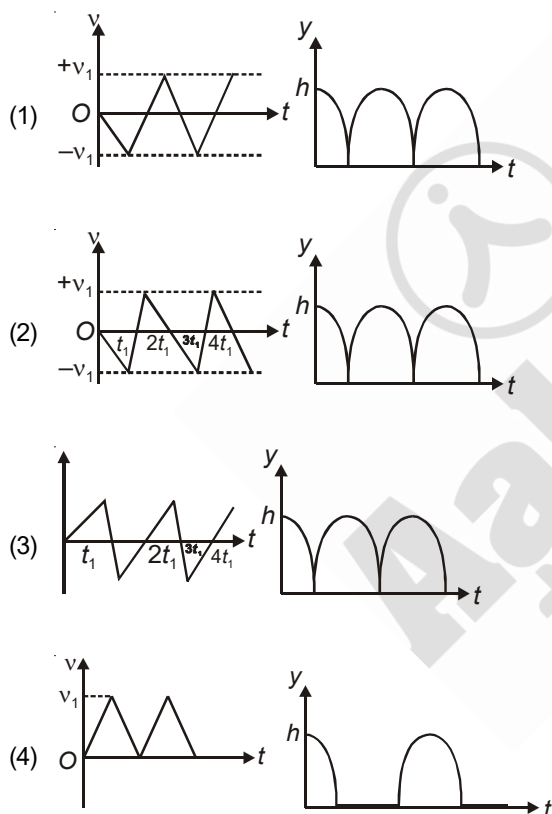


Chapter 1

Motion in a Straight Line

1. Consider a rubber ball freely falling from a height $h = 4.9$ m onto a horizontal elastic plate. Assume that the duration of collision is negligible and the collision with the plate is totally elastic.

Then the velocity as a function of time and the height as a function of time will be **[AIEEE-2009]**



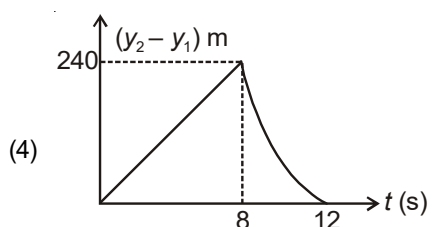
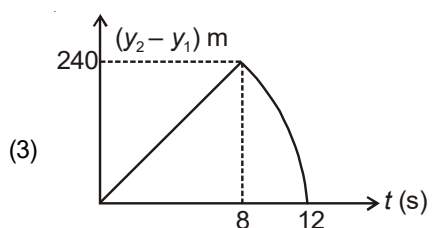
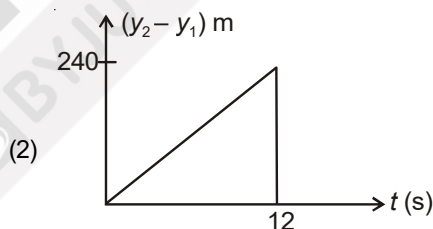
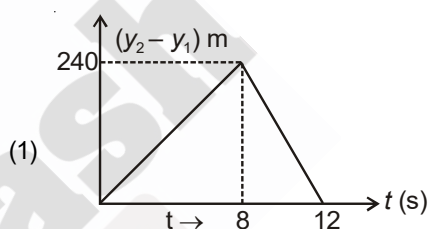
2. From a tower of height H , a particle is thrown vertically upwards with a speed u . The time taken by the particle, to hit the ground, is n times that taken by it to reach the highest point of its path. The relation between H , u and n is **[JEE (Main)-2014]**

- (1) $2gH = n^2u^2$
- (2) $gH = (n - 2)^2u^2$
- (3) $2gH = nu^2(n - 2)$
- (4) $gH = (n - 2)u^2$

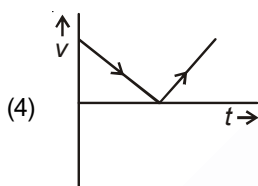
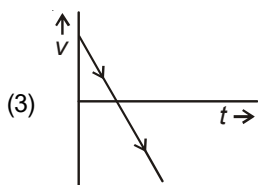
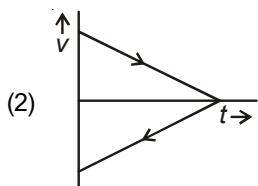
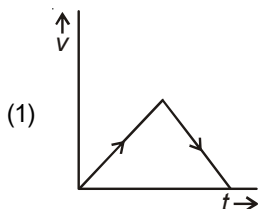
3. Two stones are thrown up simultaneously from the edge of a cliff 240 m high with initial speed of 10 m/s and 40 m/s respectively. Which of the following graph best represents the time variation of relative position of the second stone with respect to the first? **[JEE (Main)-2015]**

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

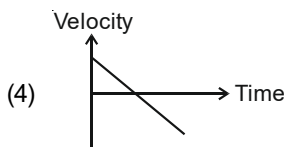
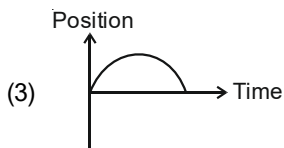
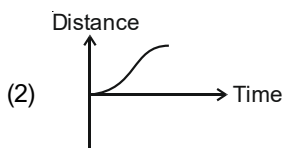
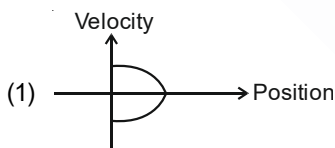
(The figures are schematic and not drawn to scale)



4. A body is thrown vertically upwards. Which one of the following graphs correctly represent the velocity vs time? [JEE (Main)-2017]



5. All the graphs below are intended to represent the same motion. One of them does it incorrectly. Pick it up. [JEE (Main)-2018]

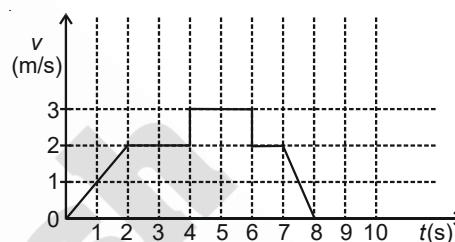


6. In a car race on straight road, car A takes a time t less than car B at the finish and passes finishing point with a speed ' v ' more than that of car B. Both the cars start from rest and travel with constant acceleration a_1 and a_2 respectively. Then ' v ' is equal to [JEE (Main)-2019]

(1) $\frac{a_1 + a_2}{2} t$ (2) $\frac{2a_1 a_2}{a_1 + a_2} t$

(3) $\sqrt{2a_1 a_2} t$ (4) $\sqrt{a_1 a_2} t$

7. A particle starts from the origin at time $t = 0$ and moves along the positive x-axis. The graph of velocity with respect to time is shown in figure. What is the position of the particle time $t = 5$ s?



[JEE (Main)-2019]

- (1) 9 m (2) 6 m
(3) 10 m (4) 3 m

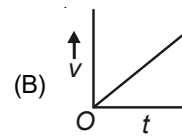
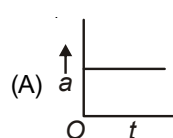
8. A passenger train of length 60 m travels at a speed of 80 km/hr. Another freight train of length 120 m travels at a speed of 30 km/hr. The ratio of times taken by the passenger train to completely cross the freight train when : (i) they are moving in the same direction, and (ii) in the opposite directions is [JEE (Main)-2019]

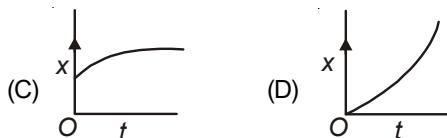
(1) $\frac{25}{11}$ (2) $\frac{5}{2}$

(3) $\frac{11}{5}$ (4) $\frac{3}{2}$

9. A particle starts from origin O from rest and moves with a uniform acceleration along the positive x-axis. Identify all figures that correctly represent the motion qualitatively. (a = acceleration, v = velocity, x = displacement, t = time)

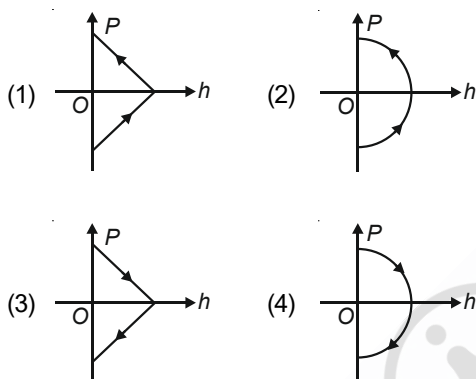
[JEE (Main)-2019]





- (1) (A) (2) (A), (B), (C)
(3) (A), (B), (D) (4) (B), (C)

10. A ball is thrown vertically up (taken as + z-axis) from the ground. The correct momentum-height ($P-h$) diagram is [JEE (Main)-2019]



11. The position of a particle as a function of time t , is given by

$$x(t) = at + bt^2 - ct^3$$

where a , b and c are constants. When the particle attains zero acceleration, then its velocity will be

[JEE (Main)-2019]

- (1) $a + \frac{b^2}{4c}$ (2) $a + \frac{b^2}{3c}$
(3) $a + \frac{b^2}{2c}$ (4) $a + \frac{b^2}{c}$

12. A particle is moving with speed $v = b\sqrt{x}$ along positive x -axis. Calculate the speed of the particle at time $t = \tau$ (assume that the particle is at origin at $t = 0$). [JEE (Main)-2019]

- (1) $b^2\tau$ (2) $\frac{b^2\tau}{4}$
(3) $\frac{b^2\tau}{2}$ (4) $\frac{b^2\tau}{\sqrt{2}}$

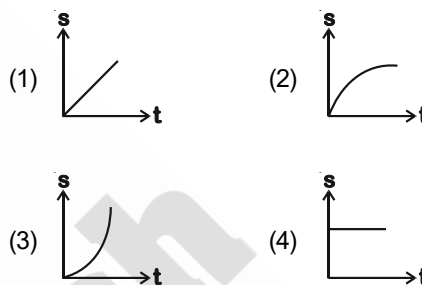
13. Train A and train B are running on parallel tracks in the opposite directions with speeds of 36 km/hour and 72 km/hour, respectively. A person is walking in train A in the direction opposite to its motion with a

speed of 1.8 km/hour. Speed (in ms^{-1}) of this person as observed from train B will be close to (take the distance between the tracks as negligible)

[JEE (Main)-2020]

- (1) 30.5 ms^{-1} (2) 29.5 ms^{-1}
(3) 31.5 ms^{-1} (4) 28.5 ms^{-1}

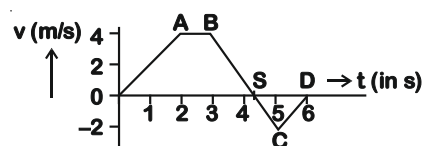
14. A particle is moving unidirectionally on a horizontal plane under the action of a constant power supplying energy source. The displacement (s) - time (t) graph that describes the motion of the particle is (graphs are drawn schematically and are not to scale) [JEE (Main)-2020]



15. A helicopter rises from rest on the ground vertically upwards with a constant acceleration g . A food packet is dropped from the helicopter when it is at a height h . The time taken by the packet to reach the ground is close to [g is the acceleration due to gravity] [JEE (Main)-2020]

- (1) $t = 3.4 \sqrt{\frac{h}{g}}$ (2) $t = 1.8 \sqrt{\frac{h}{g}}$
(3) $t = \sqrt{\frac{2h}{3g}}$ (4) $t = \frac{2}{3} \sqrt{\frac{h}{g}}$

16. The velocity (v) and time (t) graph of a body in a straight line motion is shown in the figure. The point S is at 4.333 seconds. The total distance covered by the body in 6 s is [JEE (Main)-2020]

