\frac{v_{\text{avg}}}{v_{\max}} = \frac{12\sqrt{a_1 L}}{11 \times 2\sqrt{a_1 L}} = \frac{6}{11}$

Question13

The velocity of a particle is given by the equation $v(x) = 3x^2 - 4x$, where x is the distance covered by the particle. The expression for its acceleration is

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Options:

A. $(6x - 4)$

B. $6\left(3x^2 - 4x\right)$

C. $\left(3x^2 - 4x\right)(6x - 4)$

D. $(6x-4)^2$

Answer: C

Solution:

Given the velocity of a particle as $v(x)=3x^2-4x$, we need to find the expression for its acceleration. The formula that relates acceleration to velocity is:

$a=v\frac{dv}{dx}$

Let's derive the acceleration step by step:

Velocity Function:

$v(x)=3x^2-4x$

Find the Derivative $\frac{dv}{dx}$ of the Velocity:

$\frac{d}{dx}(3x^2-4x)=6x-4$

Substitute into the Acceleration Formula:

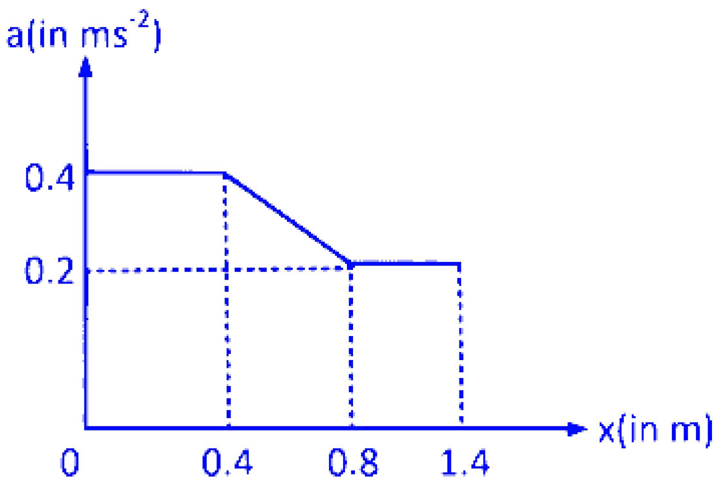
$a=(3x^2-4x)(6x-4)$

Thus, the acceleration is given by:

$a=(3x^2-4x)(6x-4)$

Question14

The acceleration of a particle which moves along the positive X-axis varies with its position as shown in the figure. If the velocity of the particle is $0.8\ \mathrm{ms}^{-1}$ at $x=0$, then its velocity at $x=1.4\ \mathrm{m}$ is (in ms^{-1})



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Options:

A. 1.6

B. 1.2

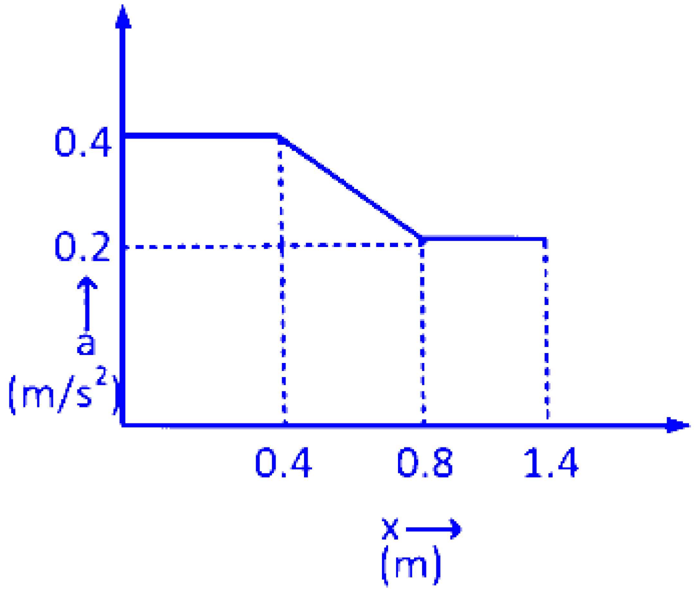
C. 1.4

D. 0.8

Answer: B

Solution:

