Motion in a Straight Line

Question1

Two stones begin to fall from rest from the same height, with the second stone starting to fall ' Δt ' seconds after the first falls from rest. The distance of separation between the two stones becomes ' H ', ' t_0 ' seconds after the first stone starts its motion. Then t_0 is equal to

KCET 2025

Options:

A. $\frac{H}{\Delta t}+\frac{\Delta t}{2 g}$

B. $\frac{H}{g \Delta t}-\frac{\Delta t}{2}$

C. $\frac{H}{g \Delta t}+\frac{\Delta t}{2}$

D. $\frac{H}{g \Delta t}$

Answer: C

Solution:

To solve this problem, we need to determine the time, denoted as t_0, at which the separation between two falling stones becomes H. The second stone starts falling Δt seconds after the first stone.

Distance Fallen by the First Stone (S_1):

The first stone falls for t_0 seconds, so the distance it covers is given by:

$S_1=\frac{1}{2} g t_0^2$

Distance Fallen by the Second Stone (S_2):

The second stone starts falling Δt seconds after the first, so it falls for $(t_0-\Delta t)$ seconds. Thus, the distance it covers is:

$S_2=\frac{1}{2} g(t_0-\Delta t)^2$

Distance of Separation (H):

The separation distance between the two stones is:

$H = S_1 - S_2 = \frac{1}{2} g t_0^2 - \frac{1}{2} g (t_0 - \Delta t)^2$

Simplifying the equation:

$$H = \frac{1}{2} g t_0^2 - \frac{1}{2} g (t_0^2 - 2 t_0 \Delta t + (\Delta t)^2)$$
$$= \frac{1}{2} g \cdot (2 t_0 \Delta t - (\Delta t)^2)$$
$$= g \cdot (t_0 \Delta t - \frac{1}{2} \Delta t^2)$$

Expression for t_0:

Solving the above equation for t_0, we have:

$H = g(t_0 \Delta t - \frac{1}{2} \Delta t^2)$

$t_0 \Delta t = \frac{H}{g} + \frac{1}{2} \Delta t^2$

$t_0 = \frac{H}{g \Delta t} + \frac{\Delta t}{2}$

Therefore, the time t_0 at which the separation between the two stones becomes H is given by:

$t_0 = \frac{H}{g \Delta t} + \frac{\Delta t}{2}$

Question2

A body is moving along a straight line with initial velocity v_0. Its acceleration a is constant. After t seconds, its velocity becomes v. The average velocity of the body over the given time interval is

KCET 2023

Options:

A. $\bar{v} = \frac{v^2 - v_0^2}{at}$

B. $\bar{v} = \frac{v^2 + v_0^2}{2at}$

C. $\bar{v} = \frac{v^2 + v_0^2}{at}$

D. $\bar{v} = \frac{v^2 - v_0^2}{2at}$

Answer: D

Solution:

To determine the average velocity of a body moving along a straight line with a constant acceleration a, given its initial velocity v_0 and its final velocity v after t seconds, we can use the following approach:

Information Given:

Initial velocity, v_0

Final velocity after time t, v

Constant acceleration, a

Using the Equation of Motion:

The equation related to velocity and displacement is:

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

Rearranging for displacement s:

$s = \frac{v^2 - v_0^2}{2a}$

This equation gives us the total distance covered.

Calculating Average Velocity:

The average velocity $\bar{v}$ over an interval is the total distance divided by the total time:

$\bar{v} = \frac{\text{Total distance}}{\text{Total time}} = \frac{s}{t}$

Substituting for s from the displacement equation:

$\bar{v} = \frac{\frac{v^2 - v_0^2}{2a}}{t}$

Simplifying:

$\bar{v} = \frac{v^2 - v_0^2}{2at}$

Hence, the average velocity is given by:

$v_{\text{avg}} = \frac{v^2 - v_0^2}{2at}$

This formula provides the average velocity of the body over the given time interval t.

