Motion in a Straight Line

Question1

A particle is moving along x-axis with its position (x) varying with time (t) as $x = \alpha t^4 + \beta t^2 + \gamma t + \delta$. The ratio of its initial velocity to its initial acceleration, respectively, is:

[NEET 2024 Re]

Options:

A.

$2\alpha : \delta$

B.

$\gamma : 2\delta$

C.

$4\alpha : \beta$

D.

$\gamma : 2\beta$

Answer: D

Solution:

Position of particle, $x = \alpha t^4 + \beta t^2 + \gamma t + \delta$

Velocity $v = \frac{dx}{dt} = 4\alpha t^3 + 2\beta t + \gamma$

Initial velocity $= v(t = 0) = \gamma$

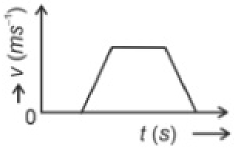
Acceleration $a = \frac{dv}{dt} = 12\alpha t^2 + 2\beta$

Initial acceleration $= a(t = 0) = 2\beta$

$\therefore \frac{v(t = 0)}{a(t = 0)} = \frac{\gamma}{2\beta}$

Question2

The velocity (v)− time (t) plot of the motion of a body is shown below:

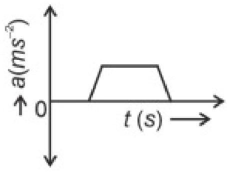


The acceleration (a)− time (t) graph that best suits this motion is :

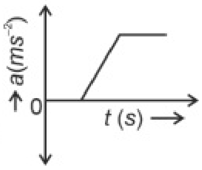
[NEET 2024]

Options:

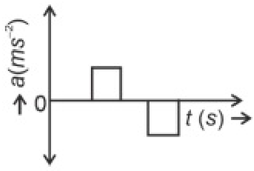
A.



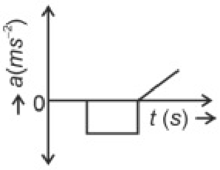
B.



C.



D.



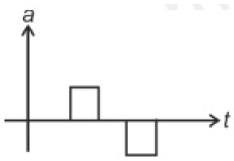
Answer: C

Solution:

Initially, the body has zero velocity and zero slope. Hence the acceleration would be zero initially. After that, the slope of v-t curve is constant and positive.

After some time, velocity becomes constant and acceleration is zero.

After that, the slope of v-t curve is constant and negative.



Question3

The position of a particle is given by

$\vec{r}(t) = 4t\hat{i} + 2t^2\hat{j} + 5\hat{k}$

where t is in seconds and r in metre. Find the magnitude and direction of velocity v(t), at t = 1 s, with respect to x-axis
[NEET 2023 mpr]

Options:

A.

$4\sqrt{2}ms^{-1}$, 45°

B.

$4\sqrt{2}ms^{-1}$, 60°

C.

$3\sqrt{2}ms^{-1}$, 30°

D.

$3\sqrt{2}ms^{-1}$, 45°

Answer: A

Solution:

$\vec{V} = \frac{d\vec{r}}{dt} = 4\hat{i} + 4\hat{j} + 0\hat{k}$

at $t = 1$ sec

$\vec{V} = 4\hat{i} + 4(1)\hat{j}$

$|\vec{V}| = \sqrt{4^2 + 4^2} = 4\sqrt{2}$

$\tan\alpha = \frac{4}{4} = 1$

$\alpha = 45^\circ$

Question4

A vehicle travels half the distance with speed v and the remaining distance with speed 2v. Its average speed is

[NEET 2023]

Options:

A.

B.

4v/3

C.

3v/4

D.

v/3

Answer: B

Solution:

$$v_{avg} = \frac{2v_1v_2}{v_1+v_2}$$

$$= \frac{2 \times v \times 2v}{v+2v}$$

$$= \frac{4v}{3}$$

Question5

A bullet from a gun is fired on a rectangular wooden block with velocity u. When bullet travels 24cm through the block along its length horizontally, velocity of bullet becomes u/3. Then it further penetrates into the block in the same direction before coming to rest exactly at the other end of the block. The total length of the block is

[NEET 2023]

Options:

A.

24cm

B.

28cm

C.

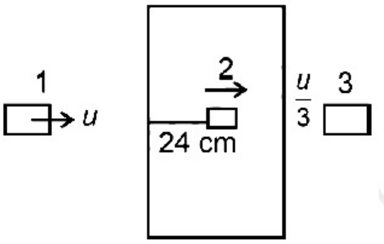
30cm

D.

27cm

Answer: D

Solution:



between 1 to 2

$\left(\frac{u}{3}\right)^2 = u^2 - 2a \times 24$

$\Rightarrow 2a(24) = \frac{8u^2}{9}$ ······ (i)

between 2 to 3

$0 = \left(\frac{u}{3}\right)^2 - 2a$ ······(ii)

From equation (I) and (II)

$2as = \frac{2a(24)}{8}$

$s = 3\,\text{cm}$

Length of wooden block is $24 + 3 = 27\,\text{cm}$

Question6

A horizontal bridge is built across a river. A student standing on the bridge throws a small ball vertically upwards with a velocity 4m s^{-1}. The ball strikes the water surface after 4 s. The height of bridge above water surface is (. Take g = 10m s^{-2})

[NEET 2023]

Options:

A.

60m

B.

64m

C.

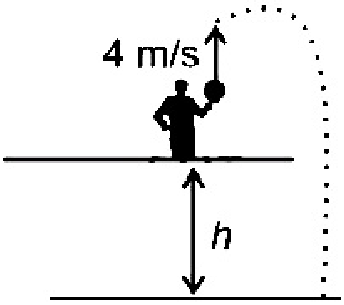
68m

D.

56m

Answer: B

Solution:



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

$= 16 - \frac{1}{2} \times 10 \times 16$

$= -64\text{m}$

Height of bridge above water surface $= 64\text{m}$

Question7

The ratio of the distances travelled by a freely falling body in the 1^{st}, 2^{nd}, 3^{rd} and 4^{th} second
[NEET-2022]

Options:

A. 1 : 2 : 3 : 4

B. 1 : 4 : 9 : 16

C. 1 : 3 : 5 : 7

D. 1 : 1 : 1 : 1

Answer: C

Solution:

$S_{n^{th}} = u + \frac{1}{2}a(2n - 1)$

$S_{1^{st}} = \frac{1}{2}g(2 \times 1 - 1) = \frac{g}{2}$

$S_{2^{nd}} = \frac{1}{2}g(2 \times 2 - 1) = 3\left(\frac{1}{2}g\right)$

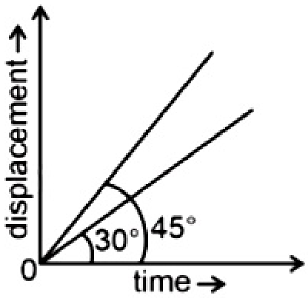
$S_{3^{rd}} = \frac{1}{2}g(2 \times 3 - 1) = 5 \times \left(\frac{1}{2}g\right)$