As we know, Area under $a - x$ graph gives $\frac{v^2-u^2}{2}$



Area of the given curve is

$0.4 \times 0.2 + 0.4 \times 0.2 + 0.4$

$\times 0.2 + \frac{1}{2} \times 0.4 \times 0.2 + 0.6 \times 0.2$

$$\Rightarrow \quad \text{Area } = 0.4$$

$$\Rightarrow \quad v^2 - u^2 = 2 \times 0.4$$

$$\Rightarrow v^2 - u^2 = 0.8 \quad \ldots (ii)$$

$$\text{As, } u = 0.8 \text{ m/s}$$

$$\Rightarrow v^2 = 0.8 + (0.8)^2$$

$$\Rightarrow \quad v^2 = 1.44$$

$$\Rightarrow \quad v = 1.2 \text{ m/s}$$

Question15

An object projected upwards from the foot of a tower. The object crosses the top of the tower twice with an interval of 8 s and the object reaches foot after 16 s . The height of the tower is $\left(g = 10 \text{ ms}^{-2}\right)$

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Options:

A. 220 m

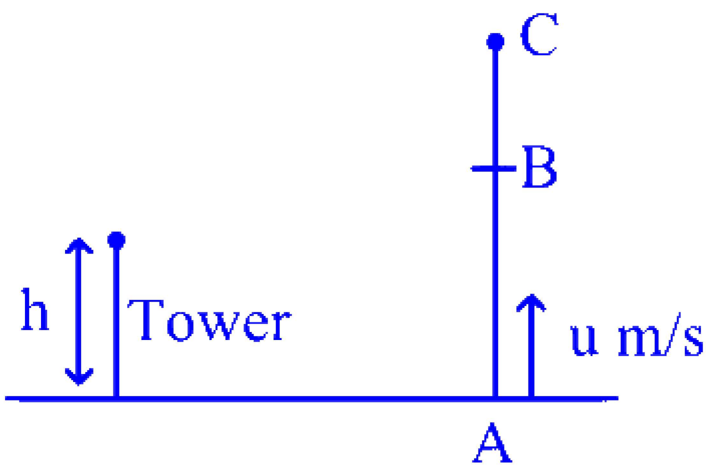
B. 240 m

C. 640 m

D. 80 m

Answer: B

Solution:



Let, height of tower $= h$

According to question,

$$t_{BC} = \frac{8}{2} = 4 \text{ s}$$
$$t_{AC} = \frac{16}{2} = 8 \text{ s}$$
$$\therefore t_{AB} = 4 \text{ s}$$

By using first equation of motion, as at top ($v = 0$)

$$\therefore \quad 0 = v - 10 \times 8$$
$$u = 80 \text{ m/s}$$

When we throw the object upward, then the distance travelled by it in initial 4 s is equal to the height of tower.

$$\text{i.e. } h = ut_{AB} - \frac{1}{2}gt_{AB}^2$$
$$h = 80 \times 4 - \frac{1}{2} \times 10 \times 16$$
$$h = 320 - 80$$
$$h = 240 \text{ m}$$

Question16

The relation between time t and displacement x is $t = \alpha x^2 + \beta x$, where α and β are constants. If v is the velocity, the retardation is

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Options:

A. $2\alpha v^3 \beta^2$

B. $2\alpha\beta v^3$

C. $-2\beta v^3$

D. $2\alpha v^3$

Answer: D

Solution:

To find the retardation when the relation between time t and displacement x is given by $t = \alpha x^2 + \beta x$, where α and β are constants, follow these steps:

Step 1: Calculate the Velocity

Differentiate the given equation with respect to x to find the expression for velocity v.