Question3

The displacement x (in m) of a particle of mass m (in kg) moving in one dimension under the action of a force, is related to time t (in sec) by $t=\sqrt{x}+3$. The displacement of the particle when its velocity is zero, will be

KCET 2022

Options:

A. zero

B. 6 m

C. 2 m

D. 4 m

Answer: A

Solution:

Displacement of the particle related with time is given as

$t=\sqrt{x}+3 \Rightarrow \sqrt{x}=t-3$

Squaring on both sides, we get

$$\begin{aligned} & \Rightarrow \quad x=(t-3)^2 \\ & \Rightarrow \quad x=t^2-6 t+9 \quad \text{.... (i)} \end{aligned}$$

Velocity of the particle,

$v=\frac{d x}{d t}=\frac{d}{d t}\left(t^2-6 t+9\right)=2 t-6$

when $v=0$

i.e $2 t-6=0 \Rightarrow t=36$

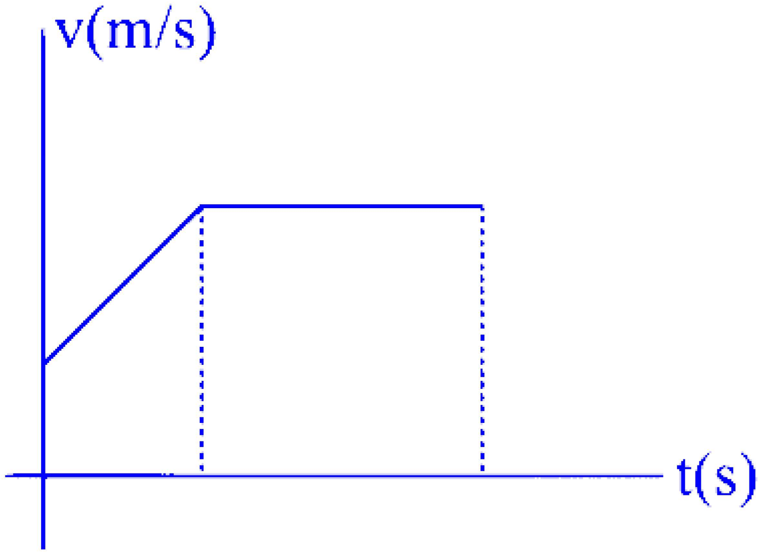
i.e velocity of particle is zero at $t=3$ s.

$\therefore$ Displacement of particle at $t=3$ s,

$$\begin{aligned} x= & 3^2-6 \times 3+9 \quad [\text{ from Eq. (i) }] \\ & =0 \end{aligned}$$

Question4

For a body moving along a straight line, the following v-t graph is obtained.



According to the graph, the displacement during

KCET 2021

Options:

A. uniform acceleration is greater than that during uniform motion

B. uniform acceleration is less than that during uniform motion

C. uniform acceleration is equal to that during uniform motion

D. uniform motion is zero

Answer: B

Solution:

Since, the area under v-t graph gives the displacement of object.

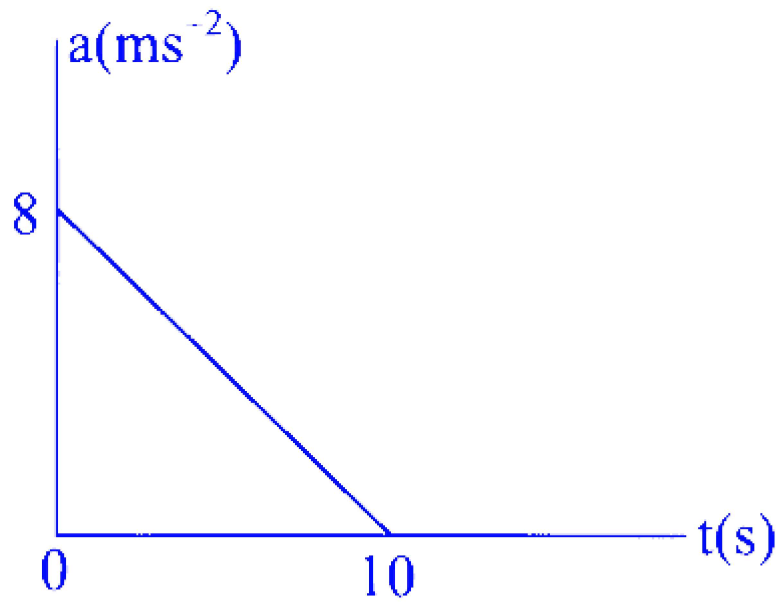
i.e., $s =$ Area of v-t graph

As area under uniform motion > Area under uniform acceleration

$\therefore$ Displacement during uniform acceleration is less than that during uniform motion.

Question5

A particle starts from rest. Its acceleration a versus time t is shown in the figure. The maximum speed of the particle will be



KCET 2021

Options:

A. 80 ms^{-1}

B. 40 ms^{-1}

C. 18 ms^{-1}

D. 2 ms^{-1}

Answer: B

Solution:

As, we know

Area under a-t graph $= v - u$

$\Rightarrow \quad \frac{1}{2} \times 8 \times 10 = v \quad (\because u = 0)$

$\Rightarrow \quad v = 40 \text{ ms}^{-1}$

Question6

At a metro station, a girl walks up a stationary escalator in 20 s. If she remains stationary on the escalator, then the escalator take her up in 30 s. The time taken by her to walk up on the moving escalator will be

KCET 2020

Options:

A. 25 s

B. 60 s

C. 12 s

D. 10 s

Answer: C

Solution:

To find the time taken by the girl to walk up on the moving escalator, we can use the concept of relative speeds.

