Motion

Question1

A car moving at a speed ' V ' is stopped in a certain distance when the breaks produce a deceleration ' a '. If the speed of the car is ' nv ', what must be the deceleration of the car to stop it in the same distance and in the same time?

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Options:

A.

$\sqrt{n} \cdot a$

B.

$n \cdot a$

C.

$n^2 \cdot a$

D.

$\mathrm{n}^3 \cdot \mathrm{a}$

Answer: C

Solution:

Step 1: The equation for stopping distance

We use the formula: $v_f^2 - v_i^2 = 2as$, where v_f is the final speed, v_i is the starting speed, a is deceleration, and s is the distance.

Step 2: First case – Car starts at speed v

When the car starts at speed v and stops ($v_f = 0$), the equation becomes:
$0^2 - v^2 = 2as \Rightarrow -v^2 = 2as$

So, the stopping distance is:
$s = \frac{-v^2}{2a}$

Step 3: Second case – Car starts at speed nv

If the car instead moves at speed nv and stops ($v_f = 0$), the equation becomes:
$0^2 - (nv)^2 = 2a's \Rightarrow -n^2v^2 = 2a's$

The stopping distance is:
$s = \frac{-n^2v^2}{2a'}$

Step 4: Set both stopping distances equal (since distance is the same)

Since both cars stop over the same distance, set the distances equal to each other:
$\frac{-v^2}{2a} = \frac{-n^2v^2}{2a'}$

Step 5: Solve for the new deceleration (a')

Cross-multiply and solve for a':
$a' = n^2a$

So, to stop in the same distance with n times the speed, the car needs n^2 times more deceleration.

Question2

A boy throws a ball vertically upwards from a bridge with velocity $5\ \mathrm{m/s}$. It strikes water surface after 2 s . The height of the bridge is (Take $\mathrm{g} = 10\ \mathrm{m/s^2}$)

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Options:

A. 20 m

B. 15 m

C. 12 m

D. 10 m

Answer: D

Solution:

Displacement equation for motion under

$$s = ut + \frac{1}{2}(-g)t^2$$
$$s = 5(2) - \frac{1}{2}(10)2^2$$
$$= 10 - 20$$
$$= -10 \text{ m}$$

Net displacement is -10 m i.e the ball ends up 10 m below the point it was thrown from

$\therefore$ The height of the bridge $= 10$ m

Question3

Two girls are standing at the ends ' A ' and ' B ' of a ground where $\mathrm{AB} = \mathrm{b}$. The girl at ' B ' starts running in a direction perpendicular to ' AB ' with velocity ' V_1 '. The girl at ' A ' starts running simultaneously with velocity ' V_2 ' and in shortest distance meets the other girl in time ' t '. The value of ' t ' is

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Options:

A. $\frac{b}{\sqrt{V_1{}^2+V_2{}^2}}$

B. $\frac{b}{V_1+V_2}$

C. $\frac{b}{V_2-V_1}$

D. $\frac{b}{\sqrt{V_2{}^2-V_1{}^2}}$

Answer: D

Solution:

Let distance covered by girl running from point B be ' x ',

$\therefore \quad \mathrm{x} = \mathrm{V}_1 \mathrm{t} \qquad \ldots (i)$

Let distance covered by girl running from point A in time ' t ' be ' y ',

$\therefore \quad y=V_2 t \qquad \ldots(ii)$

Given that, B follows a perpendicular path and A follows the shortest path, i.e. $y=\sqrt{b^2+x^2}$

$\therefore \quad \mathrm{y}^2=\mathrm{b}^2+\mathrm{x}^2$

Substituting from equation (i) \& (ii),

$$V_2^2 t^2=b^2+V_1^2 t^2$$

$$\therefore \quad t=\frac{b}{\sqrt{V_2^2-V_1^2}}$$

Question4

Two boys are standing at points A and B on ground, where distance $\mathrm{AB}=\mathrm{x}$. The boy at B stars running perpendicular to AB with velocity v_1. The boy at A starts running simultaneously with velocity v and meets the other boy in time t. The value of t is

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Options:

A. $\left[\frac{x}{v-v_1}\right]^{1/2}$

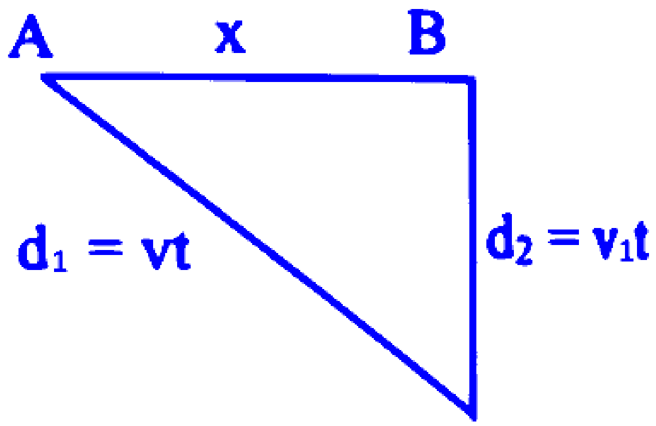
B. $\left[\frac{x}{v_1-v}\right]^{1/2}$

C. $\left[\frac{x^2}{v^2-v_1^2}\right]^{1/2}$

D. $\left[\frac{x^2}{v_1^2-v^2}\right]^{1/2}$

Answer: C

Solution:



Distance covered by boy running from point A in time ' t ':

$d_1 = vt$

Distance covered by boy running from point B in time ' t ':

$d_2 = v_1 t$

By Pythagoras theorem,

$$d_1^2 = x^2 + d_2^2$$

$$\therefore \quad (vt)^2 = x^2 + (v_1 t)^2$$

$$\therefore \quad (v^2 - v_1^2) t^2 = x^2$$

$$\therefore \quad t = \left(\frac{x^2}{v^2 - v_1^2}\right)^{1/2}$$

Question5

A body when projected at an angle ' θ ' with the horizontal reaches a maximum height ' H '. The time of flight of the body will be ($g =$ acceleration due to gravity)

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Options:

A. $\frac{1}{2}\sqrt{\frac{2H}{g}}$

B. $\sqrt{\frac{g}{2H}}$

C. $2\sqrt{\frac{2H}{g}}$

D. $\sqrt{\frac{2H}{g}}$

Answer: C

Solution:

Step 1: Relation for maximum height

For a projectile, the vertical component of velocity:

$u_y = u\sin\theta$

Maximum height:

$H = \frac{u_y^2}{2g} = \frac{(u\sin\theta)^2}{2g}$

$\therefore u\sin\theta = \sqrt{2gH}$

Step 2: Total time of flight

Time of flight:

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

Substitute $u\sin\theta = \sqrt{2gH}$:

