2. Motion in a Straight Line

Scan for Video Solution

Topic-wise Questions

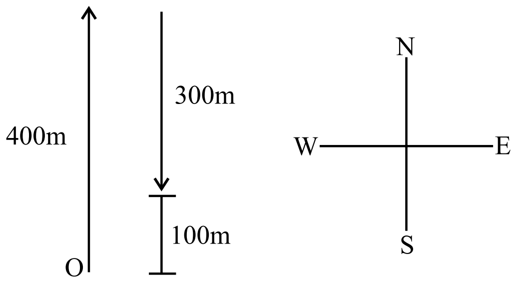
1. (b) Position of the man $\vec{r} = 20\hat{i} + 30\hat{j}$; initial position $\vec{r}_0 = 0\hat{i} + 0\hat{j}$

Displacement = change in position $= \vec{r} - \vec{r}_0 = 20\hat{i} + 30\hat{j}$

Magnitude of displacement is $= \sqrt{(20)^2 + (30)^2}$

$r = \sqrt{400 + 900} \quad = \sqrt{1300} = 36.05\,\text{m}$

2. (a) An aeroplane flies 400 m north and 300 m south so let aeroplane starts there journey from point O



Net displacement of the plane is 100 m, after it flies 1200 m upward; so the displacement or position is-

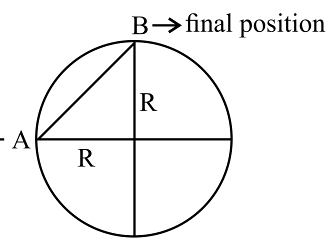
$\vec{r} = 100\hat{i} + 1200\hat{j}$

Magnitude of displacement $= r = \sqrt{(100)^2 + (1200)^2}$

$r = \sqrt{10000 + 1440000}$

$= 1204\text{ m} \simeq 1200$

3. (c) initial position ←



$\therefore$ Displacement is line segment AB

$AB = \sqrt{R^2 + R^2} = \sqrt{2}\ R$

4. (c) Displacement = (7m, –2m, –3m) – (–4m, –5m, +8m)

= (11m, 3m, –11m)

5. (b) Displacement is denoted by Δx, in time $\Delta t = t_2 - t_1$ is given by the difference between final position (t_2) and initial position (t_1).

6. (a) So, the position coordinates of point P = (+360,0,0) and point R = (–120,0,0).

7. (a) Displacement $= \Delta x = x_2 - x_1$

For journey, displacement of car moving from O to P,

$x_2 = +360\text{ m} \qquad x_1 = 0\text{ m}$

$\Rightarrow \quad \Delta x = x_2 - x_1 = 360 - 0 = +360\text{ m}$

For journey, displacement in moving from P to Q

$x_2 = +240\text{ m} \qquad x_1 = +360\text{ m}$

$\Rightarrow \quad \Delta x = x_2 - x_1 = 240 - 360 = -120\text{ m}$

Here, –ve sign implies that the displacement is in –ve direction i.e., towards left.

8. (d) For motion of the car from O to P

Displacement $= \Delta x = x_2 - x_1 = +360\text{ m} - 0\text{ m} = +360\text{ m}$

Path length = Distance OP = 360

So, displacement and path length are same.

For motion of the car from O to P and back to Q

Displacement $= \Delta x = x_2 - x_1 = +240\text{ m} - 0\text{ m} = +240\text{ m}$

Path length = OP + PQ = + 360 m + (+ 120 m)

= + 480 m = 480 m

So, displacement and path length are not equal.

9. (a) Displacement $= \Delta x = x_2 - x_1 = 0 - 0 = 0\text{ m}$

Path length of the journey

= OP + PO = + 360 m + (+ 360)m = 720 m

10. (b) Given, $x = (t-2)^2$

Velocity, $v = \dfrac{dx}{dt} = \dfrac{d}{dt}(t-2)^2 = 2(t-2)\,\text{m/s}$

Acceleration, $a = \dfrac{dv}{dt} = \dfrac{d}{dt}\left[2(t-2)\right] = 2[1-0] = 2\text{ m/s}^2$

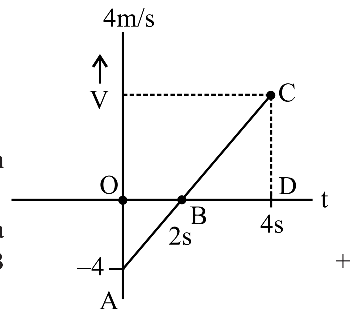
When,

t = 0, v = – 4 m/s

t = 2s; v = 0 m/s

t = 4s; v = 4 m/s

v – t graph is shown in adjacent diagram.