$\frac{dt}{dx} = \frac{d}{dx}(\alpha x^2 + \beta x) = 2\alpha x + \beta$

Since velocity $v = \frac{dx}{dt}$, it follows that:

$v = \frac{1}{\frac{dt}{dx}} = \frac{1}{2\alpha x+\beta} = (2\alpha x + \beta)^{-1}$

Step 2: Calculate Retardation

To find retardation, differentiate the expression for velocity with respect to time. Since $v = (2\alpha x + \beta)^{-1}$, use the chain rule to find:

$v\frac{dv}{dx} = -2\alpha(2\alpha x + \beta)^{-2} \times \frac{1}{2\alpha x+\beta}$

This simplifies to:

$a = -2\alpha v^3$

Thus, the expression for retardation is:

$\text{Retardation} = 2\alpha v^3$

This means the magnitude of the retardation is given by $2\alpha v^3$, indicating an opposing force to the motion with this magnitude.

Question17

A body starting from rest moving with an acceleration of $\frac{5}{4}$ ms^{-2}. The distance travelled by the body in the third second is

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Options:

A. $\frac{15}{8} m$

B. $\frac{25}{8} m$

C. $\frac{25}{4} m$

D. $\frac{12}{7} m$

Answer: B

Solution:

The body starts from rest, so the initial speed $u = 0$. It has an acceleration given by:

$a = \frac{5}{4}\ \mathrm{m/s^2}$

To find the distance traveled by the body in the n-th second, we use the formula:

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

where $n = 3$.

Substituting the values into the formula, we get:

$s_3 = 0 + \frac{5}{4} \times \frac{1}{2}(2 \times 3 - 1)$

Calculating further:

$s_3 = \frac{5}{8} \times 5 = \frac{25}{8}\ \mathrm{m}$

Question18

A car travelling at 80 kmph can be stopped at a distance of 60 m by applying brakes. If the same car travels at 160 kmph and the same braking force is applied, the stopping distance is

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Options:

A. 240 m

B. 170 m

C. 360 m

D. 480 m

Answer: A

Solution:

To determine the stopping distance of a car traveling at a higher speed when the same braking force is applied, we can use the physics equation:

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

Here, v is the final velocity (0, since the car stops), u is the initial velocity, a is the retardation (deceleration), and s is the stopping distance.

Initial Scenario

Initial Velocity (u):

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

Retardation (a):

Using the equation:

$0 = \left(\frac{200}{9}\right)^2 - 2a \times 60$

Solve for a:

$a = \frac{200\times200}{9\times9\times2\times60} = \frac{1000}{243}\text{ m/s}^2$

Second Scenario

New Initial Velocity (u_1):

$u_1 = 160\,\text{km/h} = 160 \times \frac{5}{18}\text{ m/s} = \frac{400}{9}\text{ m/s}$

Stopping Distance (s_1):

Using the equation:

$0 = \left(\frac{400}{9}\right)^2 - 2\left(\frac{1000}{243}\right)s_1$

Solve for s_1:

$s_1 = 240\,\text{m}$

Thus, if the car travels at 160 km/h with the same braking force, the stopping distance is 240 meters.

Question19

A student is at a distance 16 m from a bus when the bus begins to move with a constant acceleration of $9 \mathrm{~m} \mathrm{~s}^{-2}$. The minimum velocity with which the student should run. towards the bus so as the catch it is $\alpha \sqrt{2} \mathrm{~ms}^{-1}$. The value of α is

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Options:

A. 10

B. 12

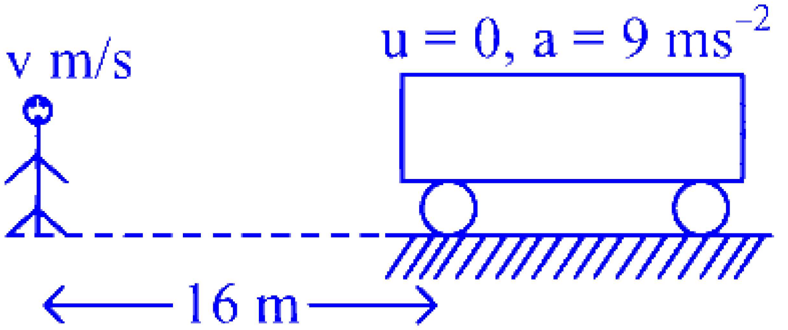
C. 15

D. 20

Answer: B

Solution:

Let v be the minimum velocity of student so, that he could catch the bus



If student catch the bus in time t, then distance travelled by student in time $t=16+$ distance travelled by bus in time t.