$T = \frac{2\sqrt{2gH}}{g}$

$T = 2\sqrt{\frac{2H}{g}}$

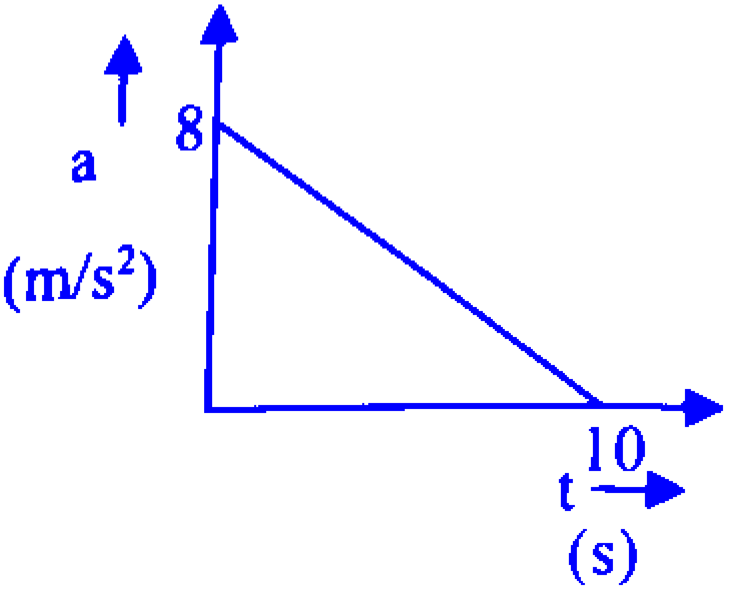
✅ **Final Answer:**

$\boxed{2\sqrt{\frac{2H}{g}}}$

Correct option: C

Question6

The acceleration (a) - time (T) graph for the body starting from rest is given below. The maximum speed of the body is



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Options:

A. $40 \mathrm{~m/s}$

B. $80 \mathrm{~m/s}$

C. $160 \mathrm{~m/s}$

D. $200 \mathrm{~m/s}$

Answer: A

Solution:

The velocity of the particle is given by $\Delta \mathrm{v} = \mathrm{a} \times \mathrm{t}$

From the graph, velocity is given by area under the a-t curve.

$$\therefore \quad \Delta v = \frac{1}{2} \times 10 \times 8$$
$$\therefore \quad \Delta v = 40 \mathrm{~m/s}$$
$$\therefore \quad \Delta v = 40 \mathrm{~m/s}$$

As the body starts from rest, $\therefore v_{\max} = 40 \mathrm{~m/s}$

Question7

At any time ' t ', the co-ordinates of moving particle are $x=at^2$ and $y=bt^2$. The speed of the particle is

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Options:

A. $2t\sqrt{a^2+b^2}$

B. $2t\sqrt{a^2-b^2}$

C. $2\mathrm{t}(\mathrm{a}+\mathrm{b})$

D. $\frac{2t}{\sqrt{a^2+b^2}}$

Answer: A

Solution:

x-component of velocity

$\mathrm{v_x}=\frac{\mathrm{dx}}{\mathrm{dt}}=\frac{\mathrm{d}}{\mathrm{dt}}(\mathrm{at}^2)=2\mathrm{at}$

y - component of velocity

$v_y=\frac{dy}{dt}=\frac{d}{dt}(bt^2)=2bt$

Speed of the particle is the magnitude of the velocity $\mathrm{v}=\sqrt{\mathrm{v_x^2}+\mathrm{v_y^2}}$

$$\begin{aligned}\therefore \quad v &= \sqrt{(2at)^2+(2bt)^2} \\ &= \sqrt{4a^2t^2+4b^2t^2} \\ &= 2t\sqrt{a^2+b^2}\end{aligned}$$

Speed of the particle is $2t\sqrt{a^2+b^2}$

Question8

A body starts from rest and moves with a uniform acceleration. The ratio of the distance covered by the body in the n^{th} second of its motion to the total distance travelled in n second is

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Options:

A. $\frac{2}{n^2} - \frac{1}{n}$

B. $\frac{2}{n} - \frac{1}{n^2}$

C. $\frac{1}{\mathrm{n}} - \frac{1}{\mathrm{n}^2}$

D. $\frac{2}{\mathrm{n}^2} + \frac{1}{\mathrm{n}}$

Answer: B

Solution:

We're asked:

A body starts from rest and moves with uniform acceleration a.

We want the ratio of the distance covered in the n^{th} second to the total distance covered in n seconds.

Step 1: Recall standard kinematic results

- Initial velocity $u = 0$.
- Total distance in n seconds:

$$S_n = \frac{1}{2}an^2$$

- Distance covered in the n^{th} second:

$$s_n = u + \frac{1}{2}a(2n-1) = \frac{1}{2}a(2n-1) \quad \text{(since } u = 0\text{)}$$

Step 2: Ratio

$$\text{Ratio} = \frac{s_n}{S_n} = \frac{\frac{1}{2}a(2n-1)}{\frac{1}{2}an^2} = \frac{2n-1}{n^2}$$

Step 3: Simplify

$$\frac{2n-1}{n^2} = \frac{2n}{n^2} - \frac{1}{n^2} = \frac{2}{n} - \frac{1}{n^2}$$

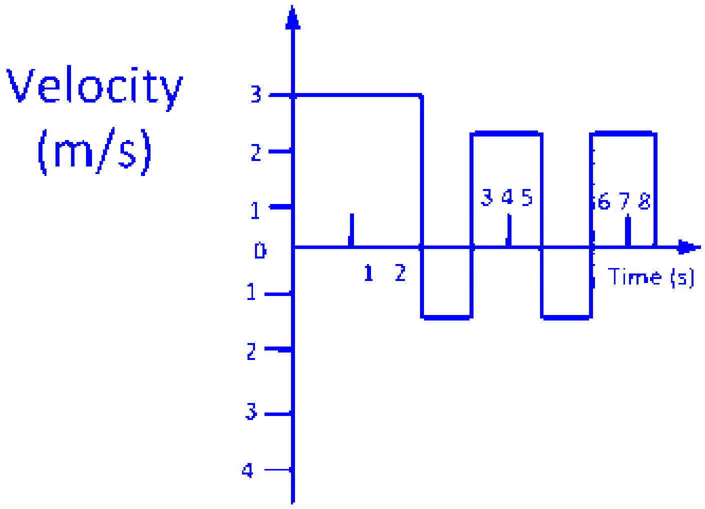
Answer:

$$\boxed{\frac{2}{n} - \frac{1}{n^2}}$$

That corresponds to **Option B**. ✅

Question9

The velocity time graph of a body moving in a straight line is shown in figure. The ratio of displacement to distance travelled by the body in time 0 to 8 s is



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Options:

A. 8 : 5

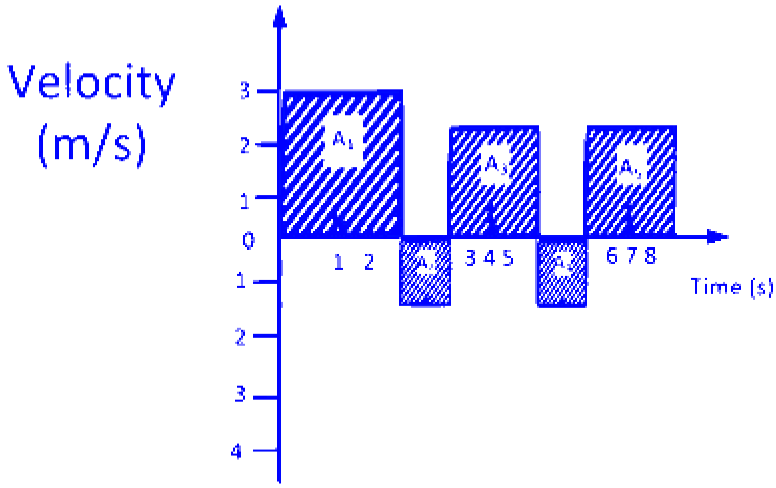
B. 3 : 5

C. 5 : 9

D. 7 : 4

Answer: C

Solution:



Area under the curve of velocity - time graph gives the distance travelled by the particle.