Let's define:

v_{girl} as the speed of the girl walking.

$v_{\text{escalator}}$ as the speed of the escalator.

When the girl walks up on the stationary escalator, she takes 20 seconds. This gives us:

$d = v_{\text{girl}} \times 20\,\text{s}$

When the escalator alone moves and the girl does not walk, the time taken is 30 seconds. Thus:

$d = v_{\text{escalator}} \times 30\,\text{s}$

When the girl walks up on the moving escalator, both her speed and the escalator's speed contribute to her total speed:

$d = (v_{\text{girl}} + v_{\text{escalator}}) \times t$

Setting the distances equal since they all cover distance d:

From v_{girl} :

$$v_{\text{girl}} = \frac{d}{20}$$

From $v_{\text{escalator}}$:

$$v_{\text{escalator}} = \frac{d}{30}$$

Combining both in the case of the moving escalator:

$$d = \left(\frac{d}{20} + \frac{d}{30}\right) \times t$$

Simplifying the combination:

$$1 = \left(\frac{1}{20} + \frac{1}{30}\right) \times t$$

Finding a common denominator and solving:

$$\frac{1}{20} + \frac{1}{30} = \frac{3}{60} + \frac{2}{60} = \frac{5}{60} = \frac{1}{12}$$

Now, solve for t:

$$1 = \frac{1}{12} \times t$$

So:

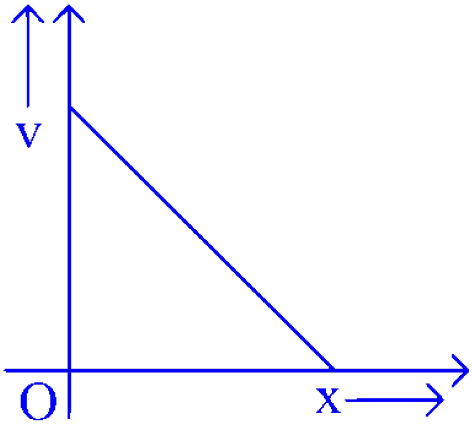
$$t = 12\,\text{s}$$

Hence, the time taken by her to walk up on the moving escalator is 12 seconds.

Option C: 12 s is the correct answer.

Question7

The given graph shows the variation of velocity v with position x for a particle moving along a straight line

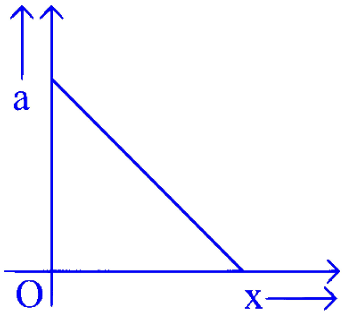


Which of the following graph shows the variation of acceleration a with position x?

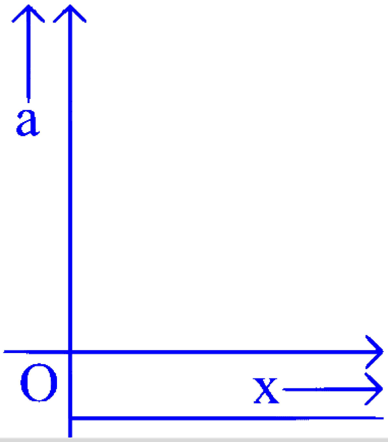
KCET 2019

Options:

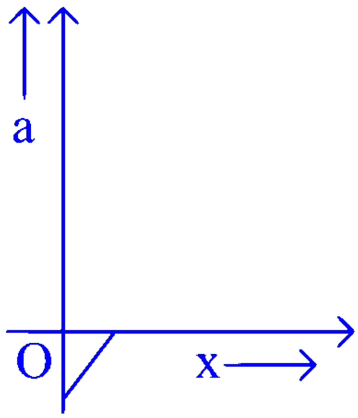
A.



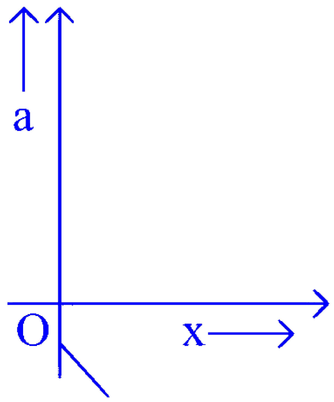
B.



