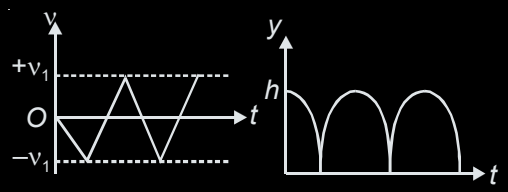
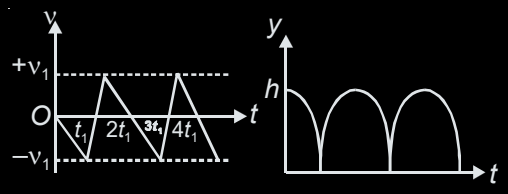
Chapter 1

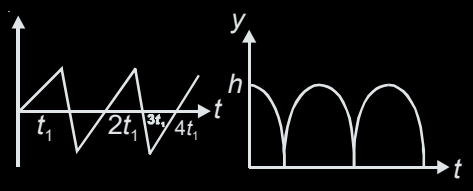
Motion in a Straight Line

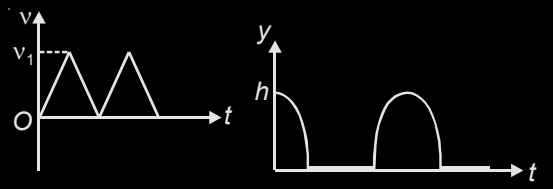
1. Consider a rubber ball freely falling from a height h = 4.9 m onto a horizontal elastic plate. Assume that the duration of collision is negligible and the collision with the plate is totally elastic.

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

(1) 

(2) 

(3) 

(4) 

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

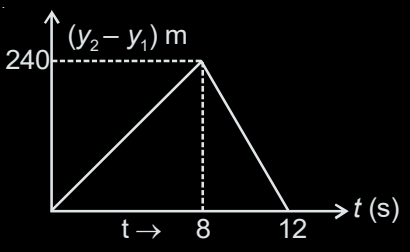
   (3) $2gH = nu^2(n-2)$

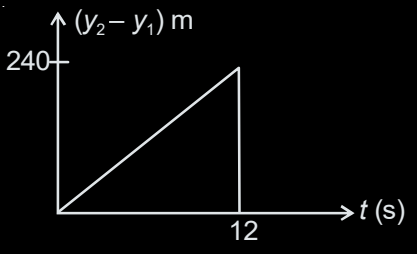
   (4) $gH = (n-2)u^2$

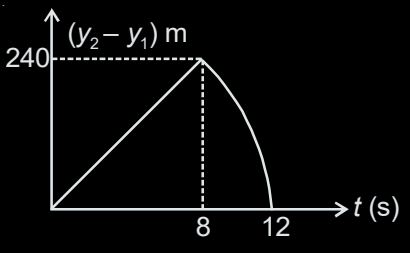
3. Two stones are thrown up simultaneously from the edge of a cliff 240 m high with initial speed of 10 m/s and 40 m/s respectively. Which of the following graph best represents the time variation of relative position of the second stone with respect to the first? **[JEE (Main)-2015]**

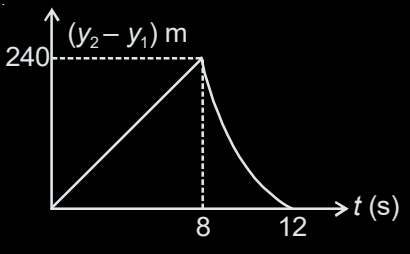
   (Assume stones do not rebound after hitting the ground and neglect air resistance, take g = 10 m/s^2)

   (The figures are schematic and not drawn to scale)

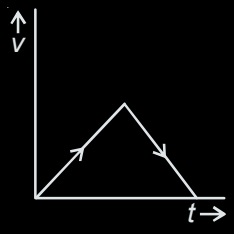
(1) 

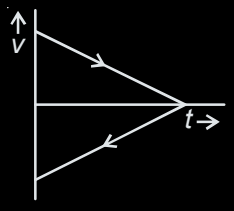
(2) 

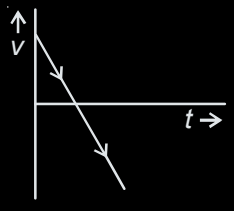
(3) 