$\Rightarrow v t=16+\left(u t+\frac{1}{2} a t^2\right)$

$\Rightarrow v t=16+0 \times t+\frac{1}{2} \times 9 \times t^2$

$\Rightarrow v t=16+\frac{9}{2} t^2 \Rightarrow 9 t^2-2 v t+32=0$

The above equation must have real roots. i.e its discriminant ≥ 0

$$\text{i.e } (2v)^2 - 4 \times 9 \times 32 \geq 0$$
$$\Rightarrow 4v^2 - 4 \times 288 \geq 0 \Rightarrow v^2 - 288 \geq 0$$
$$\Rightarrow v^2 \geq 288$$
$$v \geq 12\sqrt{2} \mathrm{~m/s}$$

Minimum velocity of student to catch the bus $= 12\sqrt{2} \mathrm{~m/s} = \alpha\sqrt{2} \mathrm{~m/s}$ (given)

$\therefore \alpha = 12$

Question20

An object moving along X-axis with a uniform acceleration has velocity $\mathbf{v} = \left(12 \mathrm{cms}^{-1}\right)\hat{\mathbf{i}}$ at $x = 3$ cm. After 2 s if it is at $x = -5$ cm, then its acceleration is

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Options:

A. $\mathbf{a} = \left(-16 \mathrm{~cms}^{-2}\right)\hat{i}$

B. $\mathbf{a} = \left(11 \mathrm{~cms}^{-2}\right)\hat{i}$

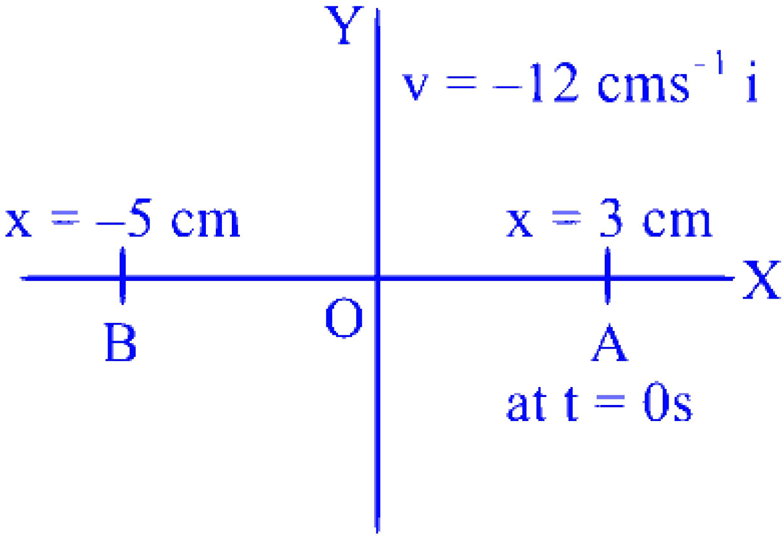
C. $\mathbf{a} = \left(-11 \mathrm{~cms}^{-2}\right)\hat{i}$

D. $\mathbf{a} = \left(8 \mathrm{~cms}^{-2}\right)\hat{i}$

Answer: A

Solution:

The given situation is shown below



At time $t = 0$ object is at point A with a distance of 3 cm.

At time $t = 2$ s object reaches from point A to point B. i.e in negative direction of X-axis.