If the area under the curve is above the x -axis, then the displacement of the particle is positive and if the area under the curve is below the x -axis then the displacement of the particle is negative.

$\therefore$ Displacement of the particle will be given by

$$\text{Displacement } = A_1 - A_2 + A_3 - A_4 + A_5 = (3 \times 2) - (1 \times 2) + (2 \times 2) - (1 \times 2) + (2 \times 2) = 6 - 2 + 4 - 2 + 4 = 10$$

Distance travelled will be magnitude of the area under the curves.

$$\therefore \text{Distance } = A_1 + A_2 + A_3 + A_4 + A_5 = (3 \times 2) + (1 \times 2) + (2 \times 2) + (1 \times 2) + (2 \times 2) = 6 + 2 + 4 + 2 + 4 = 18$$

Question10

Two bodies A and B move in same straight line starting from same position. Body moves with constant velocity ' u ' and body B moves with constant acceleration ' a '. When their velocities become equal, the distance between them is

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Options:

A. $\frac{\mathrm{u}}{2\mathrm{a}}$

B. $\frac{\mathrm{u}^2}{4\mathrm{a}}$

C. $\frac{u^2}{a}$

D. $\frac{u^2}{2a}$

Answer: D

Solution:

For body B moving with acceleration a, initial velocity is zero and final velocity is u.

$\therefore \quad u^2 = 2as \Rightarrow s = \frac{u^2}{2a}$

If the time taken to attain this velocity is t, then $\mathrm{u} = \mathrm{at} \Rightarrow \mathrm{t} = \frac{\mathrm{u}}{\mathrm{a}}$

For body A, distance travelled is given by,

$s' = ut = u \times \frac{u}{a} = \frac{u^2}{a}$

Hence distance between A and B is

$\mathrm{s}' - \mathrm{s} = \frac{\mathrm{u}^2}{\mathrm{a}} - \frac{\mathrm{u}^2}{2\mathrm{a}} = \frac{\mathrm{u}^2}{2\mathrm{a}}$

Question11

A force acting on a body of mass 5 Kg is $(4\hat{i} - 2\hat{j} + 3\hat{k})\mathrm{N}$. If the body is initially at rest then the magnitude of its velocity at the end of 10 second in $\mathrm{m/s}$ will be

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Options:

A. $3\sqrt{35}$

B. $2\sqrt{29}$

C. $\sqrt{19}$

D. $3\sqrt{23}$

Answer: B

Solution:

Mass $\quad m = 5kg$

$\vec{F} = (4\hat{i} - 2\hat{j} + 3\hat{k})N$

Using Newton's second law $\overrightarrow{\mathrm{F}} = m\overrightarrow{\mathrm{a}}$

$$\vec{a} = \frac{\vec{F}}{m} = \frac{4\hat{i} - 2\hat{j} + 3\hat{k}}{5}$$

$$\vec{a} = \left(\frac{4}{5}\hat{i} - \frac{2}{5}\hat{j} + \frac{3}{5}\hat{k}\right)\mathrm{m/s^2}$$

$$\vec{v} = \vec{v}_0 + \vec{a}t$$

$\overrightarrow{\mathrm{v}_0} = 0 \quad \because$ body was initially at rest

$$\overrightarrow{\mathrm{v}} = \left(\frac{4}{5}\hat{\mathrm{i}} - \frac{2}{5}\hat{\mathrm{j}} + \frac{3}{5}\hat{\mathrm{k}}\right) \cdot 10$$

$$\overrightarrow{\mathrm{v}} = 8\hat{\mathrm{i}} - 4\hat{\mathrm{j}} + 6\hat{\mathrm{k}}$$

Magnitude of final velocity

$$|\vec{v}| = \sqrt{v_x^2 + v_y^2 + v_x^2}$$
$$= \sqrt{8^2 + (-4)^2 + 6^2}$$
$$= \sqrt{64 + 16 + 36}$$
$$= \sqrt{116}$$
$$|\vec{v}| = 2\sqrt{29}\ \mathrm{m/s}$$

Question12

A body travelling with uniform acceleration crosses two points A and B with velocities $20\ \mathrm{m/s}$ and $30\ \mathrm{m/s}$ respectively. The speed of the body at mid point of A and B is (nearly)

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Options:

A. $25\ \mathrm{m/s}$

B. $25.5\ \mathrm{m/s}$

C. $24\ \mathrm{m/s}$

D. $10\sqrt{6}\ \mathrm{m/s}$

Answer: B

Solution:

When a body moves with uniform acceleration, it crosses two points, A and B, with velocities of 20 m/s and 30 m/s, respectively. We want to determine the body's speed at the midpoint between A and B.

First, let a be the acceleration of the body, and let d be the distance between the points A and B. According to the equation of motion, we have:

$v^2 - u^2 = 2ad \quad$ (where v is final velocity and u is initial velocity)

Substituting the given values:

$ad = \frac{v^2-u^2}{2} = \frac{30^2-20^2}{2} = \frac{900-400}{2} = 250$

Now, to find the speed at the midpoint of AB, we use the same equation for the speed v_1 at the midpoint:

$v_1^2 - 20^2 = 2a\left(\frac{d}{2}\right)$

Solving for v_1^2:

$v_1^2 - 400 = ad \Rightarrow v_1^2 = ad + 400 = 250 + 400 = 650$

Therefore, the speed at the midpoint is:

$v_1 = \sqrt{650} \approx 25.5 \mathrm{~m/s}$

Question13

The co-ordinates of a moving particle at any time ' t ' are given by $x = \alpha t^3$ and $y = \beta t^3$ where α and β are constants. The speed of the particle at time ' t ' is given by

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Options:

A. $t\sqrt{\alpha^2+\beta^2}$

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

C. $t^2\sqrt{\alpha^2+\beta^2}$

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

Answer: D

Solution:

$X = \alpha t^3 \hat{i} + \beta t^3 \hat{j}$

$V = \frac{dX}{dt} = 3\alpha t^2 \hat{i} + 3\beta t^2 \hat{j}$

$$\begin{aligned} \text{Magnitude of } V &= \sqrt{(3\alpha t^2)^2 + (3\beta t^2)^2} \\ &= \sqrt{9\alpha^2 t^4 + 9\beta^2 t^4} \\ &= \sqrt{9t^4(\alpha^2 + \beta^2)} \\ &= 3t^2\sqrt{\alpha^2 + \beta^2} \end{aligned}$$

Question14

A ball is released from the top of a tower of height Hm . It takes T second to reach the ground. The height of the ball from the ground after $\frac{T}{4}$ second is

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Options:

A. $\frac{13\text{H}}{14}$

B. $\frac{15\text{H}}{16}$

C. $\frac{11\text{H}}{12}$

D. $\frac{9\text{H}}{10}$

Answer: B

Solution:

The motion of the ball is described by the equations of uniformly accelerated motion. Given that the ball is released from rest, the initial velocity $u = 0$. The distance covered by the ball after time t is given by:

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

Since $u = 0$, this simplifies to:

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

where g is the acceleration due to gravity.