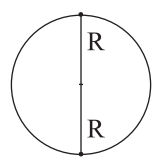


Distance traveled = area of the graph = area OAB + area CBD

11. (b) Displacement is zero

12. (c) When particle is moving with uniform velocity then acceleration is always zero. Under uniform motion speed also remains constant.

13. (a) Displacement = 2R



Time = 20 sec.

Average velocity $= \dfrac{2R}{20} = \dfrac{2 \times 80}{20} = 8\,\text{m/s}$

14. (d) $x = a + bt^2$

Differentiating both side

$\dfrac{dx}{dt} = \dfrac{d\left(a + bt^2\right)}{dt} \Rightarrow V = 0 + 2bt$

$V = 0 + 2 \times 15 \times 3 \Rightarrow V = 90\ \text{cms}^{-1}$

15. (a) $\text{Average speed} = \dfrac{\text{Total distance}}{\text{Total time}}$

Total time is $t_1 + t_2 + t_3$

$$t_1 = \frac{x}{3\times 20},\ t_2 = \frac{x}{3\times 40},\ t_3 = \frac{x}{3\times 60}$$

$$\therefore \text{Average speed} = \frac{x}{\dfrac{x}{3\times 20}+\dfrac{x}{3\times 40}+\dfrac{x}{3\times 60}}$$

$$= \frac{x}{\dfrac{x}{3}\left(\dfrac{1}{20}+\dfrac{1}{40}+\dfrac{1}{60}\right)} = \frac{3}{\dfrac{9+4.5+3}{180}} = \frac{3\times 180}{16.5}$$

Average speed = 32.7 m/s

Short trick: $\text{Av. speed} = \dfrac{3\times 20\times 40\times 60}{20\times 40+40\times 60+60\times 20}$

$$= \frac{144000}{800+2400+1200} = \frac{144000}{4400} = 32.7\ \text{m/s}$$

16. (b) $\text{Average velocity} = \dfrac{\text{Total distance / displacement}}{\text{Total time}}$

Total time = $t_1 + t_2$

Now,

$$t_1 = \frac{x}{2\times 40},\quad t_2 = \frac{x}{2\times 80}$$

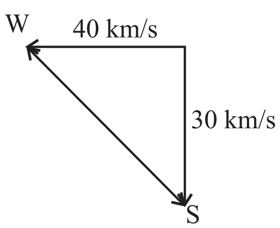
$$\therefore \text{Average velocity} = \frac{x}{\dfrac{x}{2\times 40}+\dfrac{x}{2\times 80}}$$

$$= \frac{x}{\dfrac{x}{2}\left(\dfrac{1}{40}+\dfrac{1}{80}\right)} = \frac{1}{\dfrac{1}{80}\left(1+\dfrac{1}{2}\right)} = \frac{80}{3/2} = \frac{160}{3} = 53.3\ \text{km/hr}$$

Short Trick:

$$\text{av. velocity} = \frac{2\times V_1\times V_2}{V_1+V_2} = \frac{2\times 40\times 80}{40+80} = \frac{6400}{120} = 53.3\ \text{km/hr}$$

17. (a)



$\Delta v = -40\hat{i} + 30\hat{j}$

$|\Delta v|$ Magnitude of change in velocity

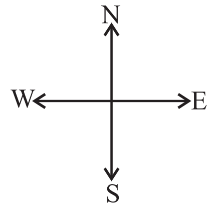
$$= \sqrt{(30)^2+(40)^2} = \sqrt{900+1600}$$

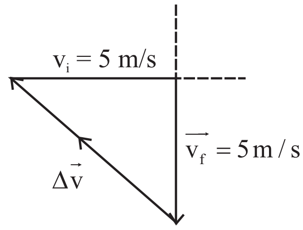
$$|\Delta v| = \sqrt{2500} = 50\ \text{km/s} \qquad |a| = \frac{50}{10}\ \text{km/s}^2 = 5\ \text{km/s}^2$$

18. (d) $v_i = 5$ m/s $\quad v_f = 5$ m/s

$\therefore \Delta v = v_f - (v_i)$

$= v_f + (-v_i)$





$$|\Delta v| = \sqrt{(v_f)^2+(v_i)^2} \qquad |\Delta v| = 5\sqrt{2}\ \text{m/s}$$

$\Delta t = 10$ seconds

$$\text{av. acceleration} = \frac{5\sqrt{2}}{10} = \frac{1}{\sqrt{2}}\ \text{m/s}^2 \text{ (towards north-west)}$$

19. (b) For maximum and minimum displacement we have to keep in mind the magnitude and direction of maximum velocity.
As maximum velocity in positive direction is v_0.
Maximum velocity in opposite direction is also v_0.
Maximum displacement in one direction = v_0T
Maximum displacement in opposite directions = $-v_0T$
Hence, $-v_0T < x < v_0T$.