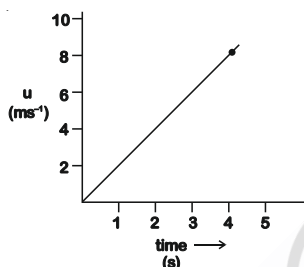


- (1) $\frac{37}{3} \text{ m}$ (2) 11 m
(3) 12 m (4) $\frac{49}{4} \text{ m}$

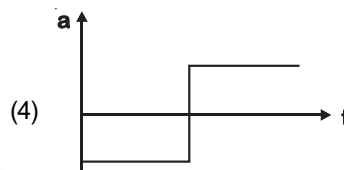
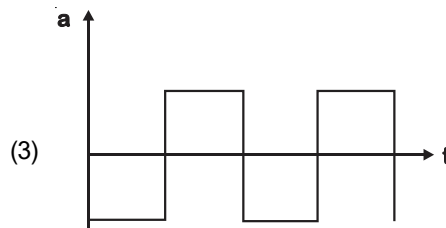
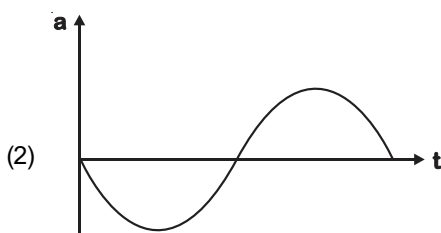
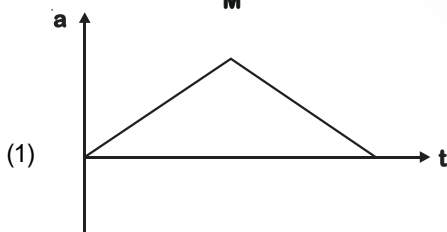
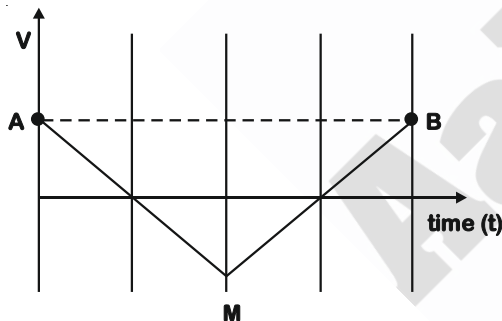
17. A ball is dropped from the top of a 100 m high tower on a planet. In the last $\frac{1}{2}$ s before hitting the ground, it covers a distance of 19 m. Acceleration due to gravity (in ms^{-2}) near the surface on that planet is _____. [JEE (Main)-2020]

18. The distance x covered by a particle in one dimensional motion varies with time t as $x^2 = at^2 + 2bt + c$. If the acceleration of the particle depends on x as x^{-n} , where n is an integer, the value of n is _____. [JEE (Main)-2020]

19. The speed versus time graph for a particle is shown in the figure. The distance travelled (in m) by the particle during the time interval $t = 0$ to $t = 5$ s will be _____. [JEE (Main)-2020]



20. If the velocity-time graph has the shape AMB, what would be the shape of the corresponding acceleration-time graph? [JEE (Main)-2021]



21. An engine of a train, moving with uniform acceleration, passes the signal-post with velocity u and the last compartment with velocity v . The velocity with which middle point of the train passes the signal post is: [JEE (Main)-2021]

(1) $\sqrt{\frac{v^2 - u^2}{2}}$ (2) $\frac{v - u}{2}$
 (3) $\sqrt{\frac{v^2 + u^2}{2}}$ (4) $\frac{u + v}{2}$

22. A stone is dropped from the top of a building. When it crosses a point 5 m below the top, another stone starts to fall from a point 25 m below the top. Both stones reach the bottom of building simultaneously. The height of the building is [JEE (Main)-2021]

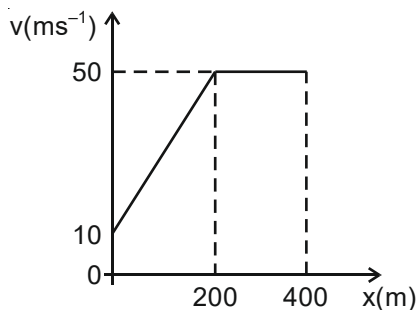
(1) 35 m
 (2) 45 m
 (3) 25 m
 (4) 50 m

23. A scooter accelerates from rest for time t_1 at constant rate a_1 and then retards at constant rate a_2 for time t_2 and comes to rest. The correct value of $\frac{t_1}{t_2}$ will be [JEE (Main)-2021]

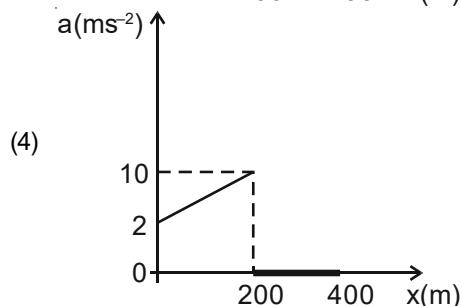
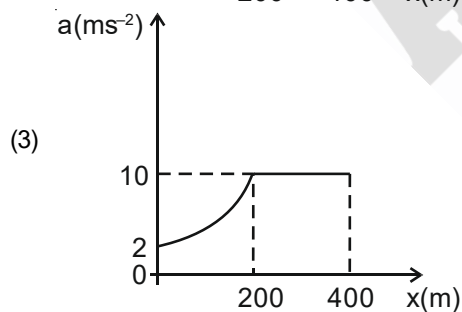
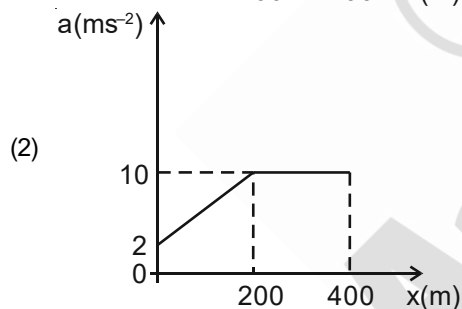
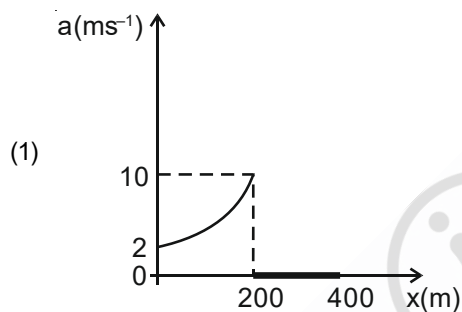
(1) $\frac{a_1 + a_2}{a_1}$ (2) $\frac{a_1}{a_2}$
 (3) $\frac{a_2}{a_1}$ (4) $\frac{a_1 + a_2}{a_2}$

24. The velocity-displacement graph describing the motion of a bicycle is shown in the figure.

[JEE (Main)-2021]



The acceleration-displacement graph of the bicycle's motion is best described by :



25. A car accelerates from rest at a constant rate α for some time after which it decelerates at a constant rate β to come to rest. If the total time elapsed is t seconds, the total distance travelled is:

[JEE (Main)-2021]

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

(3) $\frac{\alpha\beta}{4(\alpha+\beta)}t^2$ (4) $\frac{4\alpha\beta}{(\alpha+\beta)}t^2$

26. The velocity of a particle is $v = v_0 + gt + Ft^2$. Its position is $x = 0$ at $t = 0$; then its displacement after time $(t = 1)$ is :

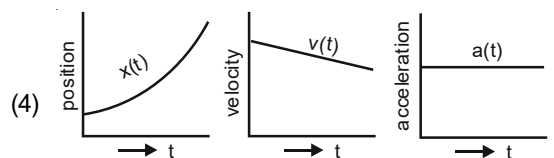
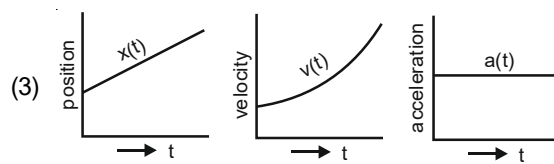
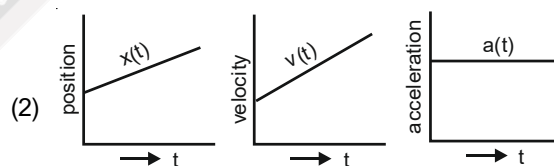
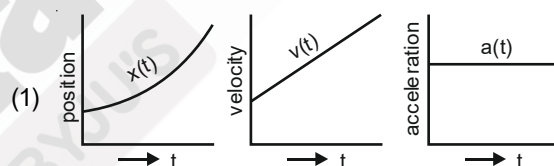
[JEE (Main)-2021]

(1) $v_0 + \frac{g}{2} + F$ (2) $v_0 + g + F$

(3) $v_0 + \frac{g}{2} + \frac{F}{3}$ (4) $v_0 + 2g + 3F$

27. The position, velocity and acceleration of a particle moving with a constant acceleration can be represented by:

[JEE (Main)-2021]



28. A butterfly is flying with a velocity $4\sqrt{2}$ m/s in North-East direction. Wind is slowly blowing at 1 m/s from North to South. The resultant displacement of the butterfly in 3 seconds is:

[JEE (Main)-2021]

- (1) $12\sqrt{2}$ m (2) 3 m
(3) 20 m (4) 15 m

29. A boy reaches the airport and finds that the escalator is not working. He walks up the stationary escalator in time t_1 . If he remains stationary on a moving escalator then the escalator takes him up in time t_2 . The time taken by him to walk up on the moving escalator will be:

[JEE (Main)-2021]

- (1) $t_2 - t_1$ (2) $\frac{t_1 t_2}{t_2 - t_1}$
(3) $\frac{t_1 + t_2}{2}$ (4) $\frac{t_1 t_2}{t_2 + t_1}$

30. Water droplets are coming from an open tap at a particular rate. The spacing between a droplet observed at 4th second after its fall to the next droplet is 34.3 m. At what rate the droplets are coming from the tap? (Take $g = 9.8$ m/s²)

[JEE (Main)-2021]

- (1) 1 drop / 7 seconds
(2) 3 drops / 2 seconds
(3) 2 drops / second
(4) 1 drop / second

31. The relation between time t and distance x for a moving body is given as $t = mx^2 + nx$, where m and n are constants. The retardation of the motion is: (Where v stands for velocity)

[JEE (Main)-2021]

- (1) $2nv^3$ (2) $2mv^3$
(3) $2mnv^3$ (4) $2n^2v^3$

32. A balloon was moving upwards with a uniform velocity of 10 m/s. An object of finite mass is dropped from the balloon when it was at a height of 75 m from the ground level. The height of the balloon from the ground when object strikes the ground was around (take the value of g as 10 m/s²)

[JEE (Main)-2021]

- (1) 250 m (2) 125 m
(3) 300 m (4) 200 m

33. The instantaneous velocity of a particle moving in a straight line is given as $v = \alpha t + \beta t^2$, where α and β are constants. The distance travelled by the particle between 1 s and 2 s is

[JEE (Main)-2021]

- (1) $\frac{3}{2}\alpha + \frac{7}{3}\beta$ (2) $\frac{\alpha}{2} + \frac{\beta}{3}$
(3) $\frac{3}{2}\alpha + \frac{7}{2}\beta$ (4) $3\alpha + 7\beta$

34. A ball is thrown up with a certain velocity so that it reaches a height ' h '. Find the ratio of the two

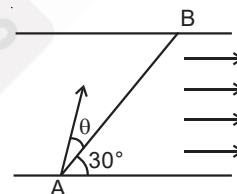
different times of the ball reaching $\frac{h}{3}$ in both the directions.

[JEE (Main)-2021]

- (1) $\frac{1}{3}$ (2) $\frac{\sqrt{3} - \sqrt{2}}{\sqrt{3} + \sqrt{2}}$
(3) $\frac{\sqrt{3} - 1}{\sqrt{3} + 1}$ (4) $\frac{\sqrt{2} - 1}{\sqrt{2} + 1}$

35. A swimmer wants to cross a river from point A to point B. Line AB makes an angle of 30° with the flow of river. Magnitude of velocity of the swimmer is same as that of the river. The angle θ with the line AB should be _____°, so that the swimmer reaches point B.

[JEE (Main)-2021]



36. Two spherical balls having equal masses with radius of 5 cm each are thrown upwards along the same vertical direction at an interval of 3 s with the same initial velocity of 35 m/s, then these balls collide at a height of ____ m. (take $g = 10$ m/s²)

[JEE (Main)-2021]

37. If the velocity of a body related to displacement x is given by $v = \sqrt{5000 + 24x}$ m/s, then the acceleration of the body is _____ m/s²

[JEE (Main)-2021]

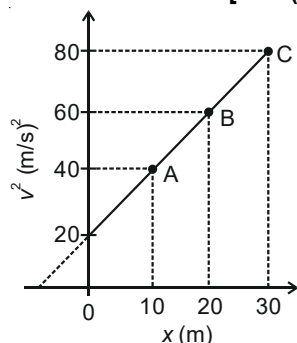
38. Water drops are falling from a nozzle of a shower onto the floor, from a height of 9.8 m. The drops fall at a regular interval of time. When the first drop strikes the floor, at that instant, the third drop begins to fall. Locate the position of second drop from the floor when the first drop strikes the floor.