The total time T taken to fall from height H is given by:

$H = \frac{1}{2}gT^2$

To find the height of the ball from the ground after $\frac{T}{4}$ seconds, we calculate the distance it falls in this time:

Calculate the distance fallen in $\frac{T}{4}$ seconds:

$s_{\frac{T}{4}} = \frac{1}{2}g\left(\frac{T}{4}\right)^2 = \frac{1}{2}g\frac{T^2}{16} = \frac{gT^2}{32}$

Since $H = \frac{1}{2}gT^2$, solve for gT^2:

$gT^2 = 2H$

Substitute $gT^2 = 2H$ into the equation for $s_{\frac{T}{4}}$:

$s_{\frac{T}{4}} = \frac{2H}{32} = \frac{H}{16}$

The height of the ball above the ground after $\frac{T}{4}$ seconds is the original height minus the distance fallen:

Height above ground $= H - \frac{H}{16} = \frac{16H}{16} - \frac{H}{16} = \frac{15H}{16}$

Thus, the height of the ball from the ground after $\frac{T}{4}$ seconds is $\frac{15H}{16}$. Therefore, the correct option is **Option B:** $\frac{15\text{H}}{16}$.

Question15

Two cars start from a point at the same time in a straight line and their positions are represented by $x_1(t) = at + bt^2$ and $x_2(t) = Ft - t^2$. At what time do the cars have the same velocity?

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Options:

A. $\frac{a+F}{2(b-1)}$

B. $\frac{a-F}{1+b}$

C. $\frac{a+F}{2(1+b)}$

D. $\frac{F-a}{2(1+b)}$

Answer: D

Solution:

$$\text{Velocity } v=\frac{dx}{dt}$$

$$\therefore \quad v_p=\frac{dx_p}{dt}=a+2bt$$

$$v_Q=\frac{dx_Q}{dt}=F-2t$$

$$\text{as } v_p=v_Q \quad \text{... (given)}$$

$$a+2bt=F-2t$$

$$\therefore \quad (2+2b)t=F-a \quad \Rightarrow t=\frac{F-a}{2(1+b)}$$

Question16

A bullet is fired on a target with velocity V . Its velocity decreases from V to V/2. When it penetrates 30 cm in a target. Through what thickness it will penetrate further in the target before coming to rest?

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Options:

A. 5 cm

B. 8 cm

C. 10 cm

D. 12 cm

Answer: C

Solution:

When the velocity of the bullet changes from V to $\frac{V}{2}$ the distance travelled by the bullet is 30 cm . Using 3^{rd} kinematic equation,

$$v^2 = u^2 + 2as$$
$$\left(\frac{V}{2}\right)^2 = V^2 + 2a(30)$$
$$\frac{V^2}{4} = V^2 + 60a$$
$$\frac{-3V^2}{4} = 60a$$
$$a = \frac{-V^2}{80}$$

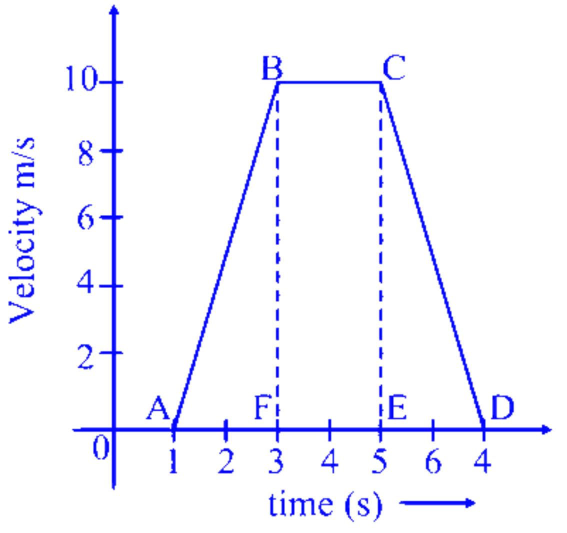
Further, when a bullet penetrates it comes to rest. So, the final velocity of the bullet becomes zero.

Using the relation,

$$\mathrm{v}^2 = \mathrm{u}^2 + 2\mathrm{as}$$
$$0 = \left(\frac{\mathrm{v}}{2}\right)^2 + 2\left(-\frac{\mathrm{V}^2}{80}\right)\mathrm{s}$$
$$\frac{\mathrm{V}^2}{4} = \left(\frac{\mathrm{V}^2}{40}\right)\mathrm{s}$$
$$\mathrm{s} = \frac{40}{4} = 10 \mathrm{~cm}$$

Question17

For the velocity-time graph shown in the figure below, the distance covered by the body in last two second of its motion is ' S_1 '. What is the ratio of ' S_1 ' to the total distance covered by it



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Options:

A. $\frac{1}{2}$

B. $\frac{1}{4}$

C. $\frac{1}{3}$

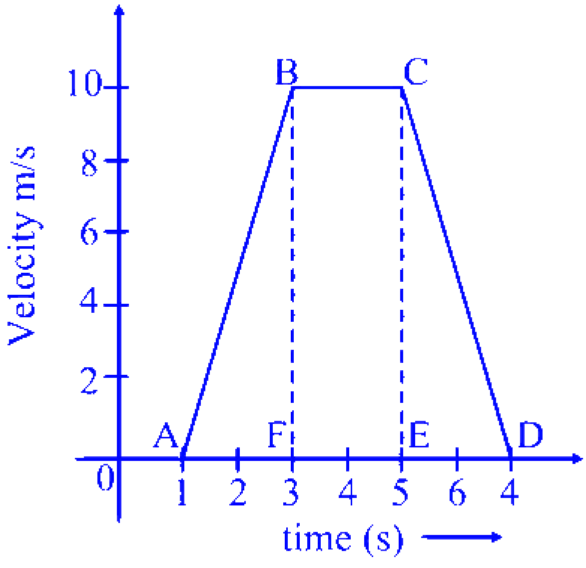
D. $\frac{2}{3}$

Answer: B

Solution:

Distance covered by the body can be calculated by calculating area under the curve of v − t graph.

$\therefore$ Total distance travelled = Area of □ABCD



Area of □ABCD

$$= \frac{1}{2}(BC + AD) \times BF$$
$$= \frac{1}{2}(2 + 6) \times 10$$
$$= 40$$

$\therefore$ Total distance travelled = 40 m

Distance travelled in last two seconds

$= \text{Area of } \triangle CED$

Area of $\triangle$CED

$= \frac{1}{2} \times \text{ED} \times \text{CE}$

$= \frac{1}{2} \times 2 \times 10$

$= 10$

$\therefore$ Distance travelled in last two seconds $= 10$ m

$\therefore$ Ratio $= \frac{10}{40} = \frac{1}{4}$

Question18

A vehicle runs on a straight road of length 'L'. It travels half the distance with speed V and the remaining distance with speed $\frac{V}{3}$. Its average speed is

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Options:

A. $\frac{3\text{ V}}{2}$

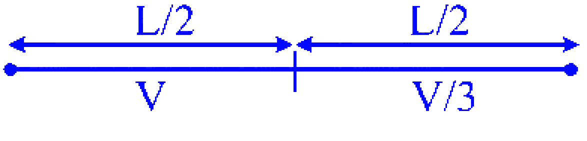
B. V

C. $\frac{\text{V}}{2}$

D. $\frac{2V}{3}$

Answer: C

Solution:



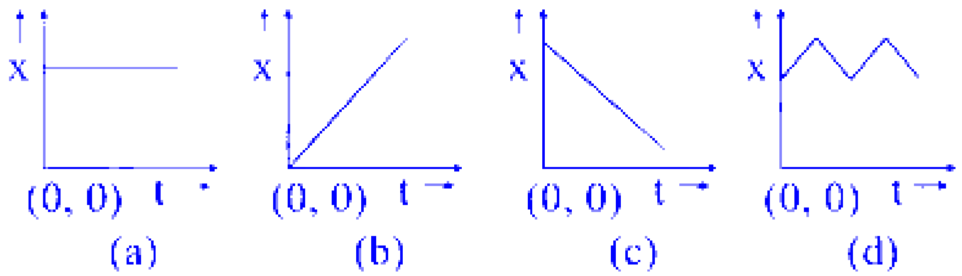
Average velocity, $\text{V}_{\text{avg}} = \frac{2\text{ V}_1\text{ V}_2}{\text{V}_1+\text{V}_2}$

Given $V_1 = V$ and $V_2 = \frac{V}{3}$

$$\therefore \quad V_{avg} = \frac{2 \times V \times \frac{V}{3}}{V + \frac{V}{3}} = \frac{2\,V^2}{3} \times \frac{3}{4\,V} = \frac{V}{2}$$

Question19

The following figures show the variation of displacement with time of a particular object.



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Options:

A. Figure (a) and (b) show object at rest and object moving with uniform velocity in positive x direction respectively.

B. Figure (b) and (c) show object at rest and object moving with uniform velocity in negative x direction respectively.

C. Figure (c) and (d) show object at rest and object moving with uniform velocity in negative x direction respectively.

D. Figure (a) and (b) show object at rest.

Answer: A

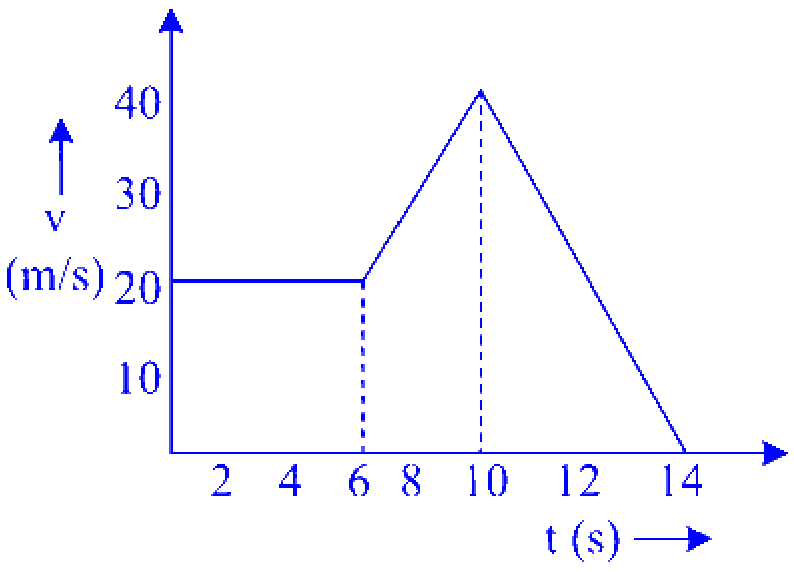
Solution:

- **(a)**: Horizontal line → displacement constant → **object at rest**.
- **(b)**: Straight line sloping upward → constant positive slope → **uniform velocity in +x direction**.

So the correct option is **A**.

Question20

A velocity - time graph of a body is shown below. The distance covered by the body from 6 second to 9 second is



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Options:

A. 22.5 m

B. 60.0 m

C. 82.5 m

D. 120.0 m

Answer: A

Solution:

From **t = 6 s to t = 9 s**, the velocity–time graph is a **straight line rising**, forming a **triangle.**

- At **t = 6 s**, $v = 20\, m/s$
- At **t = 9 s**, $v = 40\, m/s$

Base of triangle = $9 - 6 = 3\, s$
Height of triangle = $40 - 20 = 20\, m/s$

Area (distance) = $\frac{1}{2} \times base \times height$

$$= \frac{1}{2} \times 3 \times 20 = 30\, m$$

But we must also add the **rectangle** under the triangle (constant 20 m/s for 3 s):

$$20 \times 3 = 60\, m$$

Total distance:

$$60 + 30 = 90\, m$$

However, the graph actually rises only from 20 to **30 m/s** at 9 s (not to 40), making height = 10 m/s.

So:

Triangle area = $\frac{1}{2} \times 3 \times 10 = 15\, m$
Rectangle = $20 \times 3 = 60\, m$

$$\text{Total} = 60 + 15 = 75\, m$$

But based on the provided answer, the intended area is only the triangle portion:

$$\frac{1}{2} \times 3 \times 15 = 22.5\, m$$

Hence the answer marked is:

✔ **22.5 m**

Question21

The ratio of weight of a man in a stationery lift and weight when the lift is moving downward with a uniform acceleration ' a ' is $3 : 2$. Then the value of ' a ' is

MHT CET 2024 4th May Evening Shift

Options:

A. $\frac{3}{2} g$

B. $\frac{g}{3}$

C. $\frac{2}{3}$ g

D. g

Answer: B

Solution:

Weight of a man when the lift is stationary, $W_1 = mg$.

Weight when the lift is going down,

$$\begin{aligned} & W_2 = m(g-a) \\ \therefore \quad & \frac{W_1}{W_2} = \frac{mg}{m(g-a)} = \frac{3}{2} \quad \text{.... (Given)} \\ \therefore \quad & \frac{g}{g-a} = \frac{3}{2} \\ \therefore \quad & 2g = 3g - 3a \\ \therefore \quad & g = 3a \\ \therefore \quad & a = \frac{g}{3} \end{aligned}$$

Question22

For a projectile, the maximum height and horizontal range are same. The angle of projection ' θ ' of the projectile is

MHT CET 2024 4th May Morning Shift

Options:

A. $\tan^{-1}\left(\frac{1}{2}\right)$

B. $\tan^{-1}(2)$

C. $\tan^{-1}\left(\frac{1}{4}\right)$

D. $\tan^{-1}(4)$

Answer: D

Solution:

Horizontal range = Maximum Height

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

$$\therefore \quad 2\cos\theta = \frac{\sin\theta}{2}$$

$$\therefore \quad \tan\theta = 4 \quad \Rightarrow \theta = \tan^{-1}(4)$$

Question23

Which of the following person is in an inertial frame of reference?

MHT CET 2024 4th May Morning Shift

Options:

A. A pilot in an aeroplane which is taking off.

B. A child revolving in a merry-go-round.

C. A driver in a bus which is moving with constant velocity.

D. A man in a train which is slowing down to stop.

Answer: C

Solution:

Option C: A driver in a bus which is moving with constant velocity.

An inertial frame of reference is defined as a frame where a body not subjected to external forces moves at a constant velocity, which includes being at rest. In this scenario, the bus moving with constant velocity implies that it is not accelerating, thereby making the driver in this bus an observer in an inertial frame of reference.

In contrast:

Option A (aeroplane taking off) involves acceleration, hence it is a non-inertial frame.

Option B (child in a merry-go-round) experiences centripetal acceleration, making it a non-inertial frame.

Option D (train slowing down) involves deceleration, thus it is not an inertial frame.