20. (c) Time taken to travel first half distance $t_1 = \dfrac{l/2}{v_1} = \dfrac{l}{2v_1}$

Time taken to travel second half distance $t_2 = \dfrac{l}{2v_2}$

$$\text{Total time} = t_1 + t_2 = \frac{l}{2v_1}+\frac{l}{2v_2} = \frac{l}{2}\left[\frac{1}{v_1}+\frac{1}{v_2}\right]$$

We know that,

$$V_{av} = \text{Average speed} = \frac{\text{total distance}}{\text{total time}}$$

$$= \frac{l}{\dfrac{l}{2}\left[\dfrac{1}{v_1}+\dfrac{1}{v_2}\right]} = \frac{2v_1v_2}{v_1+v_2}$$

21. (b) Length of the barrel = 1.2 m
Speed of the bullet = 640 ms^{-1}
According to the third equation of motion

$V^2 = u^2 + 2as \qquad V^2 = 0 + 2as$

$$640\times 640 = 2\times a\times 1.2 \qquad \frac{320\times 640}{1.2} = a$$

$$640 = 0 + \frac{640\times 320}{1.2}\times t \Rightarrow t = \frac{1.2\times 640}{640\times 320}$$

$t = 0.0037 = t = 3.7\times 10^{-3} \Rightarrow t \approx 4$ms

22. (a) Displacement in last 2 seconds

$$\text{is} = S15 - S13 \quad = 4(15-13)+\frac{1}{2}a\left(15^2-13^2\right)$$

$$=10\times2+\frac{1}{2}\times5\times(225-169)\quad=20+140\quad=160\,\text{m}$$

23. (b) u = – 19.6 ms^{-1} a = 9.8 ms^{-2} t = 6s

$$S=ut+\frac{1}{2}at^2 \qquad S=-19.6\times6+\frac{1}{2}\times9.8\times6^2$$

$$=-19.6\times6+4.9\times36$$

S = 58.8 m

24. (a) 2as = v^2 – u^2 $a=\frac{v^2-u^2}{2s}=\frac{0-(40)^2}{2\times108}=\frac{-1600}{216}$

a = –7.4 m/s^2

And,

v = u + at v – u = at

$$\therefore t=\frac{v-u}{a}=\frac{0-(40)}{-7.4}=\frac{-40}{-7.4}=5.4\,\text{s}$$

25. (b) In vertically upward motion V = 0

v^2 – u^2 = 2as 0 – (40)^2 = 2 × –10 × s

–1600 = –20 × s ⇒ +80 m = s

26. (b) Distance covered in 8th second

$$S_{8^{th}}=u+\frac{a}{2}(2n-1)=0+\frac{a}{2}(2\times8-1)$$

$$S_{8^{th}}=\frac{a}{2}(15)$$

Distance covered in 8 second-

$$S=ut+\frac{1}{2}at^2\ \Rightarrow 0+\frac{1}{2}a\times64=64\left(\frac{a}{2}\right)$$

$$\text{Ratio, }\frac{S_{8^{th}}}{S_8}=\frac{\frac{a}{2}(15)}{\frac{a}{2}(64)}=\frac{15}{64}$$

27. (c) According to the 3rd equation of motion

v^2 – u^2 = 2as

After applying the brakes car will come to rest v = 0

u^2 ∝ s

$$\therefore\frac{s_1}{s_2}=\frac{u_1^{\,2}}{u_2^{\,2}}\Rightarrow s_2=\left(\frac{u_2}{u_1}\right)^2\times s_1$$

$$s_2=\left(\frac{30}{10}\right)^2\times20=9\times20=180\,\text{m}$$

28. (a) Let particle accelerates with acceleration α for time t_1, and retard with retardation –β for t_2.

$t_1 + t_2 = 50$

CASE -1	CASE -2
$v = u + \alpha t_1$	$v = u - \beta t_2$
$v = 0 + \alpha t_1$	$0 = u - \beta t_2$
$v = \alpha t_1$	$u = \beta t_2$

Initial velocity is equal to the final velocity of Case I.

$\alpha t_1 = \beta t_2$ $\alpha t_1 = 5\alpha t_2$

$\alpha t_1 = 5\alpha t_2 \Rightarrow 5t_2 + t_2 = 50$ $6t_2 = 50 \Rightarrow t_2 = 25/3$ sec.