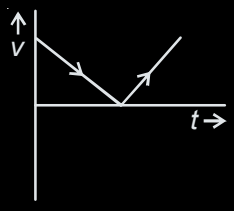
(4) 

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

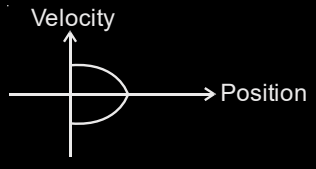
(1) 

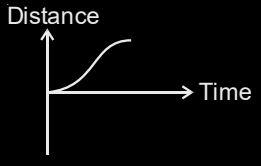
(2) 

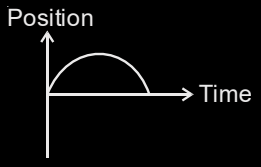
(3) 

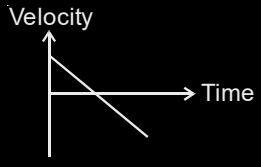
(4) 

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

(1) 

(2) 

(3) 

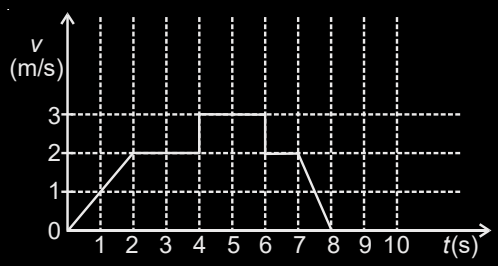
(4) 

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) $\frac{2a_1a_2}{a_1 + a_2} t$

(3) $\sqrt{2a_1a_2}\, t$ (4) $\sqrt{a_1a_2}\, t$

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) 4 m

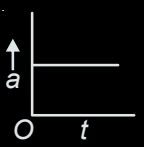
8. A passenger train of length 60 m travels at a speed of 80 km/hr. Another freight train of length 120 m travels at a speed of 30 km/hr. The ratio of times taken by the passenger train to completely cross the freight train when : (i) they are moving in the same direction, and (ii) in the opposite directions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

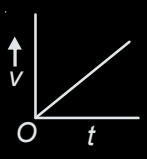
(1) $\frac{25}{11}$ (2) $\frac{5}{2}$

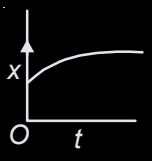
(3) $\frac{11}{5}$ (4) $\frac{3}{2}$

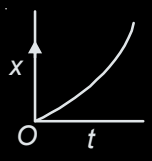
9. A particle starts from origin *O* from rest and moves with a uniform acceleration along the positive *x*-axis. Identify all figures that correctly represent the motion qualitatively. (*a* = acceleration, *v* = velocity, *x* = displacement, *t* = time)

[JEE (Main)-2019]

(A) 

(B) 

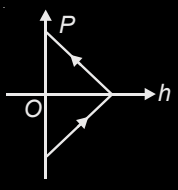
(C) 

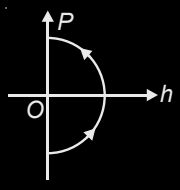
(D) 

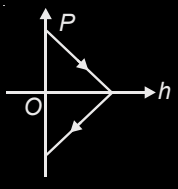
(1) (A) (2) (A), (B), (C)

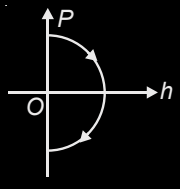
(3) (A), (B), (D) (4) (B), (C)

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]**

(1) 

(2) 

(3) 

(4) 

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) $\frac{b^2\tau}{4}$

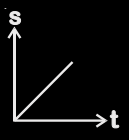
(3) $\frac{b^2\tau}{2}$ (4) $\frac{b^2\tau}{\sqrt{2}}$

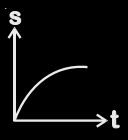
13. Train *A* and train *B* are running on parallel tracks in the opposite directions with speeds of 36 km/hour and 72 km/hour, respectively. A person is walking in train *A* in the direction opposite to its motion with a speed of 1.8 km/hour. Speed (in ms^{-1}) of this person as observed from train *B* will be close to (take the distance between the tracks as negligible) **[JEE (Main)-2020]**

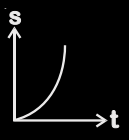
(1) 30.5 ms^{-1} (2) 29.5 ms^{-1}

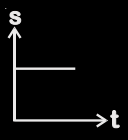
(3) 31.5 ms^{-1} (4) 28.5 ms^{-1}

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]**

(1) 