[JEE (Main)-2021]

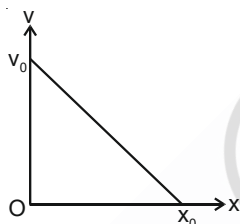
- (1) 2.45 m (2) 7.35 m
(3) 2.94 m (4) 4.18 m

39. A particle is moving with constant acceleration 'a'. Following graph shows v^2 versus x (displacement) plot. The acceleration of the particle is _____ m/s^2 .

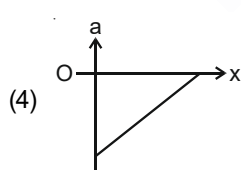
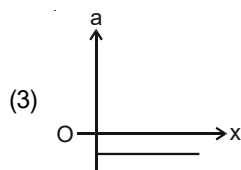
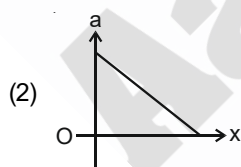
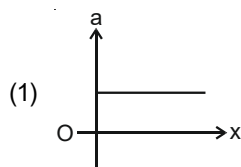
[JEE (Main)-2021]



40. The velocity-displacement graph of a particle is shown in the figure. [JEE (Main)-2021]



The acceleration-displacement graph of the same particle is represented by:



41. From the top of a tower, a ball is thrown vertically upward which reaches the ground in 6 s. A second ball thrown vertically downward from the same position with the same speed reaches the ground in 1.5 s. A third ball released, from the rest from the same location, will reach the ground in _____ s

[JEE (Main)-2022]

42. Two buses P and Q start from a point at the same time and move in a straight line and their positions are represented by $X_P(t) = \alpha t + \beta t^2$ and $X_Q(t) = ft - t^2$. At what time, both the buses have same velocity? [JEE (Main)-2022]

(1) $\frac{\alpha - f}{1 + \beta}$

(2) $\frac{\alpha + f}{2(\beta - 1)}$

(3) $\frac{\alpha + f}{2(1 + \beta)}$

(4) $\frac{f - \alpha}{2(1 + \beta)}$

43. A ball of mass 0.5 kg is dropped from the height of 10 m. The height, at which the magnitude of velocity becomes equal to the magnitude of acceleration due to gravity, is _____ m. [Use $g = 10 \text{ m/s}^2$]

[JEE (Main)-2022]

44. When a ball is dropped into a lake from a height 4.9 m above the water level, it hits the water with a velocity v and then sinks to the bottom with the constant velocity v . It reaches the bottom of the lake 4.0 s after it is dropped. The approximate depth of the lake is : [JEE (Main)-2022]

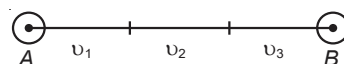
(1) 19.6 m

(2) 29.4 m

(3) 39.2 m

(4) 73.5 m

45. A car covers AB distance with first one-third at velocity $v_1 \text{ ms}^{-1}$, second one-third at $v_2 \text{ ms}^{-1}$ and last one-third at $v_3 \text{ ms}^{-1}$. If $v_3 = 3v_1$, $v_2 = 2v_1$ and $v_1 = 11 \text{ ms}^{-1}$ then the average velocity of the car is _____ ms^{-1} . [JEE (Main)-2022]



46. Two balls A and B are placed at the top of 180 m tall tower. Ball A is released from the top at $t = 0$ s. Ball B is thrown vertically down with an initial velocity u at $t = 2$ s. After a certain time, both balls meet 100 m above the ground. Find the value of u in ms^{-1} [use $g = 10 \text{ ms}^{-2}$] [JEE (Main)-2022]

(1) 10

(2) 15

(3) 20

(4) 30

47. A small toy starts moving from the position of rest under a constant acceleration. If it travels a distance of 10 m in t s, the distance travelled by the toy in the next t s will be : [JEE (Main)-2022]

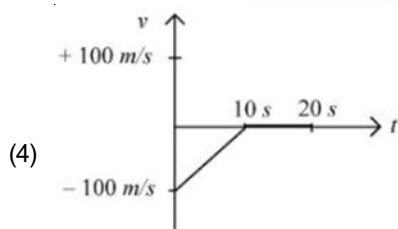
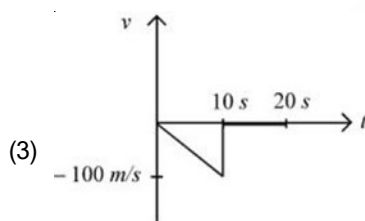
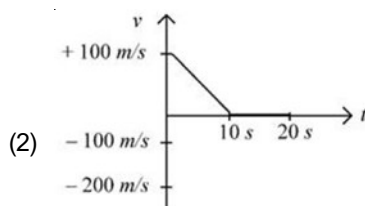
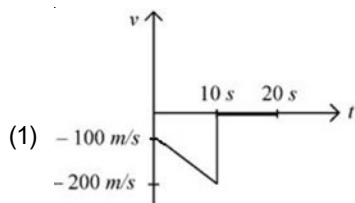
(1) 10 m

(2) 20 m

(3) 30 m

(4) 40 m

48. A bullet is shot vertically downwards with an initial velocity of 100 m/s from a certain height. Within 10 s , the bullet reaches the ground and instantaneously comes to rest due to the perfectly inelastic collision. The velocity-time curve for total time $t = -20 \text{ s}$ will be (Take $g = 10 \text{ m/s}^2$) **[JEE (Main)-2022]**



49. A NCC parade is going at a uniform speed of 9 km/h under a mango tree on which a monkey is sitting at a height of 19.6 m . At any particular instant, the monkey drops a mango. A cadet will receive the mango whose distance from the tree at time of drop is (Given $g = 9.8 \text{ m/s}^2$) **[JEE (Main)-2022]**
- (1) 5 m (2) 10 m
(3) 19.8 m (4) 24.5 m

50. A ball is thrown vertically upwards with a velocity of 19.6 ms^{-1} from the top of a tower. The ball strikes the ground after 6 s . The height from the ground up to which the ball can rise will be $\left(\frac{k}{5}\right) \text{ m}$. The value of k is _____ (use $g = 9.8 \text{ m/s}^2$) **[JEE (Main)-2022]**
51. A ball is thrown up vertically with a certain velocity so that, it reaches a maximum height h . Find the ratio of the times in which it is at height $\frac{h}{3}$ while going up and coming down respectively **[JEE (Main)-2022]**

(1) $\frac{\sqrt{2}-1}{\sqrt{2}+1}$ (2) $\frac{\sqrt{3}-\sqrt{2}}{\sqrt{3}+\sqrt{2}}$

(3) $\frac{\sqrt{3}-1}{\sqrt{3}+1}$ (4) $\frac{1}{3}$

52. A juggler throws balls vertically upwards with same initial velocity in air. When the first ball reaches its highest position, he throws the next ball. Assuming the juggler throws n balls per second, the maximum height the balls can reach is **[JEE (Main)-2022]**
- (1) $g/2n$ (2) g/n
(3) $2gn$ (4) $g/2n^2$
53. A ball is released from a height h . If t_1 and t_2 be the time required to complete first half and second half of the distance respectively. Then, choose the correct relation between t_1 and t_2 **[JEE (Main)-2022]**

(1) $t_1 = (\sqrt{2})t_2$ (2) $t_1 = (\sqrt{2}-1)t_2$

(3) $t_2 = (\sqrt{2}+1)t_1$ (4) $t_2 = (\sqrt{2}-1)t_1$

54. A particle is moving in a straight line such that its velocity is increasing at 5 ms^{-1} per meter. The acceleration of the particle is _____ ms^{-2} at a point where its velocity is 20 ms^{-1} . **[JEE (Main)-2022]**
55. A ball is projected vertically upward with an initial velocity of 50 ms^{-1} at $t = 0 \text{ s}$. At $t = 2 \text{ s}$, another ball is projected vertically upward with same velocity. At $t = \underline{\hspace{1cm}} \text{ s}$, second ball will meet the first ball ($g = 10 \text{ ms}^{-2}$) **[JEE (Main)-2022]**



Chapter 1

Motion in a Straight Line

1. Answer (2)

$$\text{From } v = u + at$$

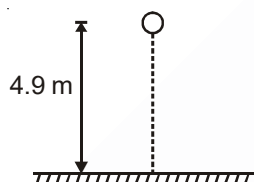
$$v = 0 - g \times t$$

$$\Rightarrow v = -gt$$

And just after collision velocity is upwarded then after some time it becomes zero and then negative. Same process repeats.

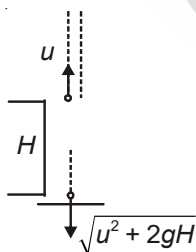
$$\text{From } S = ut + \frac{1}{2}at^2$$

$$h = 4.9 - \frac{1}{2}gt^2$$



So, graph will be downward parabola.

2. Answer (3)



Time taken to reach highest point is $t_1 = \frac{u}{g}$

$$\text{Speed on reaching ground} = \sqrt{u^2 + 2gh}$$

$$\text{Now, } v = u + at$$

$$\Rightarrow \sqrt{u^2 + 2gh} = -u + gt$$

$$\Rightarrow t = \frac{u + \sqrt{u^2 + 2gh}}{g} = \frac{nu}{g}$$

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

3. Answer (3)

Till both are in air (From $t = 0$ to $t = 8$ second)

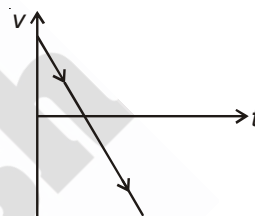
$$\Delta x = x_2 - x_1 = 30t$$

$$\Rightarrow \Delta x \propto t$$

When second stone hits ground and first stone is in air Δx decreases.

4. Answer (3)

Acceleration is constant and negative



5. Answer (2)

Options (1), (3) and (4) correspond to uniformly accelerated motion in a straight line with positive initial velocity and constant negative acceleration, whereas option (2) does not correspond to this motion.

6. Answer (4)

$$t_A = t_B - t$$

$$v_A = a_1(t_B - t) = a_2 t_B + v \quad \dots(i)$$

$$S = \frac{1}{2}a_1(t_B - t)^2 = \frac{1}{2}a_2 t_B^2$$

$$\Rightarrow t_B \left[1 - \sqrt{\frac{a_2}{a_1}} \right] = t \quad \dots(ii)$$

Solving (i) and (ii) $v = t\sqrt{a_1 a_2}$

7. Answer (1)

Displacement = Area under $v - t$ graph

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

8. Answer (3)

$$t_1 = \frac{l_1 + l_2}{v_1 - v_2} \text{ (when moving in same direction) and,}$$

$$t_2 = \frac{l_1 + l_2}{v_1 + v_2} \text{ (when moving in opposite direction)}$$

$$\therefore \frac{t_1}{t_2} = \frac{v_1 + v_2}{v_1 - v_2} = \frac{80 + 30}{80 - 30} = \frac{11}{5}$$

9. Answer (3)

$$a = \text{Constant}$$

$$v = at$$

$$x = \frac{1}{2}at^2 \text{ [Particle starts from the origin]}$$

A, B and D are correct graphs.