29. (d) As we know the relation $V_{mid}=\sqrt{\frac{V_A^{\,2}+V_B^{\,2}}{2}}$

$$V_{mid}=\sqrt{\frac{(60)^2+(40)^2}{2}}=\sqrt{\frac{3600+1600}{2}}$$

$$V_{mid}=\sqrt{\frac{5200}{2}}=\sqrt{2600}=50.9\,\text{m/s}$$

30. (b) As we know that,

v = u + at , v = –2 m/s , u = 20 m/s

(–ve sign) = opposite direction

$$\frac{v-u}{t}=a \qquad \frac{-2-20}{5}=a\Rightarrow\frac{-22}{5}=a$$

$$\text{Force}=ma=10\times\frac{-22}{5}=-44\text{N}$$

31. (a) Body covers equal distance in ascending or descending

$$h=ut+\frac{1}{2}gt^2 \qquad (u=-ve)$$

(g = +ve because after passing highest position motion is under gravity)

$$h=-19.6\times10+\frac{1}{2}\times10\times100 \qquad (g=+ve)$$

= –196 + 5 × 100 = 500 – 196 h = 304 m

32. (c) Stone is dropped, u = 0

Let t is the time taken by the stone to cover depth of 20 m.

$$20=ut+\frac{1}{2}gt^2\Rightarrow 20=\frac{1}{2}\times10\times t^2 \qquad t=2$$

Splash heard after 3 second but time taken by stone is 2 second

∴ Δt = 3 – 2 = 1 second

or velocity of particle = 20/1 = 20 m/s

33. (d) Initial velocity of the balloon w.r.t the ground

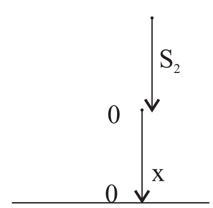
u = 6 + 16 = 22 m/s

because thrown velocity of stone and balloon is opposite in direction w.r.t the ground

Velocity after 2 second ⇒ v = u – gt

v = 22 – 10 × 2 v = 22 – 20 = 2 m/s

34. (d) Time taken by first drop to reach the ground $t=\sqrt{\frac{2h}{g}}$



$$t=\sqrt{\frac{2\times8}{10}}=\sqrt{1.6}\ \Rightarrow\ t=1.26\,\text{sec.}$$

As the water drops falls at regular intervals of time. Let it be approx second drop is halfway between third and first drop, so time difference between any two drops = 1/2 sec = 1.26/2 = 0.63 sec.

Distance of 2nd drop $S_2 = \frac{1}{2}gt^2$ (u = 0)

From the tap

$S_2 = \frac{1}{2} \times 10 \times (0.63)^2$ = 5 × 0.39 = 1.95 m

Distance of drop from ground (x) = 8 – 1.95 = 6.05 m

35. (c) Time period is independent of mass of body.

$t = \sqrt{\frac{2h}{g}}$ $\therefore \frac{t_A}{t_B} = \frac{3}{4}$

36. (c) Velocity of descent or ascent always equal.

$V = \sqrt{2 \times g \times h} = \sqrt{2 \times 10 \times 40} = \sqrt{800} = 20\sqrt{2}$ m / s

Time of ascent and descent always equal.

T = time of ascent + time of descent

$T = t_1 + t_2$

Let t_1 is the time of ascent and t_2 be that of descent

v = u – gt

$0 = u - gt_1$ $v = u + gt_2$

$u = gt_1$ $u = 0 + gt_2$

$t_1 = \frac{u}{g}$ $\frac{u}{g} = t_2$

$T = t_1 + t_2$ $T = \frac{u}{g} + \frac{u}{g} = \frac{2u}{g} = \frac{2 \times \sqrt{800}}{10}$

$T = 4 \times \sqrt{2}$ sec T = 4 × 1.41 = 5.64 seconds

37. (a) As the lift is coming in downward direction, displacement will be negative. We have to see whether the motion is accelerating or retarding.

We know that due to downward motion displacement will be negative. When the lift reaches 4th floor is about to stop hence, motion is retarding in nature. Hence, x < 0; a > 0.

As displacement is in negative direction, velocity will also be negative i.e., v < 0.

38. (b) At the time of maximum velocity, acceleration is zero.