(2) 

(3) 

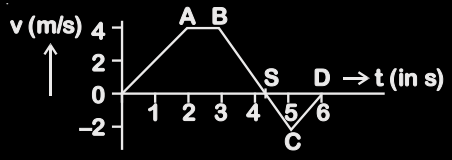
(4) 

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) $t = 3.4\sqrt{\left(\frac{h}{g}\right)}$ (2) $t = 1.8\sqrt{\frac{h}{g}}$

(3) $t = \sqrt{\frac{2h}{3g}}$ (4) $t = \frac{2}{3}\sqrt{\left(\frac{h}{g}\right)}$

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]**



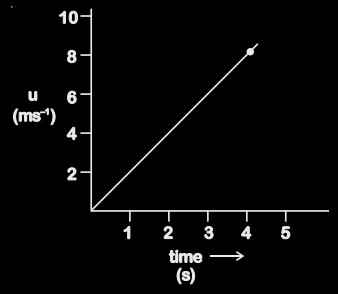
(1) $\frac{37}{3}$m (2) 11 m

(3) 12 m (4) $\frac{49}{4}$m

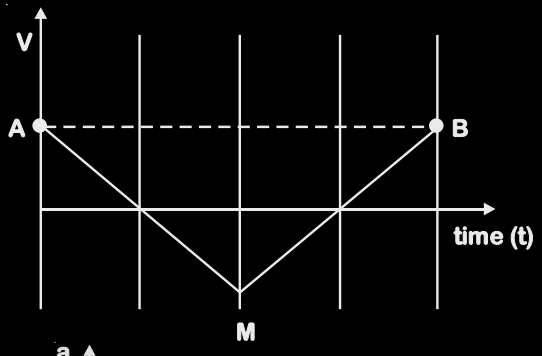
17. A ball is dropped from the to of a 100 m high tower on a planet. In the last $\frac{1}{2}$ s before hitting the ground, it covers a distance of 19 m. Acceleration due to gravity (in ms^{-2}) near the surface on that planet is _____. **JEE (Main)-2020]**

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]**

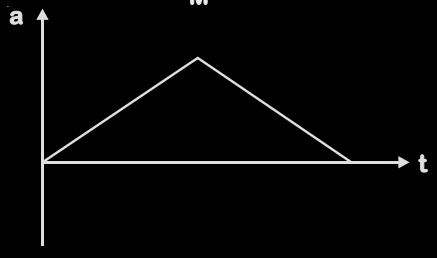
19. The speed versus time graph for a particle is shown in the figure. The distance travelled (in m) by the particle during the time interval t = 0 to t = 5 s will be _____. **[JEE (Main)-2020]**



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



(1)



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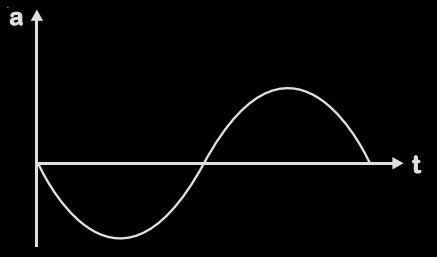

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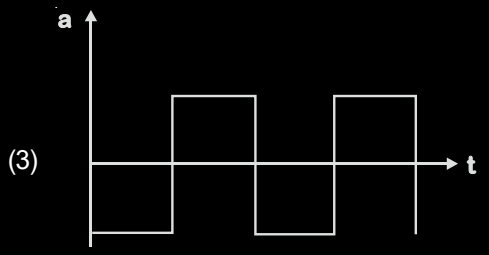

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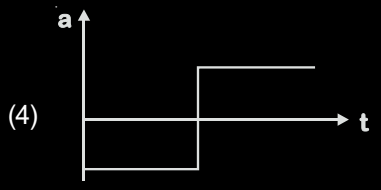


21. An engine of a train, moving with uniform acceleration, passes the signal-post with velocity u and the last compartment with velocity v. The velocity with which middle point of the train passes the signal post is: **[JEE (Main)-2021]**