10. Answer (4)

$$V = \sqrt{V_0^2 - 2gh}$$

Direction of velocity changes at top most point

11. Answer (2)

$$x = at + bt^2 - ct^3$$

$$\dot{x} = a + 2bt - 3ct^2$$

$$\ddot{x} = 2b - 6ct$$

$$\text{For } \ddot{x} = 0 \quad t = +\frac{b}{3c}$$

$$\therefore v = \dot{x} = a + 2b\left(\frac{+b}{3c}\right) - 3c\left(\frac{b^2}{3c \times 3c}\right)$$

$$\Rightarrow v = -\frac{b^2}{3c} + \frac{2b^2}{3c} + a = a + \frac{b^2}{3c}$$

12. Answer (3)

$$v = \frac{dx}{dt} = b\sqrt{x} \quad \dots(i)$$

$$\Rightarrow \int_0^x \frac{dx}{\sqrt{x}} = \int_0^\tau b dt$$

$$\Rightarrow 2\sqrt{x} = b\tau \quad \dots(ii)$$

$$\Rightarrow v = b \cdot \frac{b\tau}{2} = \frac{b^2\tau}{2}$$

13. Answer (2)

$$V_P = (10 - 0.5)$$

$$\begin{array}{cc} \text{A} & \text{B} \\ \xrightarrow{10 \text{ m/s}} & \xleftarrow{20 \text{ m/s}} \end{array}$$

$$= 9.5 \text{ m/s}$$

$$V_{PB} = 29.5 \text{ m/s}$$

14. Answer (3)

$$\frac{1}{2}mv^2 = p \times t$$

$$v \propto \sqrt{t}$$

$$\frac{ds}{dt} \propto \sqrt{t}$$

$$s \propto t^{\frac{3}{2}}$$

15. Answer (1)

$$t_0 = \sqrt{\frac{2h}{g}}$$

$$\Rightarrow V_0 = \sqrt{\frac{2h}{g}} \times g = \sqrt{2gh}$$

$$\therefore t_1 = \text{time to reach top} = \frac{v_0}{g} = \sqrt{\frac{2h}{g}}$$

$$\therefore H = h + h' = 2h$$

$$\therefore t_2 = \text{time of fall} = \sqrt{\frac{2 \times (2h)}{g}} = 2\sqrt{\frac{h}{g}}$$

$$\begin{aligned} \therefore \text{Total time} &= t_1 + t_2 \\ &= (2 + \sqrt{2})\sqrt{\frac{h}{g}} \\ &= 3.4\sqrt{\frac{h}{g}} \end{aligned}$$

16. Answer (1)

$$\text{Distance} = |A_1| + |A_2|$$

$$= \frac{1}{2} \left(1 + \frac{13}{3} \right) \times 4 + \frac{1}{2} \times \frac{5}{3} \times 2$$

$$= \frac{37}{3} \text{ m}$$

17. Answer (08.00)

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

$$\Rightarrow 200 = gt^2 \quad \dots(i)$$

$$\Rightarrow t = \sqrt{\frac{200}{g}}$$

$$\text{Also } \frac{1}{2}g\left(t - \frac{1}{2}\right)^2 = 81$$

$$\therefore g\left(t - \frac{1}{2}\right)^2 = 81 \times 2 \quad \dots(\text{ii})$$

$$\left(t - \frac{1}{2}\right) = \sqrt{\frac{81 \times 2}{g}}$$

$$\therefore \frac{1}{2} = \frac{1}{\sqrt{g}}(\sqrt{200} - \sqrt{81 \times 2})$$

$$\Rightarrow \sqrt{g} = 2(10\sqrt{2} - 9\sqrt{2})$$

$$\Rightarrow \sqrt{g} = 2\sqrt{2}$$

$$\therefore g = 8 \text{ m/s}^2$$

18. Answer (3)

$$2x \frac{dx}{dt} = 2at + 2b$$

$$x \frac{dx}{dt} = at + b \Rightarrow \frac{dx}{dt} = \frac{(at + b)}{x}$$

$$\Rightarrow x \frac{d^2x}{dt^2} + \left(\frac{dx}{dt}\right)^2 = a$$

$$\Rightarrow \frac{d^2x}{dt^2} = \frac{a - \left(\frac{dx}{dt}\right)^2}{x} = \frac{a - \left(\frac{at + b}{x}\right)^2}{x}$$

$$= \frac{ax^2 - (at + b)^2}{x^3} = \frac{ac - b^2}{x^3}$$

$$\Rightarrow a \propto x^{-3}$$

19. Answer (20)

Distance travelled = Area under the u-t graph

$$\therefore \Delta S = \frac{1}{2} \times 5 \times 8 = 20$$

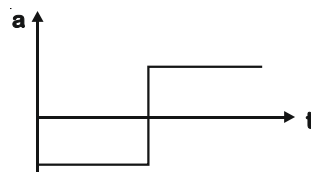
20. Answer (4)

From A to M,

Acceleration is negative and constant

From M to B

Acceleration is positive and constant.



21. Answer (3)

$$v^2 - u^2 = 2ax$$

Let velocity of middle point be v_1

$$v_1^2 - u^2 = ax$$

$$v_1 = \sqrt{\frac{u^2 + v^2}{2}}$$

22. Answer (2)

$$5 = \frac{1}{2} \times 10 \times t_1^2 \Rightarrow t_1 = 1 \text{ s}$$

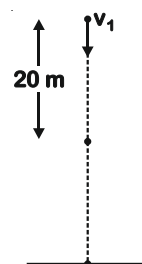
$$\therefore v_1 = gt_1 = 10 \text{ m/s}$$

Time of collision,

$$\Delta t = \frac{20}{10} = 2 \text{ s}$$

$\therefore$ Total time of fall = 3 s

$$\therefore H = \frac{1}{2} \times (10) \times 3^2 = 45 \text{ m}$$



23. Answer (3)

We have,

$$a_1 t_1 = a_2 t_2$$

$$\Rightarrow \frac{t_1}{t_2} = \frac{a_2}{a_1}$$

24. Answer (4)

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

$$v = 10 + \frac{x}{5}$$

$$a = \left(10 + \frac{x}{5}\right) \left(\frac{1}{5}\right) = 2 + \frac{x}{25}$$

$$a(x = 0) = 2 \text{ m/s}^2$$

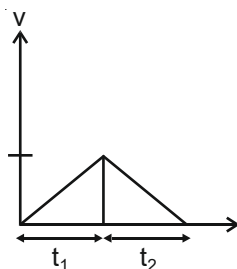
$$a(x = 200) = 10 \text{ m/s}^2$$

25. Answer (2)

$$t_1 + t_2 = t$$

$$\alpha t_1 = \beta t_2$$

$S = \text{Area under } v\text{-}t \text{ curve}$



26. Answer (3)

$$v = v_0 + gt + Ft^2$$

$$dx = \int_0^1 (v_0 + gt + Ft^2) dt$$

$$= \left[v_0 t + g \frac{t^2}{2} + \frac{Ft^3}{3} \right]_0^1$$

$$= v_0 + \frac{g}{2} + \frac{F}{3}$$

27. Answer (1)

→ Acceleration-time graph will be straight horizontal line.

→ Velocity-time graph will be straight inclined line.

→ Position-time graph will be parabolic graph opening upwards if both velocity and acceleration are positive.

28. Answer (4)

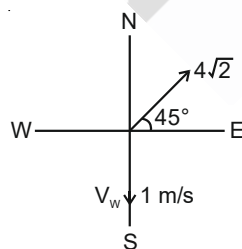
$$V_x = 4 \text{ m/s}$$

$$V_y = 3 \text{ m/s}$$

$$x = 4 \times 3 = 12 \text{ m}$$

$$y = 3 \times 3 = 9 \text{ m}$$

$$D = \sqrt{x^2 + y^2} = 15 \text{ m}$$



29. Answer (4)

Let l be the length of escalator, v_1 be the velocity of man w.r.t. escalator, v_2 be the velocity of escalator.

$$t_1 = \frac{l}{v_1}$$

$$t_2 = \frac{l}{v_2}$$

$$t = \frac{l}{v_1 + v_2} = \frac{l}{\frac{l}{t_1} + \frac{l}{t_2}}$$

$$t = \frac{t_1 t_2}{t_1 + t_2}$$

30. Answer (4)

Let N drop/sec

$$V_1 = (g) \frac{1}{N}$$

$$H_0 = \frac{1}{2} (g) \left(\frac{1}{N} \right)^2$$

At $t = 4 \text{ s}$,

$$9.8 \times \left(4 - \frac{1}{N} \right) + (4.9) \frac{1}{N^2} = 34.3 \Rightarrow N = 1$$

$$N = 1$$

31. Answer (2)

$$t = mx^2 + nx$$

$$\Rightarrow 1 = m \times 2x v + n \times v$$

$$\Rightarrow v = \frac{1}{2mx + n}$$

$$\therefore \frac{dv}{dt} = \frac{1}{(2mx + n)^2} \times (2m)^2 \times v$$

$$\Rightarrow a = (2m) \times v \times v^2$$

$$= 2mv^3$$

32. Answer (2)

$$-75 = 10t - \frac{1}{2} \times (10)t^2$$

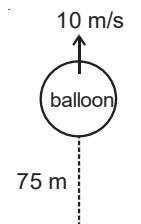
$$\Rightarrow -15 = 2t - t^2$$

$$\Rightarrow t^2 - 2t - 15 = 0$$

$$\Rightarrow t = 5 \text{ s}$$

$$H = 75 + 10 \times 5$$

$$= 125 \text{ m}$$



33. Answer (1)

$$v = \alpha t + \beta t^2$$

$$\int dx = \int_1^2 (\alpha t + \beta t^2) dt$$

$$= \alpha \left[\frac{t^2}{2} \right]_1^2 + \left[\frac{\beta}{3} t^3 \right]_1^2$$

$$= \frac{3}{2} \alpha + \frac{7}{3} \beta$$

34. Answer (2)

$$u = \sqrt{2gh}$$

$$\text{Now using, } s = ut + \frac{1}{2} at^2$$

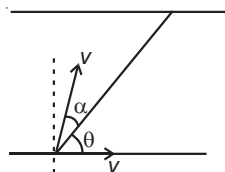
$$\frac{h}{3} = ut - \frac{1}{2} gt^2$$

$$\frac{1}{2} gt^2 - ut + \frac{4}{3} = 0$$

$$t = \frac{u \pm \sqrt{u^2 - 4 \cdot \frac{1}{2} g \cdot \frac{h}{3}}}{g}$$

$$\frac{t_1}{t_2} = \frac{\sqrt{2} - \sqrt{\frac{4}{3}}}{\sqrt{2} + \sqrt{\frac{4}{3}}} = \frac{\sqrt{3} - \sqrt{2}}{\sqrt{3} + \sqrt{2}}$$

35. Answer (30)

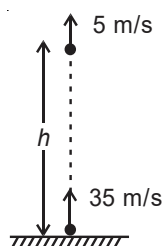


For equal magnitude v_s and v_R

$$\alpha = \theta$$

$$\Rightarrow \alpha = 30^\circ$$

36. Answer (50)



At the instant 2nd ball is thrown

$$h = 35 \times 3 - \frac{1}{2} \times 10 \times 3^2 = 60 \text{ m}$$

Balls will collide after time interval

$$= \frac{60}{35 - 5} = 2 \text{ second}$$

$$h' = 35 \times 2 - \frac{1}{2} \times 10 \times 2^2 = 50 \text{ m}$$

37. Answer (12)

$$v = \sqrt{5000 + 24x}$$

$$v^2 = 5000 + 24x$$

$$2v \frac{dv}{dx} = 24$$

$$v \frac{dv}{dx} = 12$$

38. Answer (2)

$$T = \sqrt{\frac{2H}{g}} \Rightarrow T = \sqrt{2} \text{ sec}$$

at $t = 0 \rightarrow 1^{\text{st}}$ drop

at $t = \Delta t \rightarrow 2^{\text{nd}}$ drop

at $t = 2\Delta t \rightarrow 3^{\text{rd}}$ drop

$$\Rightarrow 2\Delta t = \sqrt{2} \Rightarrow \Delta t = \frac{1}{\sqrt{2}}$$

$$h = \frac{1}{2} \times g \times (\Delta t)^2 = \left(\frac{1}{2} \right) \times 9.8 \times \frac{1}{2}$$

$$\Rightarrow H_F = 9.8 - \frac{9.8}{4} = \frac{3}{4} \times 9.8 = 7.35 \text{ m}$$