V = 2t (3 – t) $V = 6t - 2t^2$

Differentiating both side

$\frac{dv}{dt} = \frac{d(6t - 2t^2)}{dt}$ 0 = 6 – 4t t = 1.5

39. (b) $a = 8t + 5 \Rightarrow \frac{dv}{dt} = 8t + 5 \Rightarrow dv = (8t + 5)dt$

$\int_0^v dv = \int_0^t (8t + 5)dt \Rightarrow v = \frac{8t^2}{2} + 5t$

$v = 4t^2 + 5t = 4 \times 4 + 10 = 16 + 10 = 26$ m/s

40. (a) For value of A, time taken $t_2 = t + \frac{\Delta t}{2}$

[Here, t = 4.0 s and Δt = 0.5s]

$\Rightarrow$ $t_2 = 4 + \frac{0.5}{2} = 4.25$ sec.

For value of B, $\Delta x = x(t_2) - x(t_1)$

Where, $x(t_2)$ = 7.28 [From the table]

$x(t_1)$ = 3.43 [From the table]

$\Rightarrow$ Δx = 3.85 m or B = 3.85 m

For value of C, $\frac{\Delta x}{\Delta t} = \frac{x(t_2) - x(t_1)}{t_2 - t_1} = \frac{0.0384\,m}{(4.005 - 3.995)s}$

$= 3.8400$ m s^{-1} $\therefore$ C = 3.8400

41. (d) The table shown gives the limiting value of $\frac{\Delta x}{\Delta t}$ at t = 4 s

The limiting value of $\frac{\Delta x}{\Delta t}$ at t = 4s is same as instantaneous velocity at that instant.

$\therefore$ $v = \lim_{\Delta t \to 0} \frac{\Delta x}{\Delta t}$

42. (d) For given expression, for motion is

$x(t) = 0.08t^3 \Rightarrow \frac{dx}{dt} = 0.24t^2$

$\left.\frac{dx}{dt}\right|_{t=4} = 0.24 \times (4)^2 = 0.24 \times 16 = 3.8400$ ms^{-1}

We know instantaneous velocity $= v = \frac{dx}{dt}$

Also, from the table we observe that for Δt = 0.01 s, the value of $\frac{\Delta x}{\Delta t}$ = 3.8400 which is same as instantaneous velocity at t = 4 s.

43. (a) Given, $x(t) = a + bt^2$; (a = 8.5 m and b = 2.5 ms^{-2})

In notation of differential calculus, the velocity is

$v = \frac{dx}{dt} = \frac{d}{dt}(a + bt^2) = 2bt$

At t = 0, v = 2 b × 0 = 0 ms^{-1}

44. (a) Also, refer to solution no.55

Since, v = 2bt

$\Rightarrow$ At t = 2 velocity = 2 × 2.5 × 2 = 10 ms^{-1}

45. (b) Average velocity $= \frac{x(t_2) - x(t_1)}{t_2 - t_1} = \frac{x(4.0) - x(2.0)}{4.0 - 2.0}$

Given, $n(t) = a + bt^2$ $= \frac{(a + 16b) - (a + 4b)}{2.0} = 6.0\,b$

= 6.0 × 2.5 = 15 ms^{-1}

46. (b) Given, $x(t) = a - bt^2$, a = 8.5m and b = 2.5m/s^2 = $8.5 - 2.5t^2$

Velocity of object $= \frac{dx}{dt} = -2bt$

(A) velocity at $t = 2.0\,s = \left.\frac{dx}{dt}\right|_{t=2} = -4b$

= –4 × 2.5 = – 10 ms^{-1}

(B) velocity at $t = 0 = \left.\dfrac{dx}{dt}\right|_{t=0} = 0\,ms^{-1}$

(C) Instantaneous speed = Magnitude of velocity

$= |-10\ ms^{-1}| = 10\ ms^{-1}$

(D) Average velocity $= \dfrac{x(t_2) - x(t_1)}{t_2 - t_1}$

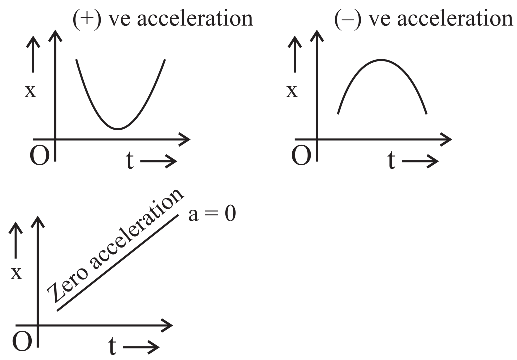
$= \dfrac{x(4) - x(2)}{4-2} \qquad = \dfrac{\left[a - b(4)^2\right] - \left[a - b(2)^2\right]}{2}$

$= \dfrac{4b - 16b}{2} = -\dfrac{12b}{2} = -6b = -6 \times 2.5\ ms^{-1} = -15\ ms^{-1}$

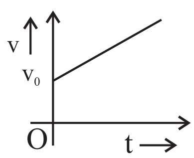
47. (a) The acceleration at an instant is the slope of the tangent to the v - t curve at that instant.