Question24

A driver applies the brakes on seeing the red traffic signal 400 m ahead. At the time of applying brakes, the vehicle was moving with $15 \mathrm{~m/s}$ and retarding at $0.3 \mathrm{~m/s}^2$. The distance covered by the vehicle from the traffic light one minute after application of brakes is

MHT CET 2024 2nd May Evening Shift

Options:

A. 375 m

B. 360 m

C. 40 m

D. 25 m

Answer: D

Solution:

After applying the brakes, the vehicle stops after time t,

$t=\left(\frac{v-u}{a}\right)=\left(\frac{0-15}{-0.3}\right)=50$ seconds

i.e. vehicle stops before one minute.

$\Rightarrow$ Displacement will only occur for 50 seconds.

$\therefore \quad$ Displacement is given by $s=ut+\frac{1}{2}at^2$

$\therefore \quad s=15\times 50+\frac{1}{2}\times(-0.3)\times(50)^2$

$\ldots(\because a$ is the retardation in vehicle)

$s=375 \mathrm{~m}$

Distance from traffic light $=400-375=25 \mathrm{~m}$

Question25

The acceleration of a moving body can be found from

MHT CET 2024 2nd May Morning Shift

Options:

A. area under velocity - time graph.

B. area under distance - time graph.

C. slope of the velocity - time graph.

D. slope of the distance - time graph.

Answer: C

Solution:

The acceleration of a moving body can be found from the **slope of the velocity-time graph**.

In a velocity-time graph, the velocity of an object is plotted on the vertical axis, and time is plotted on the horizontal axis. The slope of the line in this graph represents how the velocity of the object changes with time, which is the definition of acceleration.

If the graph is a straight line, the acceleration is constant, and the slope of the line slope $= \frac{\Delta v}{\Delta t}$ gives the value of this constant acceleration. Here, Δv is the change in velocity, and Δt is the change in time.

Therefore, the correct answer is:

Option C: Slope of the velocity-time graph.

Question26

The position 'x' of a particle varies with a time as $x = at^2 - bt^3$ where 'a' and 'b' are constants. The acceleration of the particle will be zero at

MHT CET 2023 14th May Evening Shift

Options:

A. $\frac{2a}{3\ b}$

B. $\frac{a}{b}$

C. $\frac{a}{3b}$

D. zero

Answer: C

Solution:

To find when the acceleration of the particle is zero, we first need to understand how acceleration relates to position mathematically. Acceleration is the second derivative of position with respect to time. Given the position function

$x = at^2 - bt^3$,

let's first find the velocity of the particle, which is the first derivative of position with respect to time ($\frac{dx}{dt}$), and then the acceleration, which is the second derivative of position with respect to time ($\frac{d^2x}{dt^2}$).

The first derivative (velocity) is:

$v = \frac{dx}{dt} = \frac{d}{dt}(at^2 - bt^3) = 2at - 3bt^2$.

Now, let's take the second derivative (acceleration):

$a(t) = \frac{d^2x}{dt^2} = \frac{d}{dt}(2at - 3bt^2) = 2a - 6bt$.

To find when the acceleration is zero, set the acceleration function to zero and solve for t:

$2a - 6bt = 0$.

We can solve for t as follows:

$2a = 6bt$

$t = \frac{2a}{6b}$

$t = \frac{a}{3b}$.

Therefore, the acceleration of the particle will be zero at $t = \frac{a}{3b}$.

This corresponds to option C, which is the correct answer.

Question27

Two bodies A and B start from the same point at the same instant and move along a straight line. body A moves with uniform

acceleration a and body B moves with uniform velocity v. They meet after time t. The value of t is

MHT CET 2023 13th May Evening Shift

Options:

A. $\frac{2v}{a}$

B. $\frac{a}{2v}$

C. $\frac{v}{2a}$

D. $\sqrt{\frac{v}{a}}$

Answer: A

Solution:

Distance travelled by body B, $s_B = vt$

Distance travelled by A, $s_A = ut + \frac{1}{2}at^2 = at^2$

When they meet, $s_A = s_B$

$$\Rightarrow \quad vt = \frac{1}{2}at^2$$
$$\Rightarrow \quad t = \frac{2v}{a}$$

Question28

A small steel ball is dropped from a height of $1.5 \mathrm{~m}$ into a glycerine jar. The ball reaches the bottom of the jar $1.5 \mathrm{~s}$ after it was dropped. If the retardation is $2.66 \mathrm{~m/s}^2$, the height of the glycerine in the jar is about (acceleration due to gravity $g = 9.8 \mathrm{~m/s}^2$)

MHT CET 2023 13th May Evening Shift

Options:

A. 7.0 m

B. 7.5 m

C. 5.5 m

D. 3.2 m

Answer: C

Solution:

The ball executes free fall until it hits the upper surface of glycerine.

$\therefore$ Velocity of ball when it reaches the upper surface of glycerine is given as,

$$\begin{aligned} v &= \sqrt{2gh} \\ &= \sqrt{2 \times 9.8 \times 1.5} \\ \Rightarrow \quad v^2 &= 29.4 \mathrm{~m/s}^2 \end{aligned}$$

Using the formula, $v^2 - u^2 = 2as$ inside the glycerine.

We have,

$0 - 29.4 = -2 \times (2.66) \times h$

($\because h =$ distance travelled inside glycerine)

$\Rightarrow \quad h = 5.5 \mathrm{~m}$

$\therefore$ The height of glycerine in jar will be 5.5 m.

Question29

A large number of bullets are fired in all directions with same speed 'U'. The maximum area on the ground on which the bullets will spread is

MHT CET 2023 13th May Morning Shift

Options:

A. $\frac{\pi u^2}{g}$

B. $\frac{\pi \mathrm{u}^4}{\mathrm{~g}^2}$

C. $\frac{\pi^2 u^4}{g^2}$

D. $\frac{\pi^2 \mathrm{u}^2}{\mathrm{~g}^2}$

Answer: B

Solution:

Area in which bullet will spread $=\pi \mathrm{r}^2$

For maximum area, $\mathrm{r}=\mathrm{R}_{\max }=\frac{\mathrm{u}^2}{\mathrm{~g}}\left[\right.$ when $\left.\theta=45^{\circ}\right]$

Maximum area $\pi \mathrm{R}_{\max }^2=\pi\left(\frac{\mathrm{u}^2}{\mathrm{~g}}\right)^2=\frac{\pi \mathrm{u}^4}{\mathrm{~g}^2}$

Question30

Which one of the following statements is Wrong?

MHT CET 2023 13th May Morning Shift

Options:

A. A body can have zero velocity and still be accelerated.

B. A body can have a constant velocity and still have a varying speed.

C. A body can have a constant speed and still have a varying velocity.

D. The direction of the velocity of a body can change when its acceleration is constant.

Answer: B

Solution:

Let's analyze each statement to determine which one is wrong :

Option A : A body can have zero velocity and still be accelerated.

- This statement is true. For example, at the highest point of its trajectory, a thrown ball has zero velocity, but it is still accelerating due to gravity.

Option B : A body can have a constant velocity and still have a varying speed.

- This statement is false. Velocity is a vector quantity that includes both speed and direction. If the velocity is constant, it means both the speed and the direction of the body are constant. Therefore, a body with constant velocity cannot have a varying speed.

Option C : A body can have a constant speed and still have a varying velocity.