$S_{4^{th}} = \frac{1}{2}g(2 \times 4 - 1) = 7 \times \left(\frac{1}{2}g\right)$

$S_{1^{st}} : S_{2^{nd}} : S_{3^{rd}} : S_{4^{th}}$

Question8

The displacement-time graphs of two moving particles make angles of 30° and 45° with the x-axis as shown in the figure. The ratio of their respective velocity is



[NEET-2022]

Options:

A. $\sqrt{3}$: 1

B. 1 : 1

C. 1 : 2

D. 1 : $\sqrt{3}$

Answer: D

Solution:

Solution:

Slope of $x - t$ curves gives the velocity

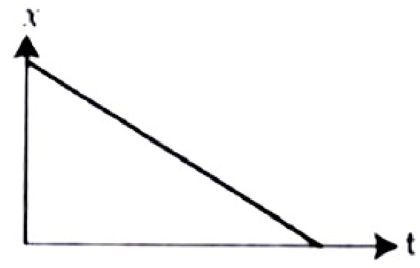
$$\Rightarrow \text{Ratio} = \frac{\tan 30^\circ}{\tan 45^\circ} = \frac{\frac{1}{\sqrt{3}}}{1} = 1 : \sqrt{3}$$

Question9

The position-time (x-t) graph for positive acceleration is :
[NEET Re-2022]

Options:

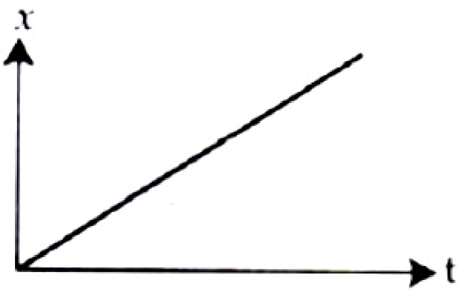
A.



B.

C.

D.



Answer: B

Solution:

Solution:

+ve acceleration

$\frac{dv}{dt} > 0$ so, velocity is increasing

⇒ slop of $x - t$ graph is increasing

∴ 

Question10

A small block slides down on a smooth inclined plane, starting from rest at time t = 0. Let S_n be the distance travelled by the block in the interval t = n − 1 to t = n. Then, the ratio $\frac{S_n}{S_{n+1}}$ is

[NEET 2021]

Options:

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

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

C. $\frac{2n+1}{2n-1}$

D. $\frac{2n}{2n-1}$

Answer: B

Solution:

Solution:

Suppose θ is inclination of inclined plane acceleration along inclined plane $a = g\sin\theta$

$S_n =$ distance travelled by object during n^{th} second.

Initial speed $u = 0$

By equation of uniformly accelerated motion

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

$S_n = 0 + \frac{g\sin\theta}{2}(2n-1) = \frac{g\sin\theta}{2}(2n-1)$ ....(i)

Distance travelled during $(n+1)^{th}$ second.

$S_{n+1} = 0 + \frac{g\sin\theta}{2}[2(n+1)-1] = \frac{g\sin\theta}{2}(2n+1)$ ....(ii)

Dividing equations (i) and (ii)

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

Question11

A car starts from rest and accelerates at 5 m/s^2. At t = 4 s, a ball is dropped out of a window by a person sitting in the car. What is the velocity and acceleration of the ball at t = 6 s?(Take g = 10 m/s^2) [NEET 2021]

Options:

A. 20 m/s, 5 m/s^2

B. 20 m/s, 0

C. $20\sqrt{2}$ m/s, 0

D. $20\sqrt{2}$ m/s, 10 m/s^2

Answer: D

Solution:

Solution:
Initial velocity of car = 0
Acceleration of car = 5 m/s^2
Velocity of car at t = 4 s; v = u + at
⇒ v = 0 + 5 × 4 = 20 ms^{-1}
At t = 4 s, A ball is dropped out of a window so velocity of ball at this instant is 20 ms^{-1} along horizontal.
After 2 seconds of motion :
Horizontal velocity of ball $= 20ms^{-1} (\because a_x = 0)$
Vertical velocity of ball $(v_y) = u_y + a_y t$
$v_y = 0 + 10 \times 2 = 20ms^{-1} (\because a_y = g = 10m/s^2)$
So magnitude of velocity of ball
$(v) = \sqrt{v_x^2 + v_y^2} = 20\sqrt{2}m/s$
Acceleration of ball at $t = 6s$ is $g = 10m/s^2$
As ball is under free free fall.

Question12

A ball is thrown vertically downward with a velocity of 20m / s from the top of a tower. It hits the ground after some time with a velocity of 80m / s
The height of the tower is : (g = 10m / s^2)
[2020]

Options:

A. 340m

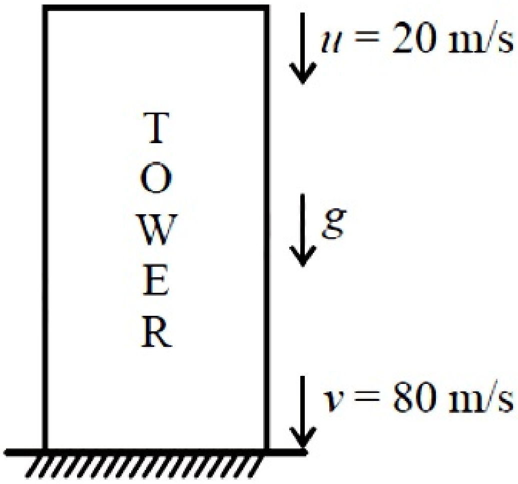
B. 320m

C. 300m

Answer: C

Solution:

Solution:



Using $v^2 = u^2 + 2gh$

Height, $h = \frac{v^2 - u^2}{2g} = \frac{(80)^2 - (20)^2}{2 \times 10}$

$= \frac{6400 - 400}{20} = 300\text{m}$

Question13

Preeti reached the metro station and found that the escalator was not working. She walked up the stationary escalator in time t_1.On other days, if she remains stationary on the moving escalator, then the escalator takes her up in time t_2.The time taken by her to walk up on the moving escalator will be
(2017 NEET)

Options:

A. $\frac{t_1 t_2}{t_2 - t_1}$

B. $\frac{t_1 t_2}{t_2 + t_1}$

C. $t_1 - t_2$

D. $\frac{t_1 + t_2}{2}$

Answer: B

Solution:

Let v_1 is the velocity of preeti on stationary escalator and d is the distance travelled by her

$\therefore v_1 = \frac{d}{t_1}$

Again, let v_2 is the velocity of escalator

$\therefore v_2 = \frac{d}{t_2}$

∴ Net velocity of Preeti on moving escalator with respect to the ground

$v = c_1 + v_2 = \frac{d}{t_1} + \frac{d}{t_2} = d\left(\frac{t_1 + t_2}{t_1 t_2}\right)$