48. (d) In graph, non-uniform acceleration during 0s to 10s and acceleration is zero between 10s to 18s and it becomes constant between 18s to 20s.

49. (b) In position-time curve, upward direction for positive acceleration and downward for negative acceleration and it is straight line for zero acceleration as shown in figure.

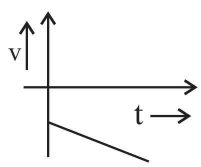


50. (a) The velocity-time graph formation with uniform acceleration (constant acceleration) is a straight line inclined to time axis. The above graph is for motion in positive direction as velocity is positive throughout the time interval and is also increasing, so the acceleration is positive. For positive acceleration, the slope of the graph must be positive.



51. (b) For object moving in positive direction, the velocity must be positive.
For negative acceleration,the velocity must be decreasing with time or the slope of the straight line must be negative.

52. (d) For negative direction, the velocity must be negative throughout the journey.



For negative acceleration,the velocity must be decreasing and hence the slope of the straight line representing the motion must be negative.

53. (c) For the graph shown, area under the v-t curve represents area of the rectangle of height μ and base T.
∵ Area under the v-t curve

= Displacement during t = 0 and t = T

$= \mu \times T = \mu T$

54. (a) As we know that, $\dfrac{V_A}{V_B} = \dfrac{\tan\theta_1}{\tan\theta_2}$

$\therefore \dfrac{V_A}{V_B} = \dfrac{\tan 30^0}{\tan 45^0} = \dfrac{1}{\sqrt{3} \times 1} = \dfrac{1}{\sqrt{3}}$

55. (c) In graph (c) for one value of displacement there are two different points of time. Hence, for one time, the average velocity is positive and for other time it is equally negative. As there are opposite velocities in the interval 0 to T. Hence average velocity can vanish.

56. (d) We are considering that the man will catch the bus after time t sec. Then, according to the second equation of motion

$10t = 48 + \dfrac{1}{2} \times 1 \times t^2$

$t^2 = 20t + 90 = 0 \qquad t^2 - 20t - 90 = 0$

$\Rightarrow (t - 12)(t - 8) = 0$

t = 8 sec. and t = 12 sec.

Minimum time will be considered.

57. (a) Effective acceleration is $g + a = 9.8 + 2.2 = 12\ m/s^2$

As we know, $s = ut + \dfrac{1}{2}a_{eff}t^2$, at the time of free fall

$u = 0$, then $t = \sqrt{\dfrac{2s}{g+a}} = \sqrt{\dfrac{2 \times 3.8}{12}} = \sqrt{\dfrac{3.8}{6}} = \sqrt{0.633}$

t = 0.132 sec

58. (a) Total length of distance that has to be crosses = 60 + 80 = 140 m
Relative speed = 10 + 25 = 35 m/s

$\text{Time} = \dfrac{140}{35} = \dfrac{20}{5} = 4\,\text{seconds}\ \left(\text{Time} = \dfrac{\text{Displacement}}{\text{Velocity}}\right)$

59. (a) Let the speed of each train be x
Relative velocities of trains are
Train 1, $V_r = x - u$ (wind is along the direction of track)
Train 2, $V_r = x + u$(Wind is in opposite direction)
According to the question

$\dfrac{x-u}{x+u} = \dfrac{1}{2} \Rightarrow 2x - 2u = x + u \Rightarrow x = 3u$

60. (b) Motion of first ball u = 0 , a = g , t = 3 sec.
We are consider that the s_1 is the distance covered by the first ball in 4 seconds.

$s_1 = ut + \dfrac{1}{2}gt^2 \qquad 0 + \dfrac{1}{2} \times 10 \times (4)^2 = 80\,m$

Let s_2 be the distance covered by the second ball in 2 seconds.

$$s_2 = 0 + \frac{1}{2} \times 10 \times (3)^2 = 45\,\text{m}$$

Separation between the two balls

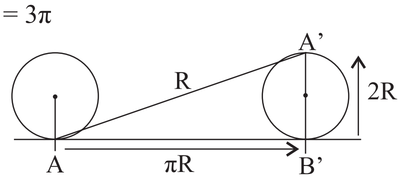
$S_1 - S_2 = 80$ m – 45 m = 35 m

Learning-Plus

1. (d) Displacement is the distance between the initial and final position of the body or object which may be equal or less than the total distance covered by the body. So the ratio of distance to displacement may be equal or more than one.

$$\frac{\text{Distance}}{\text{Displacement}} \geq 1$$

2. (d) Horizontal distance covered by the wheel in half revolution $= \pi R = 3\pi$