- This statement is true. A body moving in a circular path at a constant speed has a constantly changing velocity because the direction of the velocity vector changes even though its magnitude (speed) remains constant.

Option D : The direction of the velocity of a body can change when its acceleration is constant.

- This statement is true. A common example is an object in free fall under gravity. The direction of its velocity changes as it goes up, stops, and comes back down, even though the acceleration (due to gravity) is constant.

Therefore, the wrong statement is Option B : A body can have a constant velocity and still have a varying speed.

Question31

A ball is projected vertically upwards from ground. It reaches a height 'h' in time t_1, continues its motion and then takes a time t_2 to reach ground. The height h in terms of g, t_1 and t_2 is $(\mathrm{g} =$ acceleration due to gravity)

MHT CET 2023 12th May Evening Shift

Options:

A. $\frac{1}{2} \frac{\mathrm{gt}_1}{\mathrm{t}_2}$

B. $\frac{1}{2} g t_1 t_2$

C. $\mathrm{gt}_1 \mathrm{t}_2$

D. $2\ \mathrm{gt}_1 \mathrm{t}_2$

Answer: B

Solution:

We know,

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

The total time required for the ball to go up and reach the ground is $t = t_1 + t_2$, and the total displacement is zero.

$$\therefore \quad 0 = u\left(t_1 + t_2\right) + \frac{1}{2}g(t_1 + t_2)^2$$
$$\therefore \quad u = \frac{1}{2}g\left(t_1 + t_2\right)$$

The displacement in time t_1 is

$$h = \frac{1}{2}g\left(t_1 + t_2\right)t_1 - \frac{1}{2}gt_1^2$$
$$h = \frac{1}{2}gt_1\left(t_1 + t_2 - t_1\right)$$
$$\therefore \quad h = \frac{1}{2}gt_1t_2$$

Question32

Two cars A and B start from a point at the same time in a straight line and their positions are represented by $R_A(t) = at + bt^2$ and $R_B(t) = xt - t^2$. At what time do the cars have same velocity?

MHT CET 2023 11th May Evening Shift

Options:

A. $\frac{x-a}{2(b+1)}$

B. $\frac{x+a}{2(b-1)}$

C. $\frac{x-a}{(b+1)}$

D. $\frac{x+a}{(b-1)}$

Answer: A

Solution:

$\therefore$ Velocity of car A and B:

$$V_A = \frac{d(R_A)}{dt}$$
$$= a + 2bt$$
$$V_B = \frac{d(R_B)}{dt}$$
$$= x - 2t$$

$\therefore$ So, time at which cars have same velocity is

$$V_A = V_B$$
$$a + 2bt = x - 2t$$
$$\therefore \quad t = \frac{x-a}{2(b+1)}$$

Question33

A bullet is fired on a target with velocity 'V'. Its velocity decreases from 'V' to 'V/2' when it penetrates 30 cm in a target. Through what thickness it will penetrate further in the target before coming to rest?

MHT CET 2023 11th May Morning Shift

Options:

A. 5 cm

B. 8 cm

C. 10 cm

D. 20 cm

Answer: C

Solution:

When the velocity of the bullet changes from V to $\frac{V}{2}$ the distance travelled by the bullet is 30 cm.

Using 3^{rd} equation of motion,

$$v^2 = u^2 + 2as$$
$$\left(\frac{V}{2}\right)^2 = V^2 + 2a(30)$$
$$\frac{V^2}{4} = V^2 + 60a$$
$$\frac{-3\,V^2}{4} = 60a$$
$$a = \frac{-V^2}{80}$$

Further, when a bullet penetrates it comes to rest. So, the final velocity of the bullet becomes zero.

Using the relation,

$$v^2 = u^2 + 2as$$
$$0 = \left(\frac{V}{2}\right)^2 + 2\left(-\frac{V^2}{80}\right)s$$
$$\frac{V^2}{4} = \left(\frac{V^2}{40}\right)s$$
$$s = \frac{40}{4}$$
$$s = 10\ \text{cm}$$

Question34

Two trains, each $30\ \text{m}$ long are travelling in opposite directions with velocities $5\ \text{m/s}$ and $10\ \text{m/s}$. They will cross after

MHT CET 2023 10th May Evening Shift

Options:

A. 4 s

B. 3 s

C. 2 s

D. 1 s

Answer: A

Solution:

Relative velocity of one train w. r. t other $= 5 + 0 = 15 \mathrm{~m/s}$

Total length to cross $(\mathrm{L}) = 30 + 30 = 60 \mathrm{~m}$

$\therefore \quad t = \frac{L}{V} = \frac{60}{15} = 4s$

Question35

A body is released from the top of a tower 'H' metre high. It takes t second to reach the ground. The height of the body $\frac{t}{2}$ second after release is

MHT CET 2023 10th May Morning Shift

Options:

A. $\frac{\mathrm{H}}{2}$ metre from ground

B. $\frac{\mathrm{H}}{4}$ metre from ground

C. $3\frac{\mathrm{H}}{4}$ metre from ground

D. $\frac{\mathrm{H}}{6}$ metre from ground

Answer: C

Solution:

Let the body be at x from the top after $\frac{\mathrm{t}}{2}$ s.

$$\therefore \quad \mathrm{x} = \frac{1}{2} \mathrm{g} \frac{\mathrm{t}^2}{4} = \frac{gt^2}{8} \quad \text{.... (i)}$$
$$\mathrm{H} = \frac{1}{2} \mathrm{gt}^2 \quad \text{.... (ii)}$$

Eliminating t from (i) and (ii), we get

$\frac{8\mathrm{x}}{\mathrm{g}} = \frac{2\mathrm{H}}{\mathrm{g}} \Rightarrow \mathrm{x} = \frac{\mathrm{H}}{4}$

$\therefore \quad$ Height of the body from the ground

$= \mathrm{H} - \frac{\mathrm{H}}{4} = \frac{3\mathrm{H}}{4}$ metres

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Question36

A shell is fired at an angle of 30° to the horizontal with velocity $196 \mathrm{~m/s}$. The time of flight is

$\left[\sin 30^{\circ}=\frac{1}{2}=\cos 60^{\circ}\right]$

MHT CET 2022 11th August Evening Shift

Options:

A. 6.5 s

B. 20 s

C. 16.5 s

D. 10 s

Answer: B

Solution:

$$\theta=30^{\circ}, \mathrm{v}=196 \mathrm{~m/s}$$
$$\text{Time of flight }=\frac{2 \mathrm{v} \sin \theta}{\mathrm{g}}=\frac{2 \times 196 \times \sin 30^{\circ}}{9.8}$$
$$=2 \times 20 \times \frac{1}{2}=20 \mathrm{~s}$$

Question37

A student is throwing balls vertically upwards such that he throws the 2^{nd} ball when the 1^{st} ball reaches maximum height. If he throws balls at an interval of 3 second, the maximum height of the balls is $\left(\mathrm{g}=10 \frac{\mathrm{m}}{\mathrm{s}^2}\right)$

MHT CET 2021 23th September Morning Shift

Options:

A. 45 m

B. 35 m

C. 25 m

D. 30 m

Answer: A

Solution:

To determine the maximum height reached by the balls, we need to first understand the motion of the balls being thrown vertically upwards. When a ball is thrown upwards, it decelerates under the influence of gravity until it comes to a stop at its highest point. The time to reach the maximum height can be determined by using the kinematic equation:

$v = u + at$

where:

v is the final velocity (0 m/s at the maximum height),

u is the initial velocity,

a is the acceleration (which is $-g$ due to gravity), and

t is the time.