(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

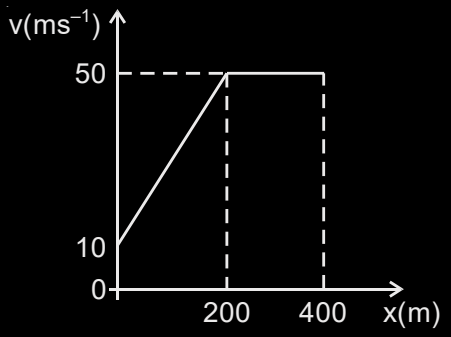
23. A scooter accelerates from rest for time t_1 at constant rate a_1 and then retards at constant rate a_2 for time t_2 and comes to rest. The correct value of $\frac{t_1}{t_2}$ will be **[JEE (Main)-2021]**

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

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

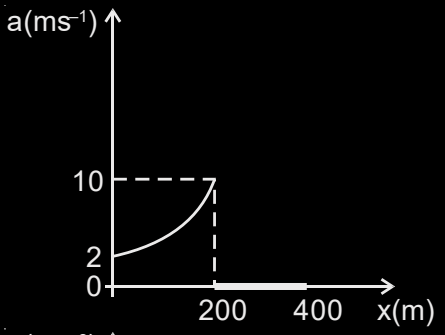
24. The velocity-displacement graph describing the motion of a bicycle is shown in the figure.

[JEE (Main)-2021]



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

(1)



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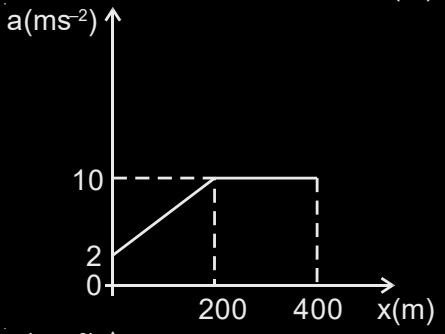

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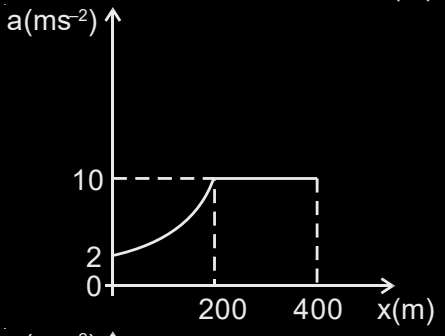

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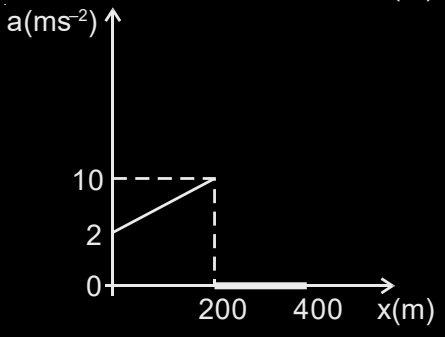


25. A car accelerates from rest at a constant rate α for some time after which it decelerates at a constant rate β to come to rest. If the total time elapsed is t seconds, the total distance travelled is: **[JEE (Main)-2021]**

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

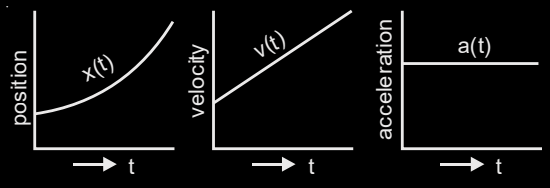
26. The velocity of a particle is $v = v_0 + gt + Ft^2$. Its position is x = 0 at t = 0; then its displacement after time (t = 1) is : **[JEE (Main)-2021]**

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

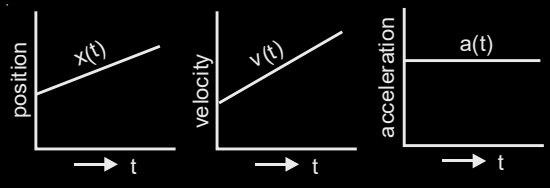
(3) $v_0 + \frac{g}{2} + \frac{F}{3}$ (4) $v_0 + 2g + 3F$

27. The position, velocity and acceleration of a particle moving with a constant acceleration can be represented by: **[JEE (Main)-2021]**

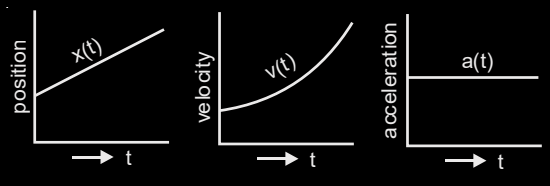
(1)