The time taken by her to walk up on the moving escalator will be

$t = \frac{d}{v} = \frac{d}{d\left(\frac{t_1 + t_2}{t_1 t_2}\right)} = \frac{t_1 t_2}{t_1 + t_2}$

Question14

If the velocity of a particle is $v = At + Bt^2$,where A and B are constants,then the distance travelled by it between 1 s and 2 s is (2016 NEET Phase-I)

Options:

A. $\frac{3}{2}A + \frac{7}{3}B$

B. $\frac{A}{2} + \frac{B}{3}$

C. $\frac{3}{2}A + 4B$

D. $3A + 7B$

Answer: A

Solution:

Solution:

Velocity of the particle is $v = At + Bt^2$

$\frac{ds}{dt} = At + Bt^2 \cdot \int ds = \int (At + Bt^2)dt$

$\therefore s = \frac{At^2}{2} + B\frac{t^3}{3} + C$

$s(t = 1s) = \frac{A}{2} + \frac{B}{3} + C \,.\, s(t = 2s) = 2A + \frac{8}{3}B + C$

Required distance $= s(t = 2s) - s(t = 1s)$

$= \left(2A + \frac{8}{3}B + C\right) - \left(\frac{A}{2} + \frac{B}{3} + C\right)$

$= \frac{3}{2}A + \frac{7}{3}B$

Question15

and their positions are represented by $x_p(t) = (at + bt^2)$ and $x_Q(t) = (f\,t - t^2)$ At what time do the cars have the same velocity ? (2016 NEET Phase-11)

Options:

A. $\frac{a - f}{1 + b}$

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

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

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

Answer: D

Solution:

Position of the car P at any time f,is

$x_p(t) = at + bt^2$

$v_p(t) = \frac{d\,x_p(t)}{d\,t} = a + 2bt..........(i)$

Similarly, for car Q,

$x_Q(t) = f\,t - t^2$

$v_Q(t) = \frac{d\,x_Q(t)}{d\,t} = f\ - 2t...........(ii)$

$\because v_p(t) = v_Q(t)$ (Given)

$\therefore a + 2bt = f\ - 2t$ or, $2t(b + 1) = f\ - a$

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

Question16

A particle of unit mass undergoes one-dimensional motion such that its velocity varies according to $v(x) = \beta x^{-2n}$, where β and n are constants and x is the position of the particle. The acceleration of the particle as a function of x is given by (2015, Cancelled)

Options:

A. $-2\beta^2x^{-2n + 1}$

B. $-2n\beta^2e^{-4n + 1}$

C. $-2n\beta^2x^{-2n - 1}$

D. $-2n\beta^2x^{-4n - 1}$

Answer: D

Solution:

According to question, velocity of unit mass varies as
$v(x) = \beta x^{-2n}$.....(i)
$\frac{dv}{dx} = -2n\beta x^{-2n-1}$....(ii)
Acceleration of the particle is given by
$a = \frac{dv}{dt} = \frac{dv}{dx} \times \frac{dx}{dt} = \frac{dv}{dx} \times v$
Using equation (i) and (ii),we get
$a = (-2n\beta x^{-2n-1}) \times (\beta x^{-2n}) = -2n\beta^2 x^{-4n-1}$

Question17

A stone falls freely under gravity. It covers distances h_1, h_2 and h_3 in the first 5 seconds, the next 5 seconds and the next 5 seconds respectively. The relation between h_1 and h_2 and h_3 is
(2013 NEET)

Options:

A. $h_2 = 3h_1$ and $h_3 = 3h_2$

B. $h_1 = h_2 = h_3$

C. $h_1 = 2h_2 = 3h_3$

D. $h_1 = \frac{h_2}{3} = \frac{h_3}{5}$

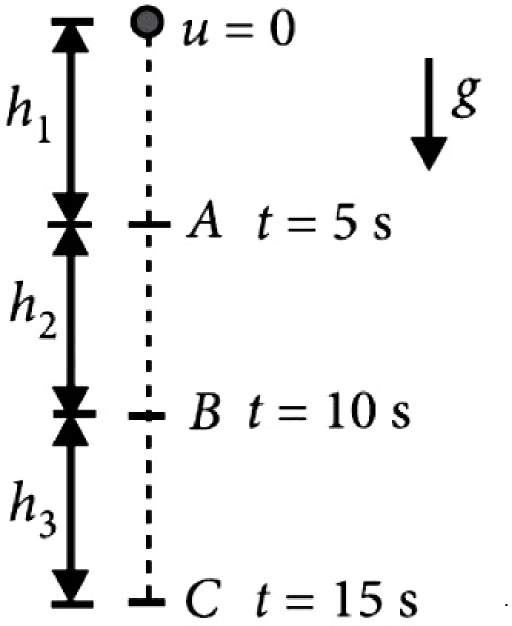
Answer: D

Solution:

Solution:
Distance covered by the stone in 5s is
$h_1 = \frac{1}{2}g(5)^2 = \frac{25}{2}g$.........(i)
Distance travelled by the stone in 10 s is
$h_1 + h_2 = \frac{1}{2}g(10)^2 = 100g$....(ii)
Distance travelled by the stone in 15 s is
$h_1 + h_2 + h_3 = \frac{1}{2}g(15)^2 = \frac{225}{2}g$.............(iii)
Subtract (i) from (ii), we get
$(h_1 + h_2) - h_1 = \frac{100}{2}g - \frac{25}{2}g = \frac{75}{2}g$
$h_2 = \frac{75}{2}g = 3h_1$..........(iv)
Subtract (ii) from (iii), we get
$(h_1 + h_2 + h_3) - (h_2 + h_1) = \frac{225}{2}g - \frac{100}{g}$

$h_3 = \frac{125}{2}g = 5h_1$.......(iv)

From (i), (iv) and (v), we get $h_1 = \frac{h_2}{3} = \frac{h_3}{5}$



Question18

The displacement ′x′ (in meter) 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
(KN NEET 2013)

Options:

A. 4m

B. 0m (zero)

C. 6m

D. 2m

Answer: B

Solution:

Solution:
Given $t = \sqrt{x} + 3$ or $\sqrt{x} = t - 3$
Squaring both sides, we get $x = (t - 3)^2$Velocity, $v = \frac{dx}{dt} = \frac{d}{dt}(t - 3)^2 = 2(t - 3)$
Velocity of the particle becomes zero, when
$2(t - 3) = 0$ or $t = 3s$
At $t = 3s$
$x = (3 - 3)^2 = 0m$

Question19

The motion of a particle along a straight line is described by equation $x = 8 + 12t - t^3$ where x is in metre and t in second. The retardation of the particle when its velocity becomes zero is
(2012)

Options:

A. $24ms^{-2}$

B. zero

C. $6ms^{-2}$

D. $12ms^{-2}$

Answer: D

Solution:

Given : $x = 8 + 12t - t^3$
Velocity, $v = \frac{dx}{dt} = 12 - 3t^2$
When $v = 0$, $12 - 3t^2 = 0$ or $t = 2s$
$a = \frac{dv}{dt} = -6t$
$a_{t=2s} = -12ms^{-2}$
Retardation $= 12ms^{-2}$

Question20

A boy standing at the top of a tower of 20 m height drops a stone. Assuming $g = 10ms^{-2}$, the velocity with which it hits the ground is
(2011)

Options:

A. 10.0 m/s

B. 20.0 m/s

C. 40.0 m/s

D. 5.0 m/s

Answer: B

Solution:

Here, $u = 0$, $g = 10ms^{-2}$, $h = 20m$
Let v be the velocity with which the stone hits theground
$\therefore v^2 = u^2 + 2gh$
or
$v = \sqrt{2gh} = \sqrt{2 \times 10 \times 20} = \frac{m}{s}$ $(\because u = 0)$

Question21

A particle covers half of its total distance with speed $v_1$and the rest half distance with speed v_2. Its average speed during the complete journey is (2011 Mains)

Options:

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

B. $\frac{v_1 v_2}{v_1 + v_2}$

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

D. $\frac{{v_1}^2 {v_2}^2}{{v_1}^2 + {v_2}^2}$

Answer: C

Solution:

Solution:
If The half distance (x) covered with the speed v_1 in time.
Using formula of speed, $v_1 = \frac{x}{t_1}$
so, $t_1 = \frac{x}{v_1}$
And another half distance (x), covered with speed v_2 in time t_2.
so, $v_2 = xt_2$
$t_2 = \frac{x}{v_2}$
Average Velocity $= \frac{\text{Total distance}}{\text{Total time}}$
Total time $= t_1 + t_2 = \frac{x}{v_1} + \frac{x}{v_2}$
$= \frac{(v_2 * x + v_1 * x)}{v_1 v_2}$
Total distance $= x + x = 2x$
On putting the values of total distance and total time in the formula of average speed, we get
Average speed $= \frac{2x}{\left(\frac{v_2 x + v_1 x}{v_1 * v_2}\right)}$
$V = \frac{2v_1 v_2}{(v_1 + v_2)}$

Question22

A particle moves a distance x in time t according to equation $x = (t + 5)^{-1}$.The acceleration of particles is proportional to (2010)

©

Options:

A. $(\text{velocity})^{\frac{3}{2}}$

B. $(\text{distance})^{2}$

C. $(\text{distance})^{-2}$

D. $(\text{velocity})^{\frac{2}{3}}$

Answer: A

Solution:

Disatance, $(x = t + 5)-1$ .....(i)
Velocity, $v = \frac{dx}{dt} = \frac{d}{dt}(t + 5)^{-1}$
$= -(t + 5)^{-2}$ ....(ii)
Acceleration, $a = \frac{dv}{dt} = \frac{d}{dt}[-(t + 5)^{-2}]$
$= 2(t + 5)^{-3}$ ....(iii)
From equation (ii), we get
$v^{\frac{3}{2}} = -(t + 5)^{-3}$ ....(iv)
Substituting this in equation (iii) we get,
Acceleration, $a = -2v^{\frac{3}{2}}$
$a \propto (\text{velocity})^{\frac{3}{2}}$

Question23

A ball is dropped from a high rise platform at 1 = 0 starting from rest. After 6 seconds another ball is thrown downwards from the same platform with a speed v. The two balls meet at t = 18 s. What is the value of v? (Take $g = 10m / s^2$) (2010)

©

Options:

B. 55 m/s

C. 40 m/s

D. 60 m/s

Answer: A

Solution:

Solution:
Let the two balls meet after t s at distance x from the platform.
For the first ball $u = 0$, $t = 18s$, $g = 10m / s^2$
Using $h = ut + \frac{1}{2}gt^2$
$\therefore x = \frac{1}{2} \times 10 \times 18^2$....(i)
For second ball $u = v$, $t = 12s$, $g = 10m / s^2$
Using $h = ut + \frac{1}{2}gt^2$
$\therefore x = v \times 12 + \frac{1}{2} \times 10 \times 12^2$......(ii)
From equations (i) and (ii), we get
$\frac{1}{2} \times 10 \times 18^2 = 12v + \frac{1}{2} \times 10 \times (12)^2$
or $12v = \frac{1}{2} \times 10 \times [(18)^2 - (12)^2]$
or $v = \frac{1 \times 10 \times 30 \times 6}{2 \times 12} = 75m / s$

Question24

A bus is moving with a speed of $10ms^{-1}$ on a straight road.A scooterist wishes to overtake the bus in 100s. If the bus is at a distance of 1 km from the scooterist,with what speed should the scooterist chase the bus ?
(2009)

Options:

A. $40ms^{-1}$

B. $25ms^{-1}$

C. $10ms^{-1}$

D. $20ms^{-1}$

Answer: D

Solution:

Solution:
Let v_s be the velocity of the scooter,the distance between the scooter and the bus =1000 m.

Relative velocity of the scooter with respect to the bus $= (v_s - 10)$

$\frac{1000}{(v_s - 10)} = 100s \Rightarrow v_s = 20ms^{-1}$

Question25

A particle starts its motion from rest under the action of a constant force. If the distance covered in first 10 seconds is S_1 and that covered in the first 20 seconds is S_2, then
(2009)

Options:

A. $S_2 = 3S_1$

B. $S_2 = 4S_1$

C. $S_2 = S_1$

D. $S_2 = 2S_1$

Answer: B

Solution:

Given : u=0

Distance travelled in 10s, $S_1 = \frac{1}{2}a \cdot 10^2 = 50a$

Distance travelled in 20s, $S_2 = \frac{1}{2}a \cdot 2o^2 = 200a$

$\therefore S_2 = 4S_1$

Question26

The distance travelled by a particle starting from rest and moving with an acceleration $\frac{4}{3}ms^{-2}$, in the third second is
(2008)

Options:

A. $\frac{10}{3}m$

B. $\frac{19}{3}m$

C. 6 m

D. 4 m

Answer: A

Solution:

Distance travelled in the 3rd second=Distance travelled in 3 s- distance travelled in 2s.As, u=0,

$S_{3^{rd}s} = \frac{1}{2}a \cdot 3^2 - \frac{1}{2}a \cdot 2^2 = \frac{1}{2} \cdot a \cdot 5$

Given.