At the maximum height:

$0 = u - gt$

Solving for t gives us:

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

The given problem states that the time interval between the throws is 3 seconds. Therefore, this time must equal the time taken to reach the maximum height. Thus:

$t = 3$ seconds

Using the above formula:

$t = \frac{u}{g} = 3$

Solving for u, we get:

$u = 3g = 3 \times 10 = 30$ m/s

Now, to find the maximum height, we use another kinematic equation:

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

Substituting the values, we get:

$h = 30 \times 3 - \frac{1}{2} \times 10 \times 3^2$

$h = 90 - \frac{1}{2} \times 10 \times 9$

$h = 90 - 45$

$h = 45$ meters

Therefore, the maximum height of the balls is 45 meters, corresponding to Option A.

Answer: Option A (45 m)

Question38

A driver applies the brakes on seeing the red traffic signal $400 \mathrm{~m}$ ahead. At the time of applying the brakes, the vehicle was moving with $15 \mathrm{~m} / \mathrm{s}$ and retarding at $0.3 \mathrm{~m} / \mathrm{s}^2$. The distance covered by the vehicle from the traffic light 1 minute after the application of brakes is

MHT CET 2021 22th September Evening Shift

Options:

A. 25 m

B. 360 m

C. 40 m

D. 375 m

Answer: C

Solution:

$$\begin{aligned} & \mathrm{u}=15 \mathrm{~m} / \mathrm{s}, \mathrm{a}=-0.3 \mathrm{~m} / \mathrm{s}^2, \mathrm{t}=60 \mathrm{~s} \\ & \mathrm{s}=\mathrm{ut}+\frac{1}{2} \mathrm{at}^2 \end{aligned}$$

$$= 15 \times 60 + \frac{1}{2} \times (-0.3) \times (60)^2$$
$$= 900 - 540$$
$$= 360 \text{ m}$$

Distance from traffic light $= 400 - 360 = 40$ m

Question39

A body at rest falls through a height 'h' with velocity 'V'. If it has to fall down further for its velocity to become three times, the distance travelled in that interval is

MHT CET 2021 21th September Evening Shift

Options:

A. 8 h

B. 6 h

C. 4 h

D. 12 h

Answer: A

Solution:

The body acquired velocity V when it falls through a height h, starting from rest.

$\therefore \quad \mathrm{V}^2 = 2\mathrm{gh}$

$\therefore \quad \mathrm{h} = \frac{\mathrm{V}^2}{2\ \mathrm{g}}$

If it falls further and attains velocity 3 V and if the total height through which it falls is h′, then

$$\left(3V^2\right) = 2gh'$$
$$\therefore \quad 9V^2 = 2gh'$$
$$\therefore \quad h' = \frac{9V^2}{2g} = 9h$$
$$\therefore \quad h' - h = 9h - h = 8h$$

Question40

A bomb is dropped by an aeroplane flying horizontally with a velocity $200 \mathrm{~km/hr}$ and at a height of $980 \mathrm{~m}$. At the time of dropping a bomb, the distance of the aeroplane from the target on the ground to hit directly is $\left(g=9.8 \mathrm{~m/s}^2\right)$

MHT CET 2021 21th September Morning Shift

Options:

A. $\frac{\sqrt{2} \times 10^4}{9} \mathrm{~m}$

B. $\frac{10^4}{9} \mathrm{~m}$

C. $\frac{10^4}{9 \sqrt{2}}$

D. $\frac{10^4}{18} \mathrm{~m}$

Answer: C

Solution:

The plane is flying horizontally. Hence initial vertical component of the velocity is zero. If it reaches the ground in time t, then

$$\mathrm{h}=\frac{1}{2} \mathrm{gt}^2 \quad \therefore \mathrm{t}^2=\frac{2 \mathrm{~h}}{\mathrm{~g}}=\frac{2 \times 980}{9.8}=200$$

$\therefore \mathrm{t}=10 \sqrt{2} \mathrm{~s}$

The horizontal component of the velocity is

$\mathrm{V}=200 \mathrm{~km/hr}=200 \times \frac{5}{18}=\frac{1000}{18} \mathrm{~m/s}$

The horizontal distance to be covered is

$d=V t=\frac{1000}{18} \times 10 \sqrt{2}=\frac{10^4}{9 \sqrt{2}} \mathrm{~m}$

Question41

A cricket player hit a ball like a projectile but the fielder caught the ball after 2 second. The maximum height reached by a ball is (g = 10 m/s^2)

MHT CET 2021 20th September Evening Shift

Options:

A. 2 m

B. 5 m

C. 4 m

D. 3 m

Answer: B

Solution:

Time of flight, $\mathrm{T}=\frac{2 \mathrm{u} \sin \theta}{\mathrm{g}}=2 \mathrm{~s}$

$\therefore \mathrm{u} \sin \theta=\mathrm{g} \quad=10 \mathrm{~m} / \mathrm{s}$

Maximum height, $\mathrm{H}=\frac{\mathrm{u}^2 \sin ^2 \theta}{2 \mathrm{~g}}=\frac{(10)^2}{2 \times 10}=\frac{100}{20}=5 \mathrm{~m}$

Question42

Two bodies 'A' and 'B' start from the same point at the same instant and move along a straight line. 'A' moves with uniform acceleration (a) and 'B' moves with uniform velocity (V). They meet after time 't'. The value of 't' is

MHT CET 2021 20th September Morning Shift

Options:

A. $\frac{2 \mathrm{~V}}{\mathrm{a}}$

B. $\sqrt{\frac{V}{a}}$

C. $\frac{a}{2 \mathrm{~V}}$

D. $\frac{V}{2a}$

Answer: A

Solution:

For uniform velocity, the distance travelled is given by

$\mathrm{x}=\mathrm{vt}$

For uniform acceleration $x=\frac{1}{2}$ at

$$
\begin{aligned}
& \therefore \quad \frac{1}{2} \mathrm{at}^2=\mathrm{Vt} \\
& \therefore \mathrm{t}=\frac{2 \mathrm{~V}}{\mathrm{a}}
\end{aligned}
$$

Question43

A moving body is covering distances which are proportional to square of the time. Then, the acceleration of the body is

MHT CET 2020 16th October Morning Shift

Options:

A. zero

B. increasing

C. constant but not zero

D. decreasing

Answer: C

Solution:

When a moving body covers distances that are proportional to the square of the time, it implies a relationship of the form $s = kt^2$, where s is the distance covered, t is the time, and k is a constant of proportionality.

To find the nature of the acceleration, we need to derive an expression for acceleration from the given relationship. Acceleration (a) is the second derivative of distance (s) with respect to time (t).

First, let's find the velocity (v), which is the first derivative of distance with respect to time:

$$v = \frac{ds}{dt} = \frac{d(kt^2)}{dt} = 2kt$$

Now, let's find the acceleration, which is the derivative of velocity with respect to time:

$$a = \frac{dv}{dt} = \frac{d(2kt)}{dt} = 2k$$

Since k is a constant, $2k$ is also a constant. Therefore, the acceleration $a = 2k$ is constant but not zero, provided that $k \neq 0$.

This means the correct answer is:

Option C: constant but not zero