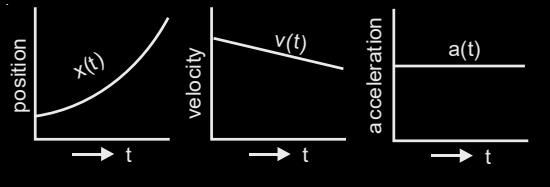
(2)



(3)



(4)



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/s^2)

[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/s^2)

[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) $\frac{\alpha}{2} + \frac{\beta}{3}$

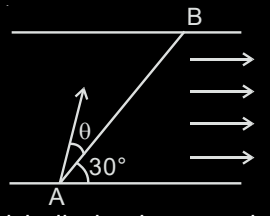
(3) $\frac{3}{2}\alpha + \frac{7}{2}\beta$ (4) $3\alpha + 7\beta$

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/s^2)

[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/s^2

[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.

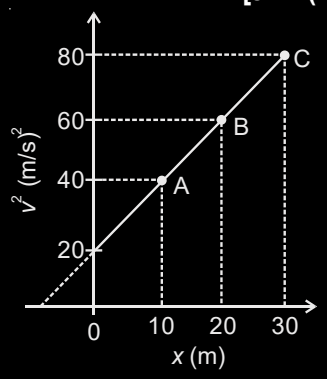
[JEE (Main)-2021]

(1) 2.45 m (2) 7.35 m

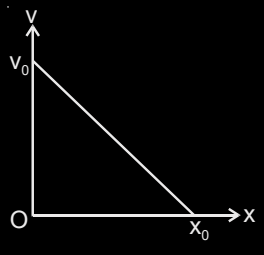
(3) 2.94 m (4) 4.18 m

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.

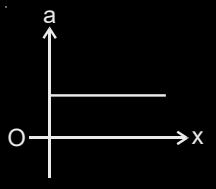
[JEE (Main)-2021]

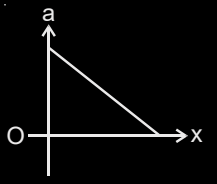


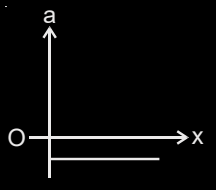
40. The velocity-displacement graph of a particle is shown in the figure. **[JEE (Main)-2021]**

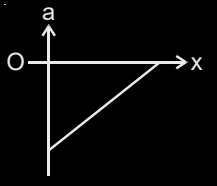


The acceleration-displacement graph of the same particle is represented by:

(1) 

(2) 

(3) 

(4) 

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

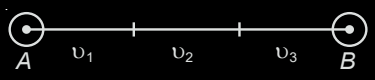
43. A ball of mass 0.5 kg is dropped from the height of 10 m. The height, at which the magnitude of velocity becomes equal to the magnitude of acceleration due to gravity, is ___ m. [Use g = 10 m/s^2] **[JEE (Main)-2022]**

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 υ_1 ms^{-1}, second one-third at υ_2 ms^{-1} and last one-third at υ_3 ms^{-1}. If $\upsilon_3 = 3\upsilon_1$, $\upsilon_2 = 2\upsilon_1$ and $\upsilon_1 = 11$ 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 ms^{-2}] **[JEE (Main)-2022]**

(1) 10 (2) 15

(3) 20 (4) 30

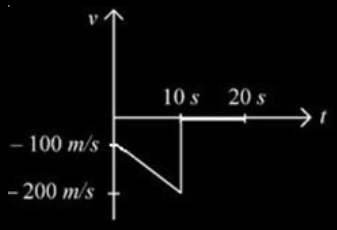
47. A small toy starts moving from the position of rest under a constant acceleration. If it travels a distance of 10 m in t s, the distance travelled by the toy in the next t s will be : **[JEE (Main)-2022]**

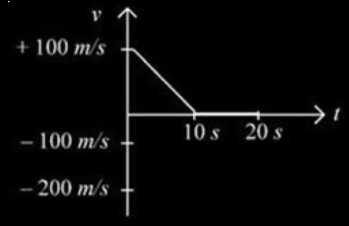
(1) 10 m (2) 20 m

(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 $t = -20$ s will be

(Take $g = 10\ m/s^2$) **[JEE (Main)-2022]**

(1)


(2)