$\therefore$ Distance travelled by the object in 2 s,

$d = 3 - (-5) = 3 + 5 = 8$ cm
$d = 8\hat{i}$

Initial velocity of object along X-axis,

$\mathbf{v} = -12\hat{i}$ cm/s

By using second equation of motion,

$$\mathbf{d} = \mathbf{u}t + \frac{1}{2}\mathbf{a}t^2$$

$\Rightarrow 8\hat{i} = -12\hat{i} \times 2 - \frac{1}{2}\mathbf{a} \times 4 \Rightarrow 8\hat{i} = -24\hat{i} - 2\mathbf{a}$

$\Rightarrow 2\mathrm{a} = -32\hat{i} \Rightarrow \mathbf{a} = -16\hat{i}$ cm/s^2

Question21

$y = (Pt^2 - Qt^3)$ m is the vertical displacement of a ball which is moving in vertical plane. Then the maximum height that the ball can reach is

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Options:

A. $\frac{27P^3}{4Q^2}$

B. $\frac{4Q^2}{27P^3}$

C. $\frac{4P^3}{27Q^2}$

D. $\frac{27Q^2}{4P^3}$

Answer: C

Solution:

Displacement equation of ball moving in vertical plane, $y = Pt^2 - Qt^3$

The ball will reach at maximum height, if

$\frac{dy}{dt} = 0$

$$\frac{d}{dt}\left(Pt^2 - Qt^3\right) = 0$$

$$\Rightarrow \quad 2Pt - 3Qt^2 = 0 \Rightarrow t(2P - 3Qt) = 0$$

$$\therefore \quad t \neq 0, 2P - 3Qt = 0$$

$$\Rightarrow \quad t = \frac{2P}{3Q}$$

$\because$ Maximum height attained by the ball,

$$y_{\max} = Pt^2 - Qt^3$$

When, $t = \frac{2P}{3Q}$

$$= P\left(\frac{2P}{3Q}\right)^2 - Q\left(\frac{2P}{3Q}\right)^3$$

$$= \frac{4P^3}{9Q^2} - \frac{8P^3}{27Q^2} = \frac{4P^3}{27Q^2}$$

Question22

A car covers a distance at speed of 60 km h^{-1}. It returns and comes back to the original point moving at a speed of v. If the average speed for the round trip is 48 kmh^{-1}, then the magnitude of v is

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Options:

A. 40 km h^{-1}

B. 36 km h^{-1}

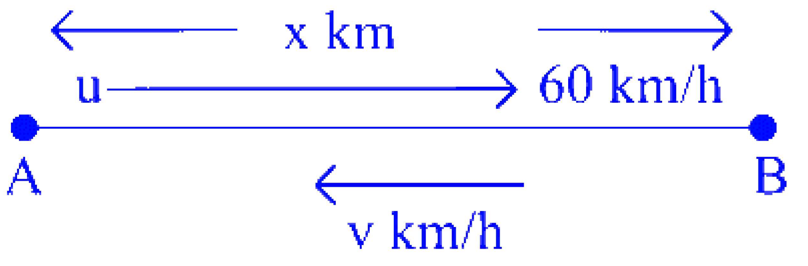
C. 44 km h^{-1}

D. 32 km h^{-1}

Answer: A

Solution:

Suppose the car covers distance x km from location A to B with speed of 60 kmh^{-1}.



$$\begin{aligned} \text{i.e} \quad & v_{AB} = 60 \text{ km/h} \\ \text{and} \quad & v_{BA} = v \text{ km/h} \end{aligned}$$

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

$$48 = \frac{x+x}{t_{AB}+t_{BA}} \quad \text{... (i)}$$

Now, $t_{AB} = \frac{x}{60}$ \$and\$ $t_{BA} = \frac{x}{v}$

From Eq.(i), we have

$$48 = \frac{x+x}{\frac{x}{60}+\frac{x}{v}}$$

$$\Rightarrow \quad 48 = \frac{2}{\frac{1}{60}+\frac{1}{v}} \Rightarrow 48 = \frac{2 \times 60v}{v+60}$$

$$\Rightarrow 48v + 2880 = 120v \Rightarrow 72v = 2880$$

$$v = \frac{2880}{72}$$

$$= 40 \text{ km h}^{-1}$$

Question23

An object is moving with a uniformacceleration which is parallel to itsinstantaneous direction of motion. Thedisplacement-velocity graph of this object is