Net displacement of the point which was initially in contact with ground.

$$R = AA' = \sqrt{(\pi R)^2 + (2R)^2}$$

$$= \sqrt{(3\pi)^2 + (2 \times 3)^2} = \sqrt{9\pi^2 + 36} \quad = 3\sqrt{\pi^2 + 4}$$

3. (a) $\sqrt{x} = 3t + 5$

Squaring both side

$(\sqrt{x})^2 = (3t+5)^2 \qquad x = 9t^2 + 25 + 30t$

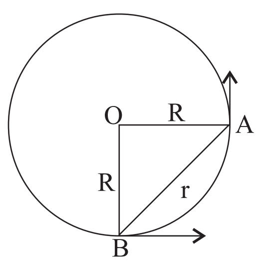
Differentiate both side

$\dfrac{dx}{dt} = \dfrac{d(9t^2 + 30t + 25)}{dt} \qquad V = 18t + 30$

Velocity will increase with time.

4. (c) Let R be the radius of the circle

Displacement of particle = r



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

$\text{Time} = \dfrac{\pi R}{2v}$ (v = velocity) $\qquad r = \sqrt{R^2 + R^2} = \sqrt{2}R$

$$\text{Average velocity} = \frac{\sqrt{2}R}{\frac{\pi R}{2v}} = \frac{2\sqrt{2}v}{\pi}$$

5. (d) Case I: Let the initial velocity of the bullet = u

After penetrating its final velocity $= \dfrac{u}{2}$

From $v^2 - u^2 = 2as \qquad \left(\dfrac{u}{2}\right)^2 - u^2 = 2 \times a \times 4$

$\dfrac{u^2}{4} - u^2 = 2 \times a \times 4 \qquad \dfrac{-3u^2}{4} = 8 \times a \Rightarrow a = \dfrac{-3u^2}{32}$

Bullet will further penetrate after penetrate 4 cm.

Case II:

Initial velocity $= \dfrac{u}{2}$ $\qquad$ Final velocity = 0

From $v^2 - u^2 = 2as \qquad 0^2 - \left(\dfrac{u}{2}\right)^2 = 2 \times \dfrac{-3u^2}{32} \times s$

$\dfrac{-u^2}{4} = \dfrac{-3u^2}{16} \times s \qquad \Rightarrow s = \dfrac{4}{3} = 1.33$ cm

6. (c) If t is the total time of flight of ball in going up and coming back, then total displacement in time t is zero because ball comes back in hand of juggler.

When ball is going at the highest point then V = 0

$V^2 - u^2 = 2as \qquad 0 - u^2 = 2 \times -g \times 40 \qquad -u^2 = -80 \times 10$

$u = \sqrt{800} \qquad u = 2\sqrt{2} \times 10 = 20\sqrt{2}$

Displacement of the ball is zero.

So, $S = ut + \dfrac{1}{2}(-g)t^2$

(g is negative because acts in opposite direction)

$0 = 20\sqrt{2}t - \dfrac{1}{2} \times 10t^2 \qquad 20\sqrt{2}t = 5t^2$

$\dfrac{20\sqrt{2}}{5} = t \qquad 4\sqrt{2} = t$

∴ Time interval of each ball

$\dfrac{4\sqrt{2}}{4} = \sqrt{2} = 1.414\,\text{sec}.$

7. (a) According to relation $= v^2 - u^2 = 2as$

$(100)^2 - (10)^2 = 2as$

$10000 - 100 = 2as \qquad 9900 = 2as$

Now acceleration just reversed = a = –a

Particle comes back to original position v = ?

$v^2 - u^2 = 2as \qquad (v)^2 - (100)^2 = 2(-a)s$

$v^2 = 10000 - 2as \qquad v^2 = 10000 - 2as$

Put 2as = 9900 $\qquad v^2 = 100 \Rightarrow v = \sqrt{100} = 10\,\text{m/s}$

8. (b) According to the relation $h = ut + \dfrac{1}{2}gt^2$

$h = \dfrac{1}{2}gt^2 \qquad (u = 0)$

$h \propto t^2 \qquad \therefore t \propto \sqrt{h} \qquad$ Hence, $\dfrac{t_a}{t_b} = \sqrt{\dfrac{a}{b}}$

9. (a) When stone is dropped $S = \dfrac{1}{2}gt^2 \qquad 180 = \dfrac{1}{2} \times 10 \times t^2$

t = 6 seconds

Second ball is taking 3 second to reach the river

$$180 = u \times 3 + \frac{1}{2} \times 10 \times 9 \Rightarrow 180 = u \times 3 + 5 \times 9$$

$$u = \frac{180 - 45}{3} = 45\,\text{m/s}$$

10. (a) As we know that $v^2 = u^2 - 2gs$ (for upward motion $g = -g$)