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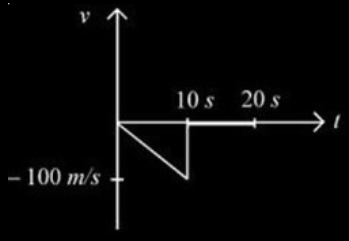

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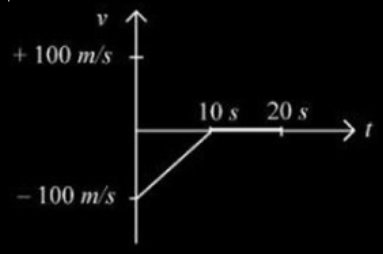


49. A NCC parade is going at a uniform speed of 9 km/h under a mango tree on which a monkey is sitting at a height of 19.6 m. At any particular instant, the monkey drops a mango. A cadet will receive the mango whose distance from the tree at time of drop is

(Given $g = 9.8\ m/s^2$) **[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 $\left(\frac{k}{5}\right)$ m. The value of k is _____ (use $g = 9.8\ m/s^2$) **[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) $t_1 = \left(\sqrt{2}\right)t_2$ (2) $t_1 = \left(\sqrt{2}-1\right)t_2$

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

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 $t = 0$ s. At $t = 2$ s, another ball is projected vertically upward with same velocity. At t = _____s, second ball will meet the first ball ($g = 10\ ms^{-2}$) **[JEE (Main)-2022]**

❑ ❑ ❑

Chapter 1

Motion in a Straight Line

1. Answer (2)

From $v = u + at$

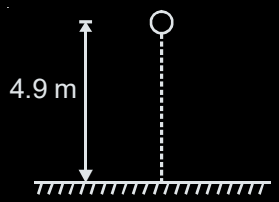
$v = 0 - g \times t$

$\Rightarrow \quad v = -gt$

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

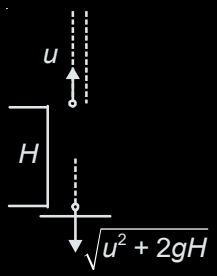
From $S = ut + \frac{1}{2}at^2$

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



So, graph will be downward parabola.

2. Answer (3)



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

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

Now, $v = u + at$

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

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

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

3. Answer (3)

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

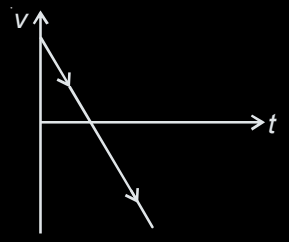
$\Delta x = x_2 - x_1 = 30t$

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

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)

$t_A = t_B - t$

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

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

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

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

7. Answer (1)

Displacement = Area under v - t graph

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

8. Answer (3)

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

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

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

9. Answer (3)

a = Constant

$v = at$

$x = \frac{1}{2}at^2$ [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)

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

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

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

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

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

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

12. Answer (3)

$v = \frac{dx}{dt} = b\sqrt{x}$ …(i)

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

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

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

13. Answer (2)

$V_P = (10 - 0.5)$

= 9.5 m/s

V_{PB} = 29.5 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)

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

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

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

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

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

$\therefore \quad$ Total time $= t_1 + t_2$

$= \left(2 + \sqrt{2}\right)\sqrt{\frac{h}{g}}$

$= 3.4\sqrt{\frac{h}{g}}$

16. Answer (1)

Distance = $|A_1| + |A_2|$

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

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

17. Answer (08.00)

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

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

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

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

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

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

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

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

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

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

18. Answer (3)

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

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

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

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

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

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

19. Answer (20)

Distance travelled = Area under the u-t graph

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

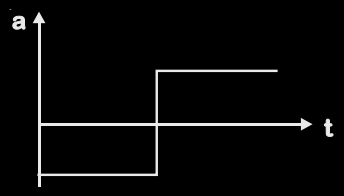
20. Answer (4)

From A to M,

Acceleration is negative and constant

From M to B

Acceleration is positive and constant.