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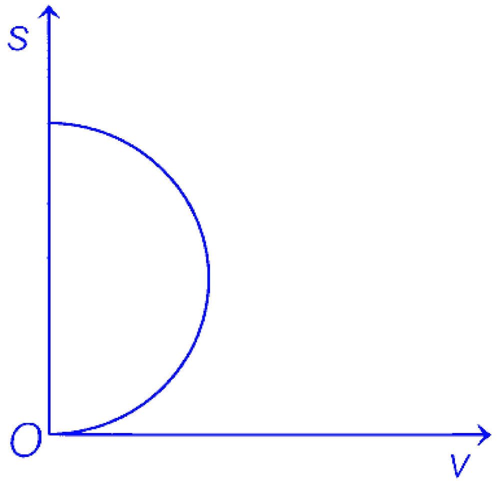
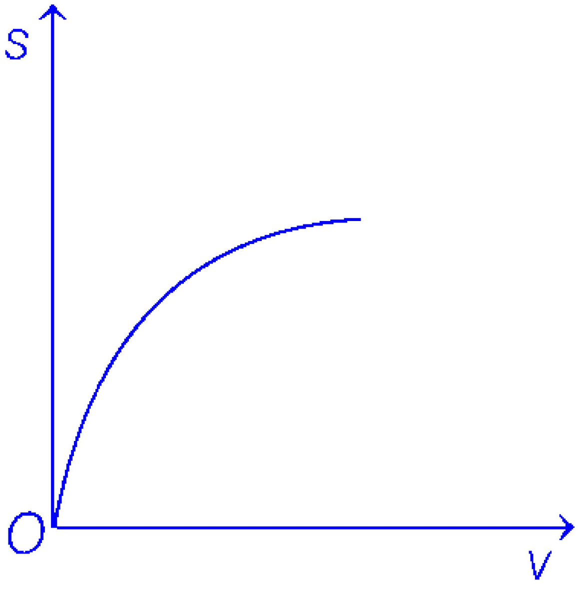
Options:

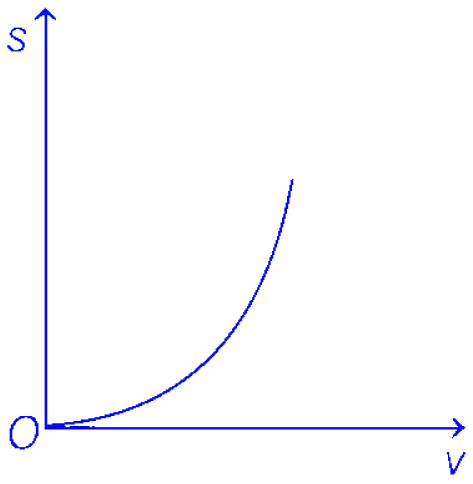
A.



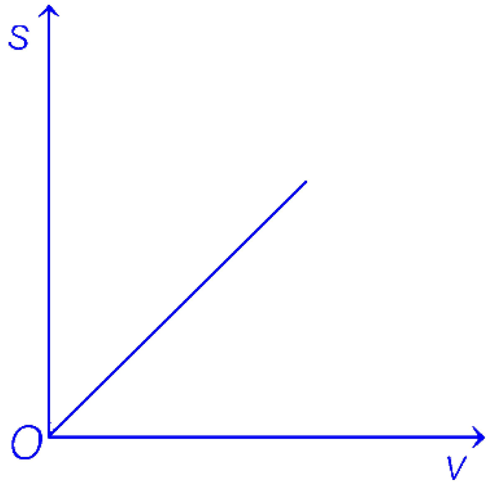
B.



C.



D.



Answer: C

Solution:

Given, value of uniform acceleration $= a$

Displacement $= s$

Velocity $= v$

By using equation of parabola,

$y = mx^2 + c$

and 3rd equation of motion,

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

If $u = 0 \text{ ms}^{-1}$

$\therefore v^2 = 2as \Rightarrow s = \frac{1}{2a}v^2 + 0$

Hence, parabola starts from origin.