39. Answer (1)

$$v^2 = u^2 + 2ax$$

$$a = \frac{1}{2} (\text{slope of } v^2 \text{ vs } x \text{ graph})$$

$$= \frac{1}{2} \left(\frac{40}{20} \right)$$

$$= 1 \text{ m/s}^2$$

40. Answer (4)

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

$$\frac{dv}{dx} < 0 \text{ and } v \text{ is decreasing with } x$$

41. Answer (3)

Based on the situation

$$h = -ut_1 + \frac{1}{2}gt_1^2 \quad \rightarrow \text{throwing up ... (i)}$$

$$h = ut_2 + \frac{1}{2}gt_2^2 \quad \rightarrow \text{throwing down ... (ii)}$$

$$h = \frac{1}{2}gt^2 \quad \rightarrow \text{dropping ... (iii)}$$

$$\text{and } 0 = u(t_1 - t_2) - \frac{1}{2}g(t_1 - t_2)^2 \quad \dots \text{(iv)}$$

solving above equations

$$t = \sqrt{t_1 t_2}$$

$$\Rightarrow t = \sqrt{6 \times 1.5} = 3 \text{ s}$$

42. Answer (4)

$$X_P = \alpha t + \beta t^2$$

$$X_Q = ft - t^2$$

$$\therefore V_P = \alpha + 2\beta t$$

$$V_Q = f - 2t$$

$$\therefore V_P = V_Q$$

$$\Rightarrow \alpha + 2\beta t = f - 2t$$

$$\Rightarrow t = \frac{f - \alpha}{2(1 + \beta)}$$

43. Answer (5)

$$gt = g$$

$$\Rightarrow t = 1 \text{ sec}$$

$$\Delta h = \frac{1}{2}gt^2 = \frac{1}{2} \times 5 \times 1^2 = 5 \text{ m}$$

$$\therefore h = H - \Delta h$$

$$= 10 - 5$$

$$= 5 \text{ m}$$

44. Answer (2)

$$t_1 = \sqrt{\frac{2h}{g}}$$

$$= \sqrt{\frac{2 \times 4.9}{9.8}} = 1 \text{ s}$$

$$\Delta t = 4 - 1 = 3 \text{ s,}$$

$$v = \sqrt{2gh} = \sqrt{2 \times 9.8 \times 4.9} = 9.8 \text{ m/s}$$

$$\therefore \text{depth} = 9.8 \times 3 = 29.4 \text{ m}$$

45. Answer (18)

$$v_{\text{mean}} = \frac{3v_1v_2v_3}{v_1v_2 + v_2v_3 + v_3v_1}$$

$$= \frac{3 \times 11 \times 22 \times 33}{11 \times 22 + 22 \times 33 + 33 \times 11}$$

$$= 18 \text{ m/sec}$$

46. Answer (4)

Let us assume that they meet at $t = t_0$

$$A: 80 = \frac{1}{2}gt_0^2 \quad \dots \text{(i)}$$

$$B: 80 = u(t_0 - 2) + \frac{1}{2}g(t_0 - 2)^2 \quad \dots \text{(ii)}$$

From (i), $t_0 = 4$

$$\Rightarrow 80 = 2u + 5(2)^2$$

$$\Rightarrow u = 30 \text{ m/s}$$

47. Answer (3)

$$\frac{1}{2}at^2 = 10 \text{ m}$$

$$\frac{1}{2}a(2t)^2 = 40 \text{ m}$$

$$\Rightarrow \text{Distance travelled in next } t \text{ s}$$

$$= 40 - 10 = 30 \text{ m}$$

48. Answer (1)

$$|v_{10}| = (100 + 10 \times 10) \text{ m/s}$$

$$v_{10} = -200 \text{ m/s and } v_0 = -100 \text{ m/s}$$

from 10 s to 20 s velocity remains zero

 $\Rightarrow$ from $t = 0$ s to 10 s velocity increases in magnitude linearly.

 $\Rightarrow$ graph given in option (1) fits correctly

49. Answer (1)

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

$$19.6 = 4.9 t^2$$

$$t = 2 \text{ sec}$$

$$D = 9 \times \frac{5}{18} \times 2 = 5 \text{ m}$$

50. Answer (392)

$$v = 19.6 \text{ m/s}$$

$$t = 6 \text{ s}$$

Time taken in upward motion above tower = 2 s

 $\Rightarrow$ Time taken from top most point to ground = 4 s

$$\Rightarrow \sqrt{\frac{2h}{g}} = 4$$

$$h = \frac{16 \times 9.8}{2} = 8 \times 9.8$$

$$\Rightarrow k = 8 \times 9.8 \times 5 = 392$$

51. Answer (2)

$$v = \sqrt{2gh}$$

$$\frac{h}{3} = \sqrt{2gh} t - \frac{1}{2}gt^2$$

$$\frac{g}{2}t^2 - \sqrt{2gh} t + \frac{h}{3} = 0$$

$$\frac{t_1}{t_2} = \frac{\sqrt{2gh} + \sqrt{2gh - 2gh/3}}{\sqrt{2gh} - \sqrt{2gh - 2gh/3}}$$

$$= \frac{\sqrt{2} + \frac{2}{\sqrt{3}}}{\sqrt{2} - \frac{2}{\sqrt{3}}} = \frac{\sqrt{3} + \sqrt{2}}{\sqrt{3} - \sqrt{2}}$$

52. Answer (4)

$$t = \frac{u}{g} = \frac{1}{n}$$

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

$$H_{\max} = \frac{u^2}{2g} = \frac{g}{2n^2}$$

53. Answer (4)

$$t_1 = \sqrt{\frac{2 \cdot \frac{H}{2}}{g}} = \sqrt{\frac{H}{g}}$$

$$\text{And } t_2 = \sqrt{\frac{2H}{g}} - t_1$$

$$\Rightarrow t_2 = \sqrt{\frac{2H}{g}} - \sqrt{\frac{H}{g}} = \sqrt{\frac{H}{g}} \{\sqrt{2} - 1\}$$

54. Answer (100)

$$\frac{dv}{dx} = 5 \text{ ms}^{-1} / \text{m}$$

Acceleration of particle

when $v = 20 \text{ m/s}$

$$a = v \frac{dv}{dx} = 20 (5) \text{ m/s}^2 = 100 \text{ m/s}^2$$

55. Answer (6)

At $t = 2 \text{ s}$, $v_1 = 50 - 2 \times 10 = 30 \text{ m/s}$

$$v_2 = v_2$$

$$\therefore a_{\text{rel}} = g - g = 0$$

$$S = \frac{u^2 - v^2}{2g} = \frac{50^2 - 30^2}{2 \times 10} = \frac{1600}{20} = 80 \text{ m}$$

$$\therefore v_{\text{rel}} = 50 - 30 = 20 \text{ m/s}$$

$$\therefore \Delta t = \frac{80}{20} = 4 \text{ s}$$

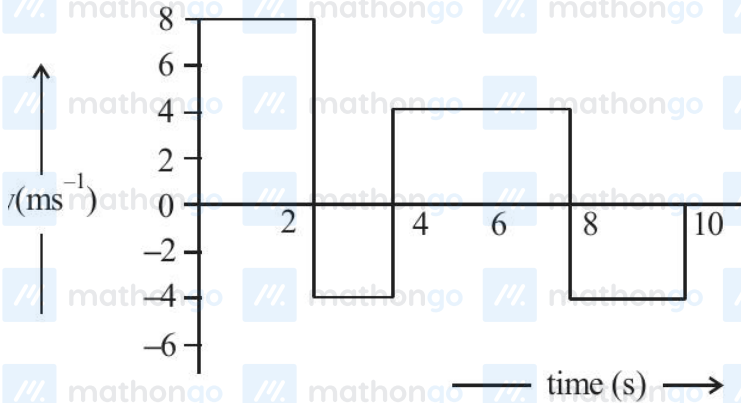
$$\therefore \text{required time } t = 2 + 4 = 6 \text{ s}$$



Q1 - 24 January - Shift 2

The velocity time graph of a body moving in a straight line is shown in figure.

Space for your notes:



The ratio of displacement to distance travelled by the body in time 0 to 10s is

- (1) 1:1
- (2) 1:4
- (3) 1:2
- (4) 1:3

Q2 - 25 January - Shift 1

A car travels a distance of 'x' with speed V_1 and then same distance 'x' with speed V_2 in the same direction. The average speed of the car is:

Space for your notes:

- (1) $\frac{v_1 v_2}{2(v_1 + v_2)}$
- (2) $\frac{v_1 + v_2}{2}$
- (3) $\frac{2x}{v_1 + v_2}$
- (4) $\frac{2v_1 v_2}{v_1 + v_2}$



Q3 - 25 January - Shift 2

The distance travelled by a particle is related to time t as $x = 4t^2$. The velocity of the particle at $t = 5$ s is .

- (1) 40 ms^{-1} (2) 25 ms^{-1}
(3) 20 ms^{-1} (4) 8 ms^{-1}

Space for your notes:

Q4 - 29 January - Shift 1

A tennis ball is dropped on to the floor from a height of 9.8 m. It rebounds to a height 5.0 m. Ball comes in contact with the floor for 0.2s. The average acceleration during contact is _____ ms^{-2} .

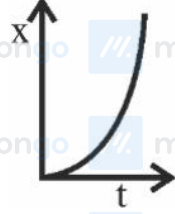
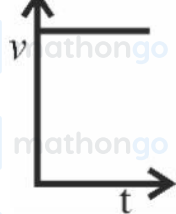
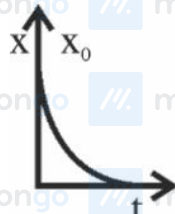
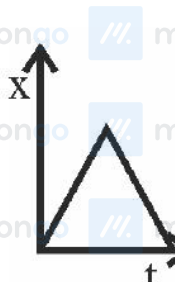
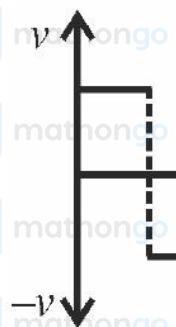
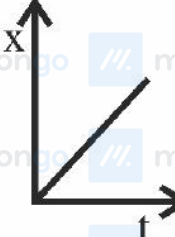
[Given $g = 10 \text{ ms}^{-2}$]

Space for your notes:

Q5 - 30 January - Shift 1

Match Column-I with Column-II :

Space for your notes:

Column-I (x-t graphs)	Column-II (v-t graphs)
A. 	I. 
B. 	II. 
C. 	III. 
D. 	IV. 

Choose the correct answer from the options given below:

- (1) A- II B-IV, C-III, D-I
- (2) A- I. B-II, C-III, D-IV
- (3) A- II B-III, C-IV, D-I
- (4) A- I. B-III. C-IV, D-II

Q6 - 30 January - Shift 1

#MathBoleTohMathonGo

A horse rider covers half the distance with 5 m/s speed. The remaining part of the distance was travelled with speed 10 m/s for half the time and with speed 15 m/s for other half of the time. The mean speed of the rider averaged over the whole time of motion is $x/7$ m/s. The value of x is

Space for your notes:

Q7 - 30 January - Shift 2

An object is allowed to fall from a height R above the earth, where R is the radius of earth. Its velocity when it strikes the earth's surface, ignoring air resistance, will be :

Space for your notes:

- (1) $2\sqrt{gR}$ (2) $\sqrt{gR}$
(3) $\sqrt{\frac{gR}{2}}$ (4) $\sqrt{2gR}$

Q8 - 30 January - Shift 2

A vehicle travels 4 km with speed of 3 km/h and another 4 km with speed of 5 km/h, then its average speed is :

Space for your notes:

- (1) 4.25 km/h (2) 3.50 km/h
(3) 4.00 km/h (4) 3.75 km/h

Q9 - 31 January - Shift 2

A body is moving with constant speed, in a circle of radius 10 m. The body completes one revolution in 4 s. At the end of 3rd second, the displacement of body (in m) from its starting point is:

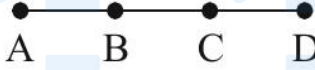
Space for your notes:

- (1) 30 (2) 15π
(3) 5π (4) $10\sqrt{2}$

Q10 - 01 February - Shift 1

#MathBoleTohMathonGo

An object moves with speed v_1 , v_2 , and v_3 along a line segment AB, BC and CD respectively as shown in figure. Where $AB = BC$ and $AD = 3 AB$, then average speed of the object will be :



(1) $\frac{(v_1 + v_2 + v_3)}{3}$

(2) $\frac{v_1 v_2 v_3}{3(v_1 v_2 + v_2 v_3 + v_3 v_1)}$

(3) $\frac{3v_1 v_2 v_3}{v_1 v_2 + v_2 v_3 + v_3 v_1}$

(4) $\frac{(v_1 + v_2 + v_3)}{3v_1 v_2 v_3}$

Space for your notes:

Q11 - 01 February - Shift 2

For a train engine moving with speed of 20 ms^{-1} . the driver must apply brakes at a distance of 500 m before the station for the train to come to rest at the station. If the brakes were applied at half of this distance, the train engine would cross the station with speed $\sqrt{x} \text{ ms}^{-1}$. The value of x is _____ (Assuming same retardation is produced by brakes)

Space for your notes:

(As per Official NTA Key released on 2 Feb)

Q4 (120)

Q8 (4)

Q11 (200)