$a = \frac{4}{3}ms^{-2} \quad \therefore S_{3^{rd}} = \frac{1}{2} \times \frac{4}{3} \times 5 = \frac{10}{3}m$

Question27

A particle moves in a straight line with a constant acceleration. It changes its velocity from $10ms^{-1}$ to $20ms^{-1}$ while passing through a distance 135 m in t second. The value of t is (2008)

Options:

A. 12

B. 9

C. 10

D. 1.8

Answer: B

Solution:

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

Given: $v = 10ms^{-1}$, $u = 10ms^{-1}$, $s = 135m$

$\therefore a = \frac{400 - 100}{2 \times 135} = \frac{300}{270} = \frac{10}{9}\frac{m}{s^2}$

$v = u + at \Rightarrow t = \frac{v - u}{a} = \frac{10\frac{m}{s}}{\frac{10}{9}\frac{m}{s^2}} = 9s$

Question28

A particle moving along x -axis has acceleration f, at time t, given by $f = f_0\left(1 - \frac{t}{T}\right)$, where f_0 and T are constants.

and the instant when $f = 0$, the particle's velocity (v_x) is (2007)

©

Options:

A. $\frac{1}{2} f_0 T^2$

B. $f_0 T^2$

C. $\frac{1}{2} f_0 T$

D. $f_0 T$

Answer: C

Solution:

Solution:

Given : At time $t = 0$, velocity, $v = 0$ Acceleration $f = f_0\left(1 - \frac{t}{T}\right)$

At $f = 0$, $0 = f_0\left(1 - \frac{t}{T}\right)$

since f_0 is a constant,

$\therefore 1 - \frac{t}{T} = 0$ or $t = T$

Also, acceleration $f = \frac{dv}{dt}$

$\therefore \int_0^{v_x} dv = \int_{t=0}^{t=T} f\,dt = \int_0^T f_0\left(1 - \frac{t}{T}\right) dt$

$\therefore v_x = \left[f_0 t - \frac{f_0 t^2}{2T}\right]_0^T = f_0 T - \frac{f_0 T^2}{2T} = \frac{1}{2} f_0 T$

Question29

A car moves from X to Y with a uniform speed v_u and returns to Y with a uniform speed v_d. The average speed for this round trip is (2007)

©

Options:

A. $\sqrt{v_u v_d}$

B. $\frac{v_d v_u}{v_d + v_u}$

C. $\frac{v_u + v_d}{2}$

D. $\frac{2 v_d v_u}{\ }$

Answer: D

Solution:

Average speed is always given by $\frac{\text{Total distance}}{\text{Total time}}$

Let's assume that distance between X and Y is d

So, time taken to go from X to Y will be $\frac{d}{v_u}$

And time taken to go from Y to X will be $\frac{d}{v_d}$

So, average speed will be $\frac{2d}{\frac{d}{v_u}+\frac{d}{v_d}} = \frac{2v_d v_u}{v_d + v_u}$

Question30

The position x of a particle with respect to time t along x -axis is given by $x = 9t^2 - t^3$ where x is in metres and t in seconds. What will be the position of this particle when it achieves maximum speed along the +x direction?
(2007)

Options:

A. 54 m

B. 81 m

C. 24 m

D. 32 m

Answer: A

Solution:

Given : $x = 9t^2 - t^3$

Speed $v = \frac{dx}{dt} = \frac{d}{dt}(9t^2 - t^3) = 18t - 3t^2$

For maximum speed, $\frac{dv}{dt} = 0 \Rightarrow 18 - 6t = 0$

$\therefore t = 3s$

$\therefore x_{max} = 81m - 27m = 54m$ (From $x = 9t^2 - t^3$)

Question31

Two bodies A (of mass 1kg) and B (of mass 3kg) are dropped from

them to reach the ground is
(2006)

Options:

A. $\frac{4}{5}$

B. $\frac{5}{4}$

C. $\frac{12}{5}$

D. $\frac{5}{12}$

Answer: A

Solution:

Solution:

Time taken by a body fall from a height h to reach the ground is $t = \sqrt{\frac{2h}{g}}$

$$\therefore \frac{t_A}{t_B} = \frac{\sqrt{\frac{2h_A}{g}}}{\sqrt{\frac{2h_B}{g}}} = \sqrt{\frac{h_A}{h_B}} = \sqrt{\frac{16}{25}} = \frac{4}{5}$$

Question32

A car runs at a constant speed on a circular track of radius 100m, taking 62.8 seconds for every circular lap. The average velocity and average speed for each circular lap respectively is
(2006)

Options:

A. 10m / s, 0

B. 0,0

C. 0, 10m / s

D. 10m / s, 10m / s

Answer: C

Solution:

Distance travelled in one rotation (lap) = $2\pi r$

$\therefore$ Average speed $= \frac{\text{distance}}{\text{time}} = \frac{2\pi r}{t}$
$= \frac{2 \times 3.14 \times 100}{62.8} = 10 ms^{-1}$
Net displacement in one lap $= 0$
Average velocity $= \frac{\text{net displacement}}{\text{time}} = \frac{0}{t} = 0$

Question33

A particle moves along a straight line OX. At a time t (in seconds) the distance x (in metres) of the particle from O is given by $x = 40 + 12t - t^3$. How long would the particle travel before coming to rest? (2006)

©

Options:

A. 16m

B. 24m

C. 40m

D. 56m

Answer: A

Solution:

Solution:
$x = 40 + 12t - t^3$
$\therefore$ Velocity, $v = \frac{dx}{dt} = 12 - 3t^2$
When particle come to rest, $\frac{dx}{dt} = v = 0$
$\therefore 12 - 3t^2 = 0 \Rightarrow 3t^2 = 12 \Rightarrow t = 2\,\text{sec}$
Distance travelled by the particle before coming to rest
$\int_0^s ds = \int_0^2 v\,dt$ or $s = \int_0^2 (12 - 3t^2)\,dt = 12t - \frac{3t^3}{3}\Big|_0^2$
$s = 12 \times 2 - 8 = 24 - 8 = 16m$

(OR)

At $t = 0$, particle is at , let's say x distance, from O;
then putting $t = 0$ in the given displacement-time equation we get;
$x = 40 + 12(0) - (0)^3 = 40m$
Particle comes to rest that means velocity of particle becomes zero after travelling certain displacement ; let's say the time be t. then after differentiating the given displacement-time equation w.r.t. time we get velocity - time equation
$v = 12 - 3t^2$
when the particle comes to rest):
at time $t = t$
$v = 0$;
$=> 12 - 3t^2 = 0$
$=> t = 2s$
Then, at $t = 2$ s we are at , let's say x' distance from O;
put this value of t (= 2) in given displacement-time equation

$= 56m$
Further; We have seen that the particle started his journey when it is at $40m$ from the point O. And came to rest at $56m$ from the point O.
then the particle traveled a distance of:
$56 - 40 = 16m$

Question34

A ball is thrown vertically upward. It has a speed of 10 m / sec when it has reached one half of its maximum height. How high does the ball rise? (Take left . g = 10m / s^2)
(2005)

©

Options:

A. 10m

B. 5m

C. 15m

D. 20m.

Answer: A

Solution:

$v^2 = u^2 - 2gh$
After reaching maximum height velocity becomes zero.
$0 = (10)^2 - 2 \times 10 \times \frac{h}{2} \therefore h = \frac{200}{20} = 10m$

Question35

The displacement x of a particle varies with time t as $x = ae^{-\alpha t} + be^{\beta t}$, where a, b, α and β are positive constants. The velocity of the particle will
(2005)

©

Options:

A. be independent of β

B. drop to zero when $\alpha = \beta$

C. go on decreasing with time

D. go on increasing with time.

Solution:

$x = ae^{-\alpha t} + be^{\beta t}; \frac{dx}{dt} = -a\alpha e^{-\alpha t} + b\beta e^{\beta t}$
$v = -a\alpha e^{-\alpha t} + b\beta e^{\beta t}$
For certain value of t, velocity will increases.