$\therefore$

21. Answer (3)

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

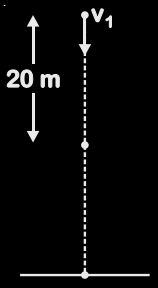
Let velocity of middle point be v_1

$v_1^2 - u^2 = ax$

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

22. Answer (2)

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



$\therefore \quad v_1 = gt_1 = 10$ m/s

Time of collision,

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

$\therefore$ Total time of fall = 3 s

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

23. Answer (3)

We have,

$a_1t_1 = a_2t_2$

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

24. Answer (4)

$$a = \frac{vdv}{dx}$$

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

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

$a(x = 0) = 2$ m/s^2

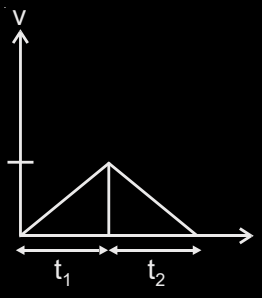
$a(x = 200) = 10$ m/s^2

25. Answer (2)

$t_1 + t_2 = t$

$\alpha t_1 = \beta t_2$

S = Area under v-t 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)

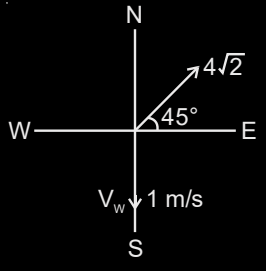
V_x = 4 m/s

V_y = 3 m/s

$x = 4 \times 3 = 12$ m

$y = 3 \times 3 = 9$ 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 s,

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

N = 1

31. Answer (2)

$t = mx^2 + nx$

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

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

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

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

$$= 2\, mv^3$$

32. Answer (2)

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

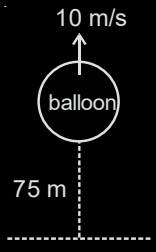
$\Rightarrow \; -15 = 2t - t^2$

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

$\Rightarrow \; t = 5$ s

H = 75 + 10 × 5

= 125 m



33. Answer (1)

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

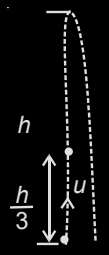
$$\int dx = \int_1^2 (\alpha t + \beta t^2) dt$$

$$= \alpha \frac{t^2}{2}\Big]_1^2 + \frac{\beta}{3} t^3 \Big]_1^2$$

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

34. Answer (2)

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



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

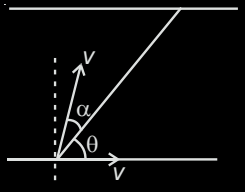
$$\frac{h}{3} = ut - \frac{1}{2}gt^2$$

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

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

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

35. Answer (30)

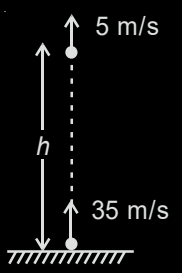


For equal magnitude v_s and v_R

$\alpha = \theta$

$\Rightarrow \quad \alpha = 30°$

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 $\rightarrow$ 1st drop

at t = Δt $\rightarrow$ 2nd drop

at t = 2Δt $\rightarrow$ 3rd 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 m/s^2

40. Answer (4)

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

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

41. Answer (3)

Based on the situation

$h = -ut_1 + \frac{1}{2}gt_1^2$ → throwing up …(i)

$h = ut_2 + \frac{1}{2}gt_2^2$ → throwing down …(ii)

$h = \frac{1}{2}gt^2$ → dropping … (iii)

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

solving above equations

$t = \sqrt{t_1 t_2}$

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

42. Answer (4)

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

$X_Q = ft - t^2$

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

$V_Q = f - 2t$

$\because \quad V_P = V_Q$

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

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

43. Answer (5)

$gt = g$

$\Rightarrow \quad t = 1$ sec

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

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

$= 10 - 5$

$= 5$ m

44. Answer (2)

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

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

$\Delta t = 4 - 1 = 3$ s,

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

$\therefore$ depth = 9.8 × 3 = 29.4 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 m/sec

46. Answer (4)

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

$A: \; 80 = \frac{1}{2}gt_0^2$ …(i)

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

From (i), $t_0 = 4$

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

$\Rightarrow \quad u = 30$ m/s

47. Answer (3)

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

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

$\Rightarrow$ Distance travelled in next t s

$= 40 - 10 = 30$ m

48. Answer (1)

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

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

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

$19.6 = 4.9\,t^2$

$t = 2$ sec

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

50. Answer (392)

v = 19.6 m/s

t = 6s

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 × 9.8 × 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)

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

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

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

54. Answer (100)

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

Acceleration of particle

when v = 20 m/s

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

55. Answer (6)

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

$v_2 = v_2$

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

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

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

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

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

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