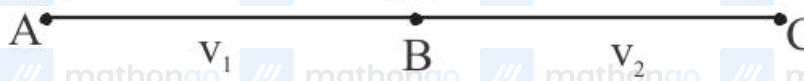
Q1 (4)

$$\text{Displacement} = \Sigma \text{area} = 16 - 8 + 16 - 8 = 16 \text{ m}$$

$$\text{Distance} = \Sigma |\text{area}| = 48 \text{ m}$$

$$\frac{\text{displacement}}{\text{Distance}} = \frac{1}{3}$$

Q2 (4)



$$\text{Average velocity} = \frac{\text{Total displacement}}{\text{Total time}}$$

$$= \frac{x + x}{\frac{x}{v_1} + \frac{x}{v_2}} = \frac{2v_1v_2}{v_1 + v_2}$$

Q3 (1)

$$x = 4t^2$$

$$v = \frac{dx}{dt} = 8t$$

$$\text{At } t = 5 \text{ sec}$$

$$v = 8 \times 5 = 40 \text{ m/s.}$$

Q4 (120)

$$v_i = \sqrt{2gh_i}$$

$$= \sqrt{2 \times 10 \times 9.8} \downarrow$$

$$= 14 \text{ m/s} \downarrow$$

$$v_f = \sqrt{2gh_f}$$

$$= \sqrt{2 \times 10 \times 5} \uparrow$$

$$= 10 \text{ m/s} \uparrow$$

$$|\vec{a}_{\text{avg}}| = \left| \frac{\Delta \vec{v}}{\Delta t} \right| = \frac{24}{0.2} = 120 \text{ m/s}^2$$

Q5 (1)

$$\frac{dx}{dt} = \text{slope} \geq 0 \text{ always increasing}$$

(A - II)

$$\frac{dx}{dt} < 0; \text{ and at } t \rightarrow \infty \frac{dx}{dt} \rightarrow 0$$

(B - IV)

$$\frac{dx}{dt} > 0 \text{ for first half } \frac{dx}{dt} < 0 \text{ for second half}$$

(C - III)

$$\frac{dx}{dt} = \text{constant}$$

Q6 (50)

A. mathongo B. mathongo C. mathongo mathongo mathongo mathongo mathongo

$$t_{AB} = \frac{x}{5 \text{ m/s}}$$

In motion BC

$$x = d_1 + d_2$$

where d_1 & d_2 we the distance travelled with 10 m/s and 15 m/s respectively in equal time intervals

't' each
 $\frac{t}{2}$

$$d_1 = \frac{10t}{2}, d_2 = \frac{15t}{2}$$

$$d_1 + d_2 = x = \frac{t}{2}(10 + 15) = \frac{25t}{2}$$

$$\langle v \rangle = \frac{2x}{\frac{x}{5} + \frac{2x}{25}} = \frac{2 \times 25}{5 + 2} = \frac{50}{7} \text{ m/s}$$

Ans. : 50

mathongo mathongo mathongo mathongo mathongo mathongo mathongo

Q7 (2)

Loss in PE = Gain in KE

$$\left(-\frac{GMm}{2R} \right) - \left(-\frac{GMm}{R} \right) = \frac{1}{2}mv^2$$

$$\Rightarrow v^2 = \frac{GM}{R} = gR$$

$$\Rightarrow v = \sqrt{gR}$$

Q8 (4)

mathongo mathongo mathongo mathongo mathongo mathongo mathongo

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#MathBoleTohMathonGo

$$\frac{2}{V_{av}} = \frac{1}{3} + \frac{1}{5} = \frac{8}{15}$$

$$\Rightarrow V_{av} = \frac{15}{8} = 3.75 \text{ km/h}$$

Q9 (4)

No Solution

Q10 (3)

$$AB = x$$

$$BC = x$$

$$2x + CD = 3x$$

$$CD = x$$

$$\langle v \rangle = \frac{3x}{\frac{x}{u_1} + \frac{x}{u_2} + \frac{x}{u_3}} = \frac{3u_1 u_2 u_3}{u_2 u_3 + u_1 u_3 + u_1 u_2}$$

Q11 (200)

$$u = 20 \text{ m/s}, S_1 = 500 \text{ m}, v = 0$$

By third equation of motion

$$0 = (20)^2 - 2a \cdot 500 \Rightarrow a = \frac{4}{10} \text{ m/s}^2$$

$$u = 20 \text{ m/s}, S_2 = 250 \text{ m}, v = ?$$

$$v^2 = (20)^2 - 2a \cdot 250$$

$$= v = \sqrt{200} \text{ m/s}$$

$$x = 200$$

Q1. JEE Main 2026 (28 January Shift 2)

A particle starts moving from time $t = 0$ and its coordinate is given as $x(t) = 4t^3 - 3t$

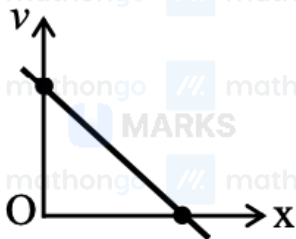
- A. The particle returns to its original position (origin) 0.866 units later
- B. The particle is 1 unit away from origin at its turning point
- C. Acceleration of the particle is non-negative
- D. The particle is 0.5 units away from origin at its turning point
- E. Particle never turns back as acceleration is non-negative

Choose the correct answer from the options given below :

- (1) A, B, C Only
- (2) C, E Only
- (3) A, C Only
- (4) A, C, D Only

Q2. JEE Main 2026 (24 January Shift 2)

The velocity (v) - Distance (x) graph is shown in figure. Which graph represents acceleration (a) versus distance (x) variation of this system?



- (1)
- (2)
- (3)
- (4)

Q3. JEE Main 2026 (23 January Shift 2)

A paratrooper jumps from an aeroplane and opens a parachute after 2 s of free fall and starts deaccelerating with 3 m/s^2 . At 10 m height from ground, while descending with the help of parachute, the speed of paratrooper is 5 m/s . The initial height of the airplane is ____ m.

($g = 10 \text{ m/s}^2$)

- (1) 82.5
- (2) 20
- (3) 62.5
- (4) 92.5

Q4. JEE Main 2026 (28 January Shift 1)

Water drops fall from a tap on the floor, 5 m below, at regular intervals of time, the first drop strikes the floor when the sixth drop begins to fall. The height at which the fourth drop will be from ground, at the instant when the first drop strikes the ground is ____ m.

($g = 10 \text{ m/s}^2$)

(1) 4.2

(2) 2.5

(3) 4.0

(4) 3.8

ANSWERS AND SOLUTIONS

1. (1)

2. (1)

3. (4)

4. (1)

1. (1) Given $x(t) = 4t^3 - 3t$, we find $v(t) = 12t^2 - 3$ and $a(t) = 24t$.

Statement A: Setting $x(t) = 0$ gives $4t^3 - 3t = 0 \Rightarrow t(4t^2 - 3) = 0$, so $t = 0$ or $t = \sqrt{3/4} = 0.866$. The particle returns to origin at $t = 0.866$ units. TRUE.

Statement B: Turning points occur at $v(t) = 0 \Rightarrow 12t^2 - 3 = 0 \Rightarrow t = \pm 0.5$. At $t = 0.5$:
 $x = 4(0.125) - 1.5 = -1$; distance = 1 unit. At $t = -0.5$: $x = 1$; distance = 1 unit. TRUE.

Statement C: For $t \geq 0$ (particle starts at $t = 0$), $a(t) = 24t \geq 0$. TRUE.

Statement D: At turning points, distance is 1 unit, not 0.5. FALSE.

Statement E: False because acceleration is non-negative only for $t \geq 0$, and particle does turn back at $t = 0.5$. FALSE.

Correct statements: A, B, C Only.

2. (1) The v-x graph shows velocity decreasing linearly with distance. Using kinematic equation $v^2 = v_0^2 + 2ax$, we can establish the relationship between acceleration and position.

From the linear v-x relationship, differentiating using $a = v \frac{dv}{dx}$ yields acceleration that is linearly proportional to distance from the origin.

The a-x graph shows a straight line passing through the origin with positive slope, indicating that acceleration increases linearly with distance while remaining positive throughout the motion.

3. (4) During the first 2 s of free fall, the paratrooper starts from rest ($u = 0$).

Velocity after 2 s is $v_1 = u + gt = 0 + 10 \times 2 = 20$ m/s.

Distance covered during free fall is $h_1 = \frac{1}{2}gt^2 = \frac{1}{2} \times 10 \times 2^2 = 20$ m.

After opening the parachute, the paratrooper decelerates at $a = -3$ m/s².

At a height of 10 m from the ground, the final velocity is $v_2 = 5$ m/s.

Let h_2 be the distance covered during deceleration until reaching 10 m height.

Using $v_2^2 = v_1^2 + 2ah_2$:

$$5^2 = 20^2 + 2(-3)h_2$$

$$25 = 400 - 6h_2$$

$$6h_2 = 375$$

$$h_2 = 62.5 \text{ m.}$$

The total height of the airplane is the sum of the free fall distance, the deceleration distance, and the remaining height from the ground.

$$H = h_1 + h_2 + 10 = 20 + 62.5 + 10 = 92.5 \text{ m.}$$

4. (1) Time for first drop to fall 5 m:

$$5 = \frac{1}{2} \times 10 \times t^2 \text{ gives } t = 1 \text{ s.}$$

Since the first drop strikes when the sixth begins, there are 5 intervals: each interval $T = \frac{1}{5} = 0.2$ s.

When drop 1 hits the ground (at $t = 1$ s), drop 4 has been falling for $t_4 = 1 - 3 \times 0.2 = 0.4$ s.

Distance fallen by drop 4: $s_4 = \frac{1}{2} \times 10 \times (0.4)^2 = 0.8$ m.

Height of drop 4 above ground: $5 - 0.8 = 4.2$ m.

Questions with Answer Keys

MathonGo

Q1 - 2024 (01 Feb Shift 1)

A particle is moving in one dimension (along x axis) under the action of a variable force. Its initial position was 16 m right of origin. The variation of its position (x) with time (t) is given as $x = -3t^3 + 18t^2 + 16t$, where x is in m and t is in s. The velocity of the particle when its acceleration becomes zero is _____ m/s.

Q2 - 2024 (01 Feb Shift 2)

Train A is moving along two parallel rail tracks towards north with speed 72 km/h and train B is moving towards south with speed 108 km/h. Velocity of train B with respect to A and velocity of ground with respect to B are (in ms^{-1}) :

- (1) -30 and 50
- (2) -50 and -30
- (3) -50 and 30
- (4) 50 and -30

Q3 - 2024 (01 Feb Shift 2)

A particle initially at rest starts moving from reference point. $x = 0$ along x-axis, with velocity v that varies as $v = 4\sqrt{x}\text{m/s}$. The acceleration of the particle is _____ ms^{-2} .

Q4 - 2024 (27 Jan Shift 1)

A particle starts from origin at $t = 0$ with a velocity $5\hat{i}\text{m/s}$ and moves in x – y plane under action of a force which produces a constant acceleration of $(3\hat{i} + 2\hat{j})\text{m/s}^2$. If the x-coordinate of the particle at that instant is 84 m, then the speed of the particle at this time is $\sqrt{\alpha}\text{m/s}$. The value of α is _____

Q5 - 2024 (27 Jan Shift 2)

A bullet is fired into a fixed target loses one third of its velocity after travelling 4 cm. It penetrates further $D \times 10^{-3}$ m before coming to rest. The value of D is :

[We changed options. In official NTA paper no option was correct.]

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Questions with Answer Keys

MathonGo

(1) 2

(2) 5

(3) 3

(4) 32

Q6 - 2024 (27 Jan Shift 2)

A body falling under gravity covers two points A and B separated by 80 m in 2 s. The distance of upper point

A from the starting point is _____ m (use $g = 10 \text{ ms}^{-2}$)

Q7 - 2024 (29 Jan Shift 1)

A body starts moving from rest with constant acceleration covers displacement S_1 in first $(p - 1)$ seconds and S_2 in first p seconds. The displacement $S_1 + S_2$ will be made in time :

(1) $(2p + 1)s$ (2) $\sqrt{(2p^2 - 2p + 1)} s$ (3) $(2p - 1)s$ (4) $(2p^2 - 2p + 1) s$

Q8 - 2024 (29 Jan Shift 2)

A particle is moving in a straight line. The variation of position ' x ' as a function of time ' t ' is given as

$x = (t^3 - 6t^2 + 20t + 15) \text{ m}$. The velocity of the body when its acceleration becomes zero is :

(1) 4 m/s

(2) 8 m/s

(3) 10 m/s

(4) 6 m/s

Q9 - 2024 (29 Jan Shift 2)

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Questions with Answer Keys

MathonGo

A particle is moving in a circle of radius 50 cm in such a way that at any instant the normal and tangential components of its acceleration are equal. If its speed at $t = 0$ is 4 m/s, the time taken to complete the first revolution will be $\frac{1}{\alpha} [1 - e^{-2\pi}]$ s, where $\alpha = \underline{\hspace{2cm}}$.