Question36

A man throws balls with the same speed vertically upwards one after the other at an interval of 2 seconds. What should be the speed of the throw so that more than two balls are in the sky at any time? (Given $g = 9.8 m / s^2$)
(2003)

Options:

A. more than 19.6 m/s

B. at least 9.8 m/s

C. any speed less than 19.6 m/s

D. only with speed 19.6 m/s

Answer: A

Solution:

Solution:
Interval of ball thrown $= 2\,sec$
If we want that minimum three (more than two) balls remain in air then time of flight of first ball must be greater than 4 sec.
$T > 4\,sec \text{ or } \frac{2u}{g} > 4\,sec \Rightarrow u > 19.6 m / s$

Question37

If a ball is thrown vertically upwards with speed u, the distance covered during the last t seconds of its ascent is
(2003)

Options:

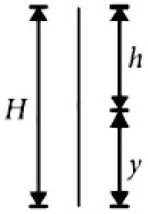
A. ut

C. $ut - \frac{1}{2}gt^2$

D. $(u + gt)t$

Answer: B

Solution:



Let total height $= H$
Time of ascent $= T$
So, $H = uT - \frac{1}{2}gT^2$
Distance covered by ball in time $(T - t)$ sec.
$y = u(T - t) - \frac{1}{2}g(T - t)^2$
So distance covered by ball in last t sec.,
$h = H - y = \left[uT - \frac{1}{2}gT^2\right] - \left[u(T - t) - \frac{1}{2}g(T - t)^2\right]$
By solving and putting $T = \frac{u}{g}$ we will get
$h = \frac{1}{2}gt^2$

Question38

A particle is thrown vertically upward. Its velocity at half of the height is $10m / s$ then the maximum height attained by it $(g = 10m / s^2)$ (2001)

Options:

A. 8m

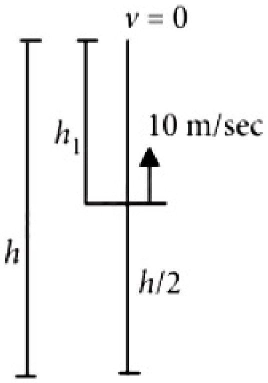
B. 20m

C. 10m

D. 16m.

Answer: C

Solution:



For half height,
$10^2 = u^2 - 2g\frac{h}{2}$...(i)
For total height,
$0 = u^2 - 2gh$...(ii)
From (i) and (ii)
$\Rightarrow 10^2 = \frac{2gh}{2} \Rightarrow h = 10m$

Question39

Motion of a particle is given by equation $s = (3t^3 + 7t^2 + 14t + 8)m$. The value of acceleration of the particle at $t = 1$ sec is (2000)

Options:

A. $10m / s^2$

B. $32m / s^2$

C. $23m / s^2$

D. $16m / s^2$

Answer: B

Solution:

$$\frac{ds}{dt} = 9t^2 + 14t + 14$$
$$\Rightarrow \frac{d^2s}{dt^2} = 18t + 14 = a$$
$$a_{t=1} = 18 \times 1 + 14 = 32m / s^2$$

Question40

A car moving with a speed of 40km / h can be stopped by applying brakes after atleast 2 m. If the same car is moving with a speed of 80km / h, what is the minimum stopping distance?

Options:

A. 4m

B. 6m

C. 8m

D. 2m.

Answer: C

Solution:

Solution:
1st case : $v^2 - u^2 = 2as$

$0 - \left(\frac{100}{9}\right)^2 = 2 \times a \times 2$ [∵ 40 km/h = 100/9 m/s]

$a = -\frac{10^4}{81 \times 4} m / s^2$

2nd case : $0 - \left(\frac{200}{9}\right)^2 = 2 \times \left(-\frac{10^4}{81 \times 4}\right) \times s$

[∵ 80 km/h = 200/9 m/s]
or $s = 8m$

Question41

A rubber ball is dropped from a height of 5m on a plane. On bouncing it rises to 1.8m. The ball loses its velocity on bouncing by a factor of (1998)

Options:

A. $\frac{3}{5}$

B. $\frac{2}{5}$

C. $\frac{16}{25}$

D. $\frac{9}{25}$

Answer: B

Solution:

Solution:
We know that when a ball is dropped from height h , it strikes the surface with speed
$v = \sqrt{2gh}$

$v = \sqrt{2 \times 10 \times 5}$,
$v = \sqrt{100}$,
$v = 10 m / s$

We also know that when a ball rebounds with speed u , the height it reaches is given by $H = \frac{u^2}{2g}$

It is given that the ball reaches height $1.8 m$ on rebound. Substituting this value and value of acceleration due to gravity in the formula, we get $1.8 = \frac{u^2}{2 \times 10}$

$u^2 = 36$,
$u = 6 m / s$

Hence the ball loses its velocity by $4 m / s$ on rebounding.

The fractional loss can be calculated by dividing the loss in velocity with initial velocity, i.e. velocity with which it strikes the floor i.e $10 m / s$

Hence, fractional loss in velocity $= \frac{4}{10}$, fractional loss in velocity $= \frac{2}{5}$.