C.



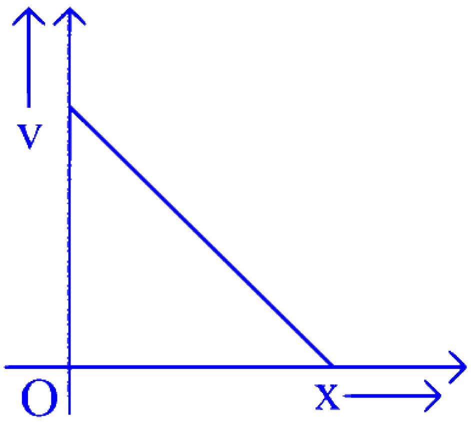
D.



Answer: C

Solution:

According to velocity-position graph.



$v=-kx+b$ .... (i)

where, k and b are constants differentiating Eq (i) w.r.t t, we have

$$\frac{dv}{dt} = -k\frac{dx}{dt} + 0$$
$$a = -kv \quad .... \text{(ii)}$$

[$\because$ acceleration, $a = \frac{dv}{dt}$]

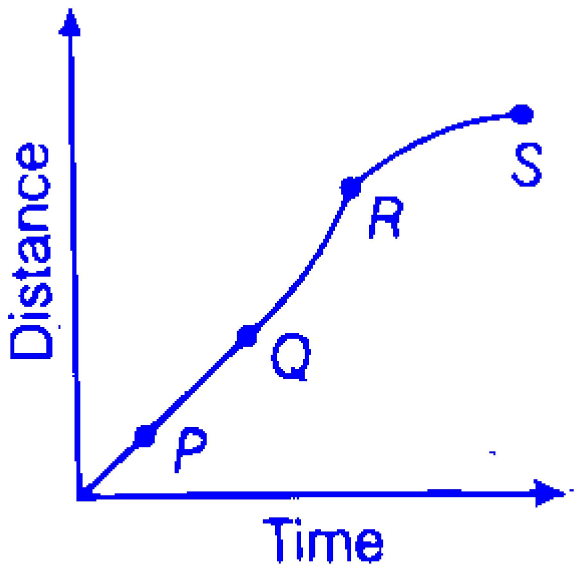
From Eqs. (i) and (ii),

$$a = -k(-kx + b)$$
$$a = k^2x - kb \quad .... \text{(iii)}$$

Correct graph of equation (iii) is represented in option (c).

Question8

A particle shows distance-time curve as shown in the figure. The maximum instantaneous velocity of the particle is around the point.



KCET 2018

Options:

A. P

B. S

C. R

D. Q

Answer: D

Solution:

Instantaneous velocity is given by,

$V=\lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}=\frac{dx}{dt}$

which is the slope of x - t graph.

Here, $\frac{dx}{dt}$ is maximum for the region QR and minimum for the region RS.

$\therefore$ Instantaneous velocity is maximum around Q.

Question9

A car moving with a velocity of 20 ms^{-1} stopped at a distance of 40 m . If the same car is travelling at double the velocity, the distance travelled by it for same retardation is

KCET 2017

Options:

A. 320 m

B. 1280 m

C. 160 m

D. 640 m

Answer: C

Solution:

Given Initial Conditions:

Initial velocity, $u=20 \mathrm{~m} / \mathrm{s}$

Stopping distance, $s=40 \mathrm{~m}$

Determine Retardation (Deceleration):

We use the equation from Newton's second law of motion:

$v^2=u^2+2 a s$

Since the car stops, its final velocity $v = 0$. Therefore, we have:

$$0^2 - u^2 = 2 \times a \times s$$

Substituting the given values:

$$0 - 20^2 = 2 \times a \times 40$$

$$-400 = 80a$$

Solving for a:

$$a = \frac{-400}{80} = -5\,\mathrm{m/s^2}$$

Increased Velocity Condition:

When the velocity is doubled, the new initial velocity is $u' = 2u = 40\,\mathrm{m/s}$.

Calculate New Stopping Distance:

Using the same formula with the new initial velocity:

$$0^2 - (40)^2 = 2 \times (-5) \times s$$

$$-1600 = -10s$$

Solving for s:

$$s = \frac{1600}{10} = 160\,\mathrm{m}$$

Thus, the stopping distance when the car's velocity is doubled is $160\,\mathrm{m}$.