Q10 - 2024 (30 Jan Shift 1)

The displacement and the increase in the velocity of a moving particle in the time interval of t to $(t + 1)$ s are 125 m and 50 m/s, respectively. The distance travelled by the particle in $(t + 2)^{\text{th}}$ s is $\underline{\hspace{2cm}}$ m.

Q11 - 2024 (31 Jan Shift 1)

The relation between time ' t ' and distance ' x ' is $t = \alpha x^2 + \beta x$, where α and β are constants. The relation between acceleration (a) and velocity (v) is:

(1) $a = -2\alpha v^3$

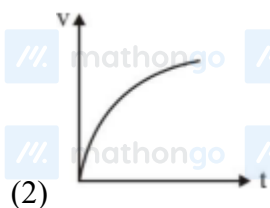
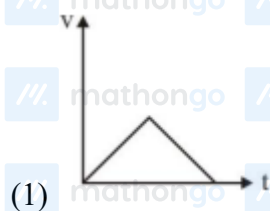
(2) $a = -5\alpha v^5$

(3) $a = -3\alpha v^2$

(4) $a = -4\alpha v^4$

Q12 - 2024 (31 Jan Shift 1)

A small steel ball is dropped into a long cylinder containing glycerine. Which one of the following is the correct representation of the velocity time graph for the transit of the ball?

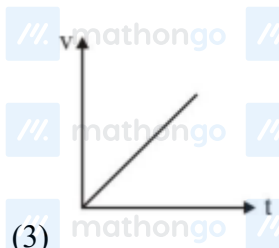


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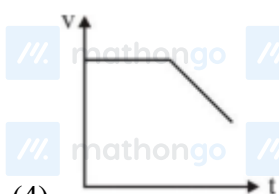
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Questions with Answer Keys

MathonGo



(3)



(4)

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MathonGo

Answer Key

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Solutions

MathonGo

Q1

$$x = 3t^3 + 18t^2 + 16t$$

$$v = -9t^2 + 36 + 16$$

$$a = -18t + 36$$

$$a = 0 \text{ at } t = 2s$$

$$v = -9(2)^2 + 36 \times 2 + 16$$

$$v = 52 \text{ m/s}$$

Q2

$$\text{B} \downarrow 30 \text{ m/s}$$

$$\text{A} \uparrow 20 \text{ m/s}$$

$$V_A = 20 \text{ m/s}$$

$$V_B = -30 \text{ m/s}$$

Velocity of B w.r.t. A

$$V_{B/A} = -50 \text{ m/s}$$

Velocity of ground w.r.t. B

$$V_{G/B} = 30 \text{ m/s}$$

Q3

$$V = 4\sqrt{x}$$

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

$$= 4\sqrt{x} \times 4 \times \frac{1}{2} x^{-1/2} = 8 \text{ m/s}^2$$

Q4

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Solutions

MathonGo

$$\begin{aligned}
 u_x &= 5 \text{ m/s} \quad a_x = 3 \text{ m/s}^2 \quad x = 84 \text{ m} \\
 v_x^2 - u_x^2 &= 2ax \\
 v_x^2 - 25 &= 2(3)(84) \\
 v_x &= 23 \text{ m/s} \\
 v_x - u_x &= a_x t \\
 \frac{23 - 5}{3} &= 6 \text{ s} \\
 v_y &= 0 + a_y t = 0 + 2 \times (6) = 12 \text{ m/s} \\
 v^2 &= v_x^2 + v_y^2 = 23^2 + 12^2 = 673 \\
 v &= \sqrt{673} \text{ m/s}
 \end{aligned}$$

Q5

$$\begin{aligned}
 v^2 - u^2 &= 2aS \\
 \left(\frac{2u}{3}\right)^2 &= u^2 + 2(-a)(4 \times 10^{-2}) \\
 \frac{4u^2}{9} &= u^2 - 2a(4 \times 10^{-2}) \\
 -\frac{5u^2}{9} &= -2a(4 \times 10^{-2}) \dots \\
 0 &= \left(\frac{2u}{3}\right)^2 + 2(-a)(x) \\
 -\frac{4u^2}{9} &= -2ax \\
 (1)/(2) \\
 \frac{5}{4} &= \frac{4 \times 10^{-2}}{x} \\
 x &= \frac{16}{5} \times 10^{-2} \\
 x &= 3.2 \times 10^{-2} \text{ m} \\
 x &= 32 \times 10^{-3} \text{ m}
 \end{aligned}$$

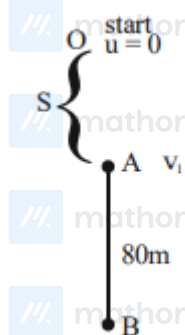
Q6

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Solutions

MathonGo

From A $\rightarrow$ B

$$-80 = -v_1 t - \frac{1}{2} \times 10 t^2$$

$$-80 = -2v_1 - \frac{1}{2} \times 10 \times 2^2$$

$$-80 = -2v_1 - 20$$

$$-60 = -2v_1$$

$$v_1 = 30 \text{ m/s}$$

From O to A

$$v^2 = u^2 + 2gS$$

$$30^2 = 0 + 2 \times (-10)(-S)$$

$$900 = 20 S$$

$$S = 45 \text{ m}$$

Q7

 S_1 in first $(p-1)$ sec S_2 in first p sec

$$S_1 = \frac{1}{2} a(p-1)^2$$

$$S_2 = \frac{1}{2} a(p)^2$$

$$S_1 + S_2 = \frac{1}{2} a t^2$$

$$(p-1)^2 + p^2 = t^2$$

$$t = \sqrt{2p^2 + 1 - 2p}$$

Q8

Do you want to practice these PYQs along with PYQs of JEE Main from 2002 till 2024?

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Solutions

MathonGo

$$x = t^3 - 6t^2 + 20t + 15$$

$$\frac{dx}{dt} = v = 3t^2 - 12t + 20$$

$$\frac{dv}{dt} = a = 6t - 12$$

$$\text{When } a = 0$$

$$6t - 12 = 0; t = 2\text{sec}$$

$$\text{At } t = 2\text{sec}$$

$$v = 3(2)^2 - 12(2) + 20$$

$$v = 8 \text{ m/s}$$

Q9

$$|\vec{a}_c| = |\vec{a}_t|$$

$$\frac{v^2}{r} = \frac{dv}{dt}$$

$$\Rightarrow \int_4^v \frac{dv}{v^2} = \int_0^t \frac{dt}{r}$$

$$\Rightarrow \left[\frac{-1}{v} \right]_4^v = \frac{t}{r}$$

$$\Rightarrow \frac{-1}{v} + \frac{1}{4} = 2t$$

$$\Rightarrow v = \frac{1}{1-8t} = \frac{ds}{dt}$$

$$4 \int_0^t \frac{dt}{1-8t} = \int_0^s ds$$

$$(r = 0.5 \text{ m})$$

$$s = 2\pi r = \pi$$

$$4 \times \frac{[\ln(1-8t)]_0^t}{-8} = \pi$$

$$\ln(1-8t) = -2\pi$$

$$1-8t = e^{-2\pi}$$

$$t = (1 - e^{-2\pi}) \frac{1}{8} \text{ s}$$

$$\text{So, } \alpha = 8$$

Q10

Do you want to practice these PYQs along with PYQs of JEE Main from 2002 till 2024?

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Solutions

MathonGo

Considering acceleration is constant

$$v = u + at$$

$$u + 50 = u + a \Rightarrow a = 50 \text{ m/s}^2$$

$$125 = ut + \frac{1}{2}at^2$$

$$125 = u + \frac{a}{2}$$

$$\Rightarrow u = 100 \text{ m/s}$$

$$\therefore S_{n_{\text{in}}} = u + \frac{a}{2}[2n - 1]$$

$$= 175 \text{ m}$$

Q11

 $t = \alpha x^2 + \beta x$ (differentiating wrt time)

$$\frac{dt}{dx} = 2\alpha x + \beta$$

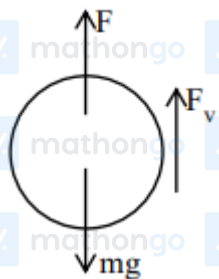
$$\frac{1}{v} = 2\alpha x + \beta$$

(differentiating wrt time)

$$-\frac{1}{v^2} \frac{dv}{dt} = 2\alpha \frac{dx}{dt}$$

$$\frac{dv}{dt} = -2\alpha v^3$$

Q12



$$mg - F_B - F_v = ma$$

$$\left(\rho \frac{4}{3}\pi r^3\right) g - \left(\rho_L \frac{4}{3}\pi r^3\right) g - 6\pi\eta r v = m \frac{dv}{dt}$$

$$\text{Let } \frac{4}{3}\pi R^3 g (\rho - \rho_L) = K_1 \text{ and } \frac{6\pi\eta R}{m} = K_2$$

$$\frac{dv}{dt} = K_1 - K_2 v$$

$$\int_0^v \frac{dv}{K_1 - K_2 v} = \int_0^t dt$$

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Solutions

MathonGo

$$-\frac{1}{K_2} \ln[K_1 - K_2 v]_0^v = t$$

$$\ln\left(\frac{K_1 - K_2 v}{K_1}\right) = -K_2 t$$

$$K_1 - K_2 v = K_1 e^{-K_2 t}$$

$$v = \frac{K_1}{K_2} [1 - e^{-K_2 t}]$$

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1. A particle of mass 10 g moves in a straight line with retardation $2x$, where x is the displacement in SI units. Its loss of kinetic energy for above displacement is $\left(\frac{10}{x}\right)^{-n}$ J. The value of n will be _____.

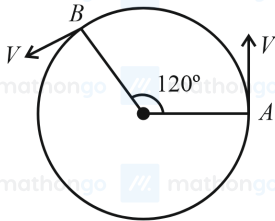
[2023 (06 Apr Shift 1)]

2. A particle starts with an initial velocity of 10.0 ms^{-1} along x -direction and accelerates uniformly at the rate of 2.0 m s^{-2} . The time taken by the particle to reach the velocity of 60.0 m s^{-1} is _____.

[2023 (06 Apr Shift 2)]

- (1) 25 s
- (2) 3 s
- (3) 6 s
- (4) 30 s

3. As shown in the figure, a particle is moving with constant speed $\pi \text{ m s}^{-1}$. Considering its motion from A to B , the magnitude of the average velocity is:



[2023 (06 Apr Shift 2)]

- (1) $\sqrt{3} \text{ m s}^{-1}$
- (2) $\pi \text{ m s}^{-1}$
- (3) $1.5\sqrt{3} \text{ m s}^{-1}$
- (4) $2\sqrt{3} \text{ m s}^{-1}$

4. Given below are two statements:

Statement I: Area under velocity-time graph gives the distance travelled by the body in a given time.

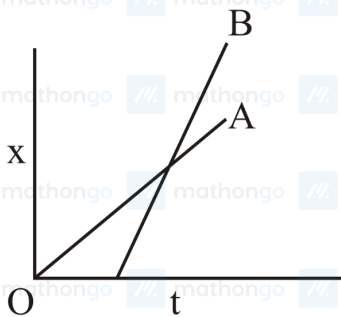
Statement II: Area under acceleration-time graph is equal to the change in velocity in the given time.

In the light of given statements, choose the correct answer from the options given below.