Question42

The position x of a particle varies with time, (t) as $x = at^2 - bt^3$. The acceleration will be zero at time t is equal to (1997)

Options:

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

B. 0

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

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

Answer: A

Solution:

Solution:

Distance $(x) = at^2 - bt^3$

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

and acceleration $= \frac{dv}{dt} = \frac{d}{dt}(2at - 3bt^2) = 2a - 6bt = 0$

or $t = \frac{2a}{6b} = \frac{a}{3b}$

Question43

If a car at rest accelerates uniformly to a speed of $144 km / h$ in $20 sec$, it covers a distance of (1997)

Options:

A. 1440cm

B. 2980cm

C. 20m

D. 400 m

Answer: D

Solution:

Solution:
Initial velocity $u = 0$,
Final velocity $= 144\,km/h = 40m/s$ and time $= 20\,sec$
Using $v = u + at \Rightarrow a = \frac{v}{t} = 2m/s^2$
Again, $s = ut + \frac{1}{2}at^2 = \frac{1}{2} \times 2 \times (20)^2 = 400m$

Question44

A body dropped from a height h with initial velocity zero, strikes the ground with a velocity 3m / s. Another body of same mass dropped from the same height h with an initial velocity of 4m / s. The final velocity of second mass, with which it strikes the ground is
(1996)

Options:

A. 5m / s

B. 12m / s

C. 3m / s

D. 4m / s

Answer: A

Solution:

Solution:
Initial velocity of first body $(u_1) = 0$;
Final velocity $(v_1) = 3m/s$ and initial velocity of second body $(u_2) = 4m/s$
height $(h) = \frac{v_1^2}{2g} = \frac{(3)^2}{2 \times 9.8} = 0.46m$
Therefore velocity of the second body,
$v_2 = \sqrt{u_2^2 + 2gh} = \sqrt{(4)^2 + 2 \times 9.8 \times 0.46} = 5m/s$

Question45

The acceleration of a particle is increasing linearly with time t as bt. The particle starts from origin with an initial velocity v_0. The distance travelled by the particle in time t will be
(1995)

Options:

A. $v_0 t + \frac{1}{3} b t^2$

B. $v_0 t + \frac{1}{2} b t^2$

C. $v_0 t + \frac{1}{6} b t^3$

D. $v_0 t + \frac{1}{3} b t^3$

Answer: C

Solution:

Solution:

Acceleration $\propto bt$. i.e., $\frac{d^2x}{dt^2} = a \propto bt$

Integrating, $\frac{dx}{dt} = \frac{bt^2}{2} + C$

Initially, $t = 0$, $d\frac{x}{d}t = v_0$

Therefore, $\frac{dx}{dt} = \frac{bt^2}{2} + v_0$

Integrating again, $x = \frac{bt^3}{6} + v_0 t + C$

When $t = 0$, $x = 0 \Rightarrow C = 0$.

i.e., distance travelled by the particle in time $= v_0 t + \frac{bt^3}{6}$

Question46

The water drop falls at regular intervals from a tap 5m above the ground. The third drop is leaving the tap at instant the first drop touches the ground. How far above the ground is the second drop at that instant?
(1995)

Options:

A. 3.75m

C. 1.25m

D. 2.50m.

Answer: A

Solution:

Solution:
Height of tap $= 5\text{m}$. For the first drop,
$5 = ut + \frac{1}{2}gt^2 = \frac{1}{2} \times 10t^2 = 5t^2$ or $t^2 = 1$
or $t = 1$ sec. It means that the third drop leaves after one second of the first drop, or each drop leaves after every 0.5 sec. Distance covered by the second drop in 0.5 sec
$= \frac{1}{2}gt^2 = \frac{1}{2} \times 10 \times (0.5)^2 = 1.25\text{m}$
Therefore distance of the second drop above the ground $= 5 - 1.25 = 3.75\text{m}$

Question47

A car accelerates from rest at a constant rate α for some time after which it decelerates at a constant rate β and comes to rest. If total time elapsed is t, then maximum velocity acquired by car will be (1994)

Options:

A. $\frac{(\alpha^2 - \beta^2)t}{\alpha\beta}$

B. $\frac{(\alpha^2 + \beta^2)t}{\alpha\beta}$

C. $\frac{(\alpha + \beta)t}{\alpha\beta}$

D. $\frac{\alpha\beta t}{\alpha + \beta}$

Answer: D

Solution:

Solution:
Initial velocity $(u) = 0$; acceleration in the first phase $= \alpha$; deceleration in the second phase $= \beta$ and total time $= t$.
When car is accelerating then final velocity
$(v) = u + \alpha t = 0 + \alpha t_1$
or $t_1 = \frac{v}{\alpha}$ and when car is decelerating,
then final velocity $0 = v - \beta t$ or $t_2 = \frac{v}{\beta}$
Therefore total time $(t) = t_1 + t_2 = \frac{v}{\alpha} + \frac{v}{\beta}$
$t = v\left(\frac{1}{\alpha} + \frac{1}{\beta}\right) = v\left(\frac{\beta + \alpha}{\alpha\beta}\right)$ or $v = \frac{\alpha\beta t}{\alpha + \beta}$

Question48

A particle moves along a straight line such that its displacement at any time t is given by s = $(t^3 - 6t^2 + 3t + 4)$ metres. The velocity when the acceleration is zero is
(1994)

Options:

A. 3 m/s

B. 42 m/s

C. -15 m/s

D. -9 m/s

Answer: D

Solution:

Solution:
Displacement (s) = $t^3 - 6t^2 + 3t + 4m$
Velocity (v) = $\frac{ds}{dt} = 3t^2 - 12t + 3$
Acceleration (a) = $\frac{dv}{dt} = 6t - 12$
When $a = 0$, we get $t = 2$ seconds.
Therefore velocity when the acceleration is zero (v) = $3 \times (2)^2 - (12 \times 2) + 3 = -9$ m/s

----

Question49

The velocity of train increases uniformly from 20 km / h to 60 km / h in 4 hours. The distance travelled by the train during this period is
(1994)

Options:

A. 160 km

B. 180 km

C. 100 km

D. 120 km

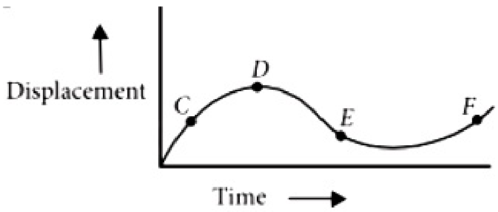
Answer: A

Solution:

Initial velocity (u) = $20\,km/h$;
Final velocity (v) = $60\,km/h$ and time (t) = 4 hours.
velocity (v) = $60 = u + at = 20 + (a \times 4)$
or, $a = \frac{60-20}{4} = 10\,km/h^2$
Therefore distance travelled in 4 hours is s
$s = ut + \frac{1}{2}at^2 = (20 \times 4) + \frac{1}{2} \times 10 \times (4)^2 = 160\,km$

Question50

The displacement-time graph of a moving particle is shown below. The instantaneous velocity of the particle is negative at the point (1994)



Options:

A. E

B. F

C. C

D. D

Answer: A

Solution:

Solution:
The velocity (v) = $\frac{ds}{dt}$
Therefore, instantaneous velocity at point E is negative.

Question51

A body starts from rest, what is the ratio of the distance travelled by the body during the 4^{th} and 3^{rd} second? (1993)

Options:

A. $\frac{7}{5}$

C. $\frac{7}{3}$

D. $\frac{3}{7}$

Answer: A

Solution:

Distance covered in n^{th} second is given by

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

Here, $u = 0$.