Question24

The displacement of a particle starting from rest at $t = 0$ is given by $s = 9t^2 - 2t^3$. The time in seconds at which the particle will attain zero velocity is

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Options:

A. 8 s

B. 6 s

C. 4 s

D. 3 s

Answer: D

Solution:

Given,

Displacement of particle, $s = 9t^2 - 2t^3$

Initial velocity, $u = 0 \text{ ms}^{-1}$

Velocity, $v = \frac{ds}{dt} = \frac{d}{dt}\left(9t^2 - 2t^3\right) \Rightarrow v = 18t - 6t^2$

Since, $\quad v = 0$

$\Rightarrow 18t - 6t^2 = 0 \Rightarrow t = 3 \text{ s}$

Question25

Two cars A and B are moving with a velocityof 30 km/h in the same direction. They areseparated by 10 km. The speed of another carC moving in the opposite direction, if it meetsthese two cars at an interval of eight minutesis

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Options:

A. 45 km/h

B. 40 km/h

C. 15 km/h

D. 30 km/h

Answer: A

Solution:

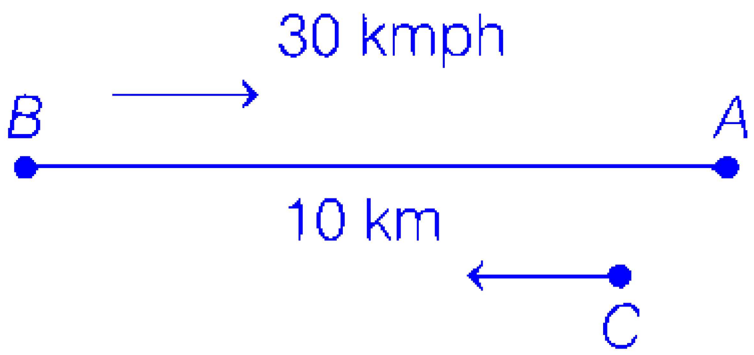
Given, velocity of car A and B, = 30 km/h

Separation between two cars A and B = 10 km

Let velocity of car C be v_c

Time taken, t = 8 min = 8/60 h

Therefore,



$$\therefore v_C + 30 = \frac{A \times B}{t} = \frac{10 \times 60}{8}$$

$$\Rightarrow v_C + 30 = 75$$

$$\Rightarrow v_C = 75 - 30 = 45 \text{ km/h}$$

Question26

An object travelling at a speed of 36 km/hcomes to rest in a distance of 200 m after thebrakes were applied. The retardationproduced by the brakes is

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Options:

A. 0.25 ms^{-2}

B. 0.20 ms^{-2}

C. 0.15 ms^{-2}

D. 0.10 ms^{-2}

Answer: A

Solution:

Given, initial speed, u = 36 km/h = 10 ms^{-1}

Final speed, v = 0 ms^{-1}

Distance travelled, s = 200 m

Let retardation be a.

$$\because \quad v^2 - u^2 = 2as$$
$$\therefore \quad a = \frac{v^2 - u^2}{2s} = \frac{0 - 10^2}{2 \times 200} = -\frac{100}{400} = -0.25 \text{ ms}^{-2}$$
$$\therefore \quad \text{Retardation } (a) = 0.25 \text{ ms}^{-2}$$

Question27

A ball is projected upwards. Its accelerationat the highest point is

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Options:

A. zero

B. directed upward

C. directed downwards

D. such as cannot be predicted

Answer: C

Solution:

Given, as we know that gravity always pullsthe body towards ground and at maximum height,speed of body will be zero, so net acceleration ofbody will be g towards earth (downward).

Question28

Which of the following decreases, in motionon a straight line, with constant retardation?

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Options:

A. Speed

B. Acceleration

C. Displacement

D. Distance

Answer: A

Solution:

As we know that,In case of retardation, the velocity of the bodyreduces continuously and as the body is moving ina straight line. Therefore, displacement of thebody will be equal to distance.

Hence, velocity of body is equal to speed andspeed of body will decrease due to retardation.