[2023 (08 Apr Shift 2)]

- (1) Both Statement I and Statement II are true
- (2) Both Statement I and Statement II are false
- (3) Statement I is correct but Statement II is false
- (4) Statement I is incorrect but Statement II is true

5. The position-time graphs for two students A and B returning from the school to their homes are shown in figure.



- (A) A lives closer to the school
- (B) B lives closer to the school
- (C) A takes lesser time to reach home
- (D) A travels faster than B
- (E) B travels faster than A

Choose the correct answer from the options given below

[2023 (10 Apr Shift 1)]

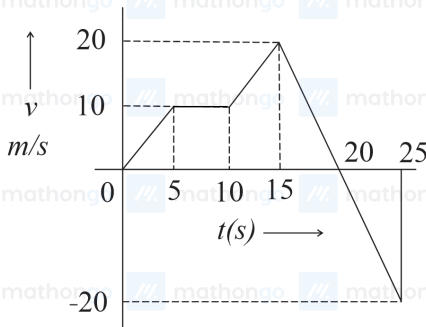
- (1) (A), (C) and (D) only
- (2) (A), (C) and (E) only
- (3) (B) and (E) only
- (4) (A) and (E) only

6. A person travels x distance with velocity v_1 and then x distance with velocity v_2 in the same direction. The average velocity of the person is v , then the relation between v , v_1 and v_2 will be

[2023 (10 Apr Shift 2)]

- (1) $v = \frac{v_1 + v_2}{2}$
(2) $\frac{1}{v} = \frac{1}{v_1} + \frac{1}{v_2}$
(3) $v = v_1 + v_2$
(4) $\frac{2}{v} = \frac{1}{v_1} + \frac{1}{v_2}$

7. From the $v - t$ graph shown, the ratio of distance to displacement in 25 s of motion is:



[2023 (11 Apr Shift 1)]

- (1) 1
(2) $\frac{1}{2}$
(3) $\frac{5}{3}$
(4) $\frac{3}{5}$

8. A ball is thrown vertically upward with an initial velocity of 150 m s^{-1} . The ratio of velocity after 3 s and 5 s is $\frac{x+1}{x}$. The value of x is _____. {take, $g = 10 \text{ m s}^{-2}$ }

[2023 (12 Apr Shift 1)]

- (1) 10
(2) -5
(3) 6
(4) 5

9. Given below are two statements:

Statement I : A truck and a car moving with same kinetic energy are brought to rest by applying breaks which provide equal retarding forces. Both come to rest in equal distance.

Statement II : A car moving towards east takes a turn and moves towards north, the speed remains unchanged. The acceleration of the car is zero.

In the light of given statements, choose the most appropriate answer from the options given below

[2023 (12 Apr Shift 1)]

- (1) Statement I is correct but statement II is incorrect
(2) Statement I is incorrect but statement II is correct
(3) Both statement I and Statement II are correct
(4) Both statement I and statement II are incorrect

10. Two trains A and B of length l and $4l$ are travelling into a tunnel of length L in parallel tracks from opposite directions with velocities 108 km h^{-1} and 72 km h^{-1} , respectively. If train A take 35 s less time than train B to cross the tunnel then, length L of tunnel is:
(Given $L = 60 l$)

[2023 (13 Apr Shift 1)]

- (1) 1200 m
(2) 900 m
(3) 1800 m
(4) 2700 m

11. The distance travelled by an object in time t is given by $s = (2.5)t^2$. The instantaneous speed of the object at $t = 5 \text{ s}$ will be :

[2023 (13 Apr Shift 2)]

- (1) 25 m s^{-1}
(2) 5 m s^{-1}
(3) 62.5 m s^{-1}
(4) 12.5 m s^{-1}

12. A passenger sitting in a train A moving at 90 km h^{-1} observes another train B moving in the opposite direction for 8 s. If the velocity of the train B is 54 km h^{-1} , then length of train B is:

[2023 (13 Apr Shift 2)]

- (1) 120 m
(2) 320 m
(3) 80 m
(4) 200 m

13. The position of a particle related to time is given by $x = (5t^2 - 4t + 5) \text{ m}$. The magnitude of velocity of the particle at $t = 2 \text{ s}$ will be :

[2023 (15 Apr Shift 1)]

- (1) 06 m s^{-1}
(2) 14 m s^{-1}
(3) 10 m s^{-1}
(4) 16 m s^{-1}

ANSWER KEYS

1. (2) 2. (1) 3. (3) 4. (4) 5. (4) 6. (4) 7. (3) 8. (4)
9. (1) 10. (3) 11. (1) 12. (2) 13. (4)

1. (2)

Acceleration can be written as, $a = v \frac{dv}{dx}$.

Given: $a = -2x$ (-ve sign is due to retardation)

Therefore,

$$v \frac{dv}{dx} = -2x$$

$$\Rightarrow v dv = (-2x) dx$$

Integrating both sides, we get

$$\frac{1}{2} (v_f^2 - v_i^2) = -2 \left(\frac{x^2}{2} \right) = -x^2$$

$$\Rightarrow \left| \frac{1}{2} m (v_f^2 - v_i^2) \right| = m x^2$$

$$\Rightarrow |\Delta KE| = 0.01 x^2 = \left(\frac{10}{x} \right)^{-2}$$

Hence, $n = 2$.

2. (1)

The given data is

$$v = 60 \text{ m s}^{-1}$$

$$u = 10 \text{ m s}^{-1}$$

$$a = 2 \text{ m s}^{-2}$$

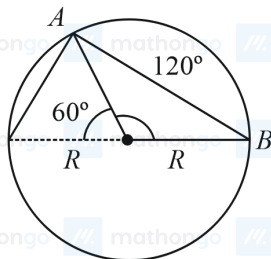
Using the equation $v = u + at$, we get

$$60 = 10 + 2t$$

$$\Rightarrow t = \frac{(60-10)}{2}$$

$$\Rightarrow t = 25 \text{ s}$$

3. (3)



The given data is

$$v = \pi \text{ m s}^{-1}$$

By using trigonometric ratios in the triangle shown above the displacement can be found out by

$$\sin 60^\circ = \frac{AB}{2R}$$

$$\Rightarrow AB = R\sqrt{3}$$

The formula for distance is

$$d = vt$$

$$\Rightarrow t = \frac{d}{v}$$

$$\Rightarrow t = \frac{120^\circ}{360^\circ} \times \frac{2\pi R}{\pi} = \frac{2R}{3}$$

So, the average velocity is

$$v_{\text{avg}} = \frac{\sqrt{3}R}{\frac{2R}{3}} = \frac{3\sqrt{3}}{2}$$

$$= 1.5\sqrt{3} \text{ m s}^{-1}$$

4. (4)

The definition of displacement is given by the product of velocity and time.

$\int v dt = \Delta x$ = displacement of body in given time.

Distance is a scalar quantity and displacement is a vector quantity defined by the shortest distance between the initial and the final position.

Acceleration is defined by the rate of change of velocity.

$\int a dt = \Delta v$ = change in velocity in given time.

Thus, the area under the velocity time graph gives the displacement of the body and the area under the acceleration time graph gives the change in velocity of the body.

5. (4)

From the position time graph the velocity is found out by the slope of the line. The slope is given by $\frac{x_2 - x_1}{t_2 - t_1}$.

The slope of B is greater than A. Hence, the velocity of B is greater than A. As can be seen from the graph $X_A < X_B$. So A lives closer to the school and $V_B > V_A$. Hence, this is the correct option.

6. (4)

The time (t_1) taken by the person to travel distance x with velocity v_1 is given by

$$t_1 = \frac{x}{v_1} \dots (1)$$

The time (t_2) taken by the person to travel distance x with velocity v_2 is given by

$$t_2 = \frac{x}{v_2} \dots (2)$$

The formula to calculate the average speed (v) of the person is given by

$$v = \frac{2x}{t_1 + t_2} \dots (3)$$

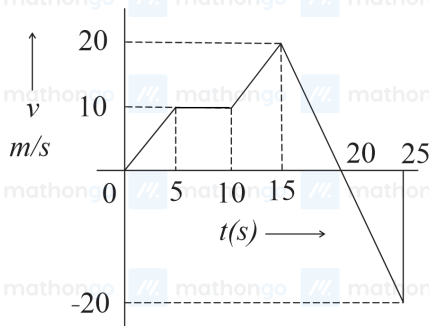
Substitute the expressions from equations (1) and (2) into equation (3) to obtain the required relation.

$$v = \frac{2x}{\left(\frac{x}{v_1} + \frac{x}{v_2}\right)}$$

$$\Rightarrow \frac{x}{v_1} + \frac{x}{v_2} = \frac{2x}{v}$$

$$\Rightarrow \frac{2}{v} = \frac{1}{v_1} + \frac{1}{v_2}$$

7. (3)



The area under the velocity time graph gives the displacement. The area for $t = 0$ s to $t = 25$ s is

$$(Area) = \left(\frac{1}{2} \times 5 \times 10\right) + (5 \times 10) + \left(\frac{1}{2} \times 30 \times 5\right) + \left(\frac{1}{2} \times 20 \times 5\right) - \left(\frac{1}{2} \times 20 \times 5\right)$$

$$\Rightarrow Area = 25 + 50 + 75 + 50 - 50 = 150 \text{ m}$$

Hence, the displacement = 150 m

The distance is defined as the path taken by the object to travel from initial to final position. Also note that displacement is a vector quantity, but distance is a scalar quantity.

Distance

$$= \left(\frac{1}{2} \times 5 \times 10\right) + (5 \times 10) + \left(\frac{1}{2} \times 30 \times 5\right) + \left(\frac{1}{2} \times 20 \times 5\right) + \left(\frac{1}{2} \times 20 \times 5\right)$$

$$= (200 + 50) = 250 \text{ m}$$

Therefore, required ratio

$$\frac{\text{distance}}{\text{displacement}} = \frac{250}{150} = \left(\frac{5}{3}\right)$$

8. (4)

The formula to calculate the velocity of the ball after 3 s is given by

$$v_3 = u - 3g \dots (1)$$

The formula to calculate the velocity of the ball after 5 s is given by

$$v_5 = u - 5g \dots (2)$$

Divide equation (1) by equation (2) to obtain the required ratio.

$$\frac{v_3}{v_5} = \frac{u-3g}{u-5g} \dots (3)$$

Substitute the values of the known parameters into equation (3) to calculate the required ratio.

$$\begin{aligned} \frac{v_3}{v_5} &= \frac{150-30}{150-50} \\ &= \frac{120}{100} \\ &= \frac{6}{5} \\ &= \frac{5+1}{5} \end{aligned}$$

Comparing the above equation with the given expression, it can be written that $x = 5$.

9. (1)

The work done in stopping the car and the truck can be written as

$$W = Fx$$

$$= \Delta KE$$

As both the car and the truck are moving initially with the same kinetic energy, after being stopped, they will have the same change of kinetic energy.

Also, they are stopped with the same applied force.

Hence, from the above equation, it can be written that they have the same displacement, i.e., $x_1 = x_2$.

Acceleration is a vector quantity. As the direction of motion of the car is different in the two given situations, the acceleration of the car will not be the same.

10. (3)

The time taken for A

$$\Delta t_A = \frac{l+L}{V_A}$$

The time taken for B

$$\Delta t_B = \frac{4l+L}{V_B}$$

It is given that B takes more time than A. So,

$$\Rightarrow \frac{4l+L}{20} - \frac{l+L}{30} = 35$$

$$\Rightarrow \frac{64l}{20} - \frac{61l}{30} = 35$$

$$\Rightarrow l = \frac{35 \times 600}{700} = 30 \text{ m}$$

Therefore,

$$L = 1800 \text{ m.}$$

11. (1)

It is given that

$$s = 2.5t^2$$

Differentiating,

$$v = \frac{ds}{dt} = \frac{d(2.5t^2)}{dt} = 5t$$

$$\text{At } t = 5 \text{ s, } v = 25 \text{ m s}^{-1}$$

12. (2)

Let the velocity of A be v_A and the velocity of B be v_B .

The relative velocity is

$$\vec{v}_{BA} = \vec{v}_B - \vec{v}_A$$

$$\Rightarrow v_{BA} = 54 - (-90) = 144 \text{ km h}^{-1}$$

$$\Rightarrow v_{BA} = 40 \text{ m s}^{-1}$$

$$\text{Time} = \frac{\text{length}}{v_{BA}}$$

$$\Rightarrow \text{length} = 40 \text{ m s}^{-1} \times 8 \text{ s} = 320 \text{ m}$$

13. (4) mathongo mathongo mathongo mathongo mathongo mathongo mathongo mathongo mathongo mathongo n

It is given that

$$x = 5t^2 - 4t + 5$$

The velocity is given by

$$v = \frac{dx}{dt} = \frac{d(5t^2 - 4t + 5)}{dt} = 10t - 4$$

At $t = 2$ s,

$$v = 10(2) - 4 = 16 \text{ m s}^{-1}$$

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