$\therefore s_4 = 0 + \frac{a}{2}(2 \times 4 - 1) = \frac{7a}{2}$

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

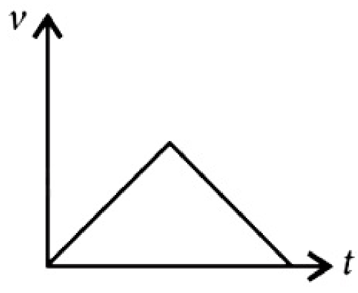
$\therefore \frac{s_4}{s_3} = \frac{7}{5}$

Question52

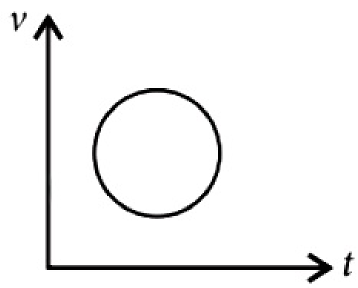
Which of the following curve does not represent motion in one dimension?
(1992)

Options:

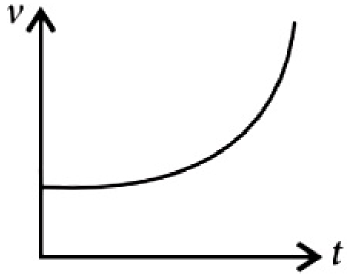
A.



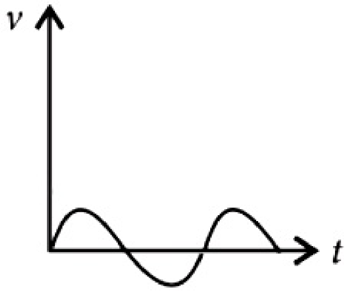
B.



C.



D.



Answer: B

Solution:

Solution:
In one dimensional motion, the body can have at a time one value of velocity but not two values of velocities.

Question53

A body dropped from top of a tower fall through 40m during the last two seconds of its fall. The height of tower is ($g = 10m / s^2$) (1992)

Options:

A. 60m

B. 45m

C. 80m

D. 50m

Answer: B

Solution:

Let h be height of the tower and t is the time taken by the body to reach the ground.
Here, $u = 0$, $a = g$
$\therefore h = ut + \frac{1}{2}gt^2$ or $h = 0 \times t + \frac{1}{2}gt^2$
or $h = \frac{1}{2}gt^2$ ....(i)

Distance covered in last two seconds is
$40 = \frac{1}{2}gt^2 - \frac{1}{2}g(t-2)^2$ (Here ,u = 0)
or $40 = \frac{1}{2}gt^2 - \frac{1}{2}g(t^2 + 4 - 4t)$
or $40 = (2t - 2)g$ or $t = 3s$
From eqn (i), we get
$h = \frac{1}{2} \times 10 \times (3)^2$ or $h = 45m$

Question54

A car moves a distance of 200m. It covers the first half of the distance at speed 40 km / h and the second half of distance at speed v. The average speed is 48 km / h. The value of v is
(1991)

Options:

A. 56 km / h

B. 60 km / h

C. 50 km / h

D. 48 km / h

Answer: B

Solution:

Solution:
Total distance travelled = 200m
Total time taken $= \frac{100}{40} + \frac{100}{v}$
Average speed $= \frac{\text{total distance travelled}}{\text{total time taken}}$
$48 = \frac{200}{\left(\frac{100}{40} + \frac{100}{v}\right)}$ or $48 = \frac{2}{\left(\frac{1}{40} + \frac{1}{v}\right)}$
or $\frac{1}{40} + \frac{1}{v} = \frac{1}{24}$
or $\frac{1}{v} = \frac{1}{24} - \frac{1}{40} = \frac{1}{60}$
or $v = 60$ km / hr

Question55

A bus travelling the first one-third distance at a speed of 10 km / h, the next one-third at20 km / h and at last one-third at 60 km / h. The average speed of the bus is
(1991)

Options:

A. 9 km / h

B. 16 km / h

C. 18 km / h

D. 48 km / h

Answer: C

Solution:

Solution:
Total distance travelled = s

Total time taken $= \frac{s/3}{10} + \frac{s/3}{20} + \frac{s/3}{60}$

$= \frac{s}{30} + \frac{s}{60} + \frac{s}{180} = \frac{10s}{180} = \frac{s}{18}$

Average speed $= \frac{\text{total distance travelled}}{\text{total time taken}} = \frac{s}{s/18} = 18\text{ km / hr}$

Question56

A car covers the first half of the distance between two places at 40 km / h and another half at 60 km / h. The average speed of the car is (1990)

Options:

A. 40 km / h

B. 48 km / h

C. 50 km / h

D. 60 km / h

Answer: B

Solution:

Solution:
Total distance covered = s

Total time taken $= \frac{s/2}{40} + \frac{s/2}{60} = \frac{5s}{240} = \frac{s}{48}$

∴ Average speed $= \frac{\text{total distance covered}}{\text{total time taken}} = \frac{s}{(s/48)} = 48\text{ km / hr}$

Question57

from rest in 4th and 5th seconds of journey?
(1989)

Options:

A. 4 : 5

B. 7 : 9

C. 16 : 25

D. 1 : 1

Answer: B

Solution:

Solution:
Distance covered in n^{th} second is given by
$s_n = u + \frac{a}{2}(2n - 1)$
Given : $u = 0, a = g$
$\therefore s_4 = \frac{g}{2}(2 \times 4 - 1) = \frac{7g}{2}$
$s_5 = \frac{g}{2}(2 \times 5 - 1) = \frac{9g}{2}$
$\therefore \frac{s_4}{s_5} = \frac{7}{9}$

Question58

A car is moving along a straight road with a uniform acceleration. It passes through two points P and Q separated by a distance with velocity 30 km / h and 40 km / h respectively. The velocity of the car midway between P and Q is
(1988)

Options:

A. 33.3 km / h

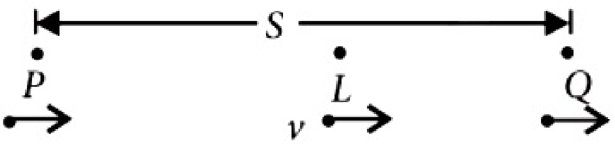
B. $20\sqrt{2}$ km / h

C. $25\sqrt{2}$ km / h

D. 35 km / h

Answer: C

Solution:



Let $PQ = s$ and L is the midpoint of PQ and v be velocity of the car at point L.
Using third equation of motion, we get
$(40)^2 - (30)^2 = 2as$

or $a = \frac{(40)^2 - (30)^2}{2s} = \frac{350}{s}$.....(i)

Also, $v^2 - (30)^2 = 2a\frac{s}{2}$

or $v^2 - (30)^2 = 2 \times \frac{350}{s} \times \frac{s}{2}$ [Using (i)]

or $v = 25\sqrt{2}\,\text{km / hr}$