$V = 0$ at maximum height

$-u^2 = -2gs \qquad u^2 \propto s$

$$\frac{}{V} = \frac{}{3h} \Rightarrow V = \sqrt{3}V$$

11. (c) $v^2 = u^2 - 2gs \Rightarrow 0 = u^2 - 2gs$

$u^2 = 2gs \Rightarrow u^2 \propto S$

Motion under gravity is independent of mass

$$\frac{u^2}{16u^2} = \frac{50}{h} \qquad h = 16 \times 50 \Rightarrow h = 800\text{ m}$$

12. (a) Case I : Ascending

$u = u, \quad V = 0, \quad g = -g, \quad t = t_1$

$V = u + gt \qquad 0 = u - gt_1 \qquad u = gt_1$

$$t_1 = \frac{u}{g}$$

Case II : Descending

Similarly

$v = u\ ,\ u = 0\ ,\ g = g\ ,\ t = t_2$

$V = u + gt \qquad u = 0 + gt_2 \qquad t_2 = \frac{u}{g}$

Total time of journey

$$t_1 + t_2 = \frac{u}{g} + \frac{u}{g} \qquad t_1 + t_2 = \frac{2u}{g} \Rightarrow u = \frac{g(t_1 + t_2)}{2}$$

13. (d) $v = (150 - 10x)^{1/2} \Rightarrow \frac{dv}{dt} = \frac{d(150 - 10x)^{1/2}}{dt} \times \frac{dx}{dx}$

$$\frac{dv}{dt} = \frac{d(150 - 10x)^{1/2}}{dx} \times \frac{dx}{dt} \Rightarrow a = \frac{d(150 - 10x)^{1/2}}{dx} v$$

$$a = \frac{1}{2} \times (150 - 10x)^{-1/2} (-10) \times (150 - 10x)^{1/2} \Rightarrow a = -5\text{ m/s}^2$$

14. (d) I. The instantaneous speed is always positive as it is the magnitude of the velocity at an instant.

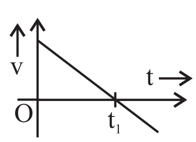
II. For t = 0s to t = 5s, the motion is uniform. So, the average velocity and the instantaneous velocity are equal.

III. During t = 0s to t = 5s. The slope of the graph is positive, hence the average velocity and the velocity both are positive. During t = 5s to t = 10s. The slope of the graph is negative, hence the velocity is negative.

Since, there is change in sign of velocity at t = 5s the car changes its direction at that instant.

IV. In figure, instantaneous speed during t = 5s to t = 10s is negative at all time instants during the interval.

15. (c) Here, we observe that the object is moving in positive direction till time $t = 0$ to $t = t_1$ and at $t = t_1$ we find that the velocity become negative i.e., the object changes its direction at $t = t_1$ and continues in negative direction hence forth. For acceleration we can observe that throughtout the journey the slope of the v-t curve is negative and hence, acceleration is negative. Thus, the area under the v-t curve gives displacement.



16. (a) Velocity = area under acceleration time graph

Velocity = (5 × 1) – (5 × 1) + (5 × 1)

Velocity = 5 – 5 + 5 = 5 m/s^2

17. (c) Relative velocity of 1st train w.r.t 2nd = 50 – 30 = 20 m/s

Total distance = 130 + 200 = 330

$$\text{Time taken} = \frac{330}{20} = 16.5\,\text{seconds}$$

18. (b) According to the given equation

First case: Separation between the trucks decreases at the rate of 10 m/s. Due to the opposite relative motion of trucks towards each other-

$V_1 + V_2 = 10$ (condition given)......(1)

Second case: Separation between the trucks increases due to the opposite relative motion of trucks away from each other-

$V_1 - V_2 = 5$......(2) (condition given)

From equation (1) and (2), we get

$V_1 + V_2 = 10$

$V_1 - V_2 = 5$

$2V_1 = 15$

$V_1 = 7.5$ m/s

By putting the value of V_1 in equation (1)

$7.5 + V_2 = 10 \qquad V_2 = 2.5$ m/s

19. (d) Let the velocity of the scooter is V_S

Distance between the bus and scooter is 1 km

Velocity of bus = 10 m/s

Relative velocity of scooter w.r.t the bus = $V_S - 10$

$$\text{Time taken to overtake, } t = \frac{1000}{V_S - 10}$$

$$50 = \frac{1000}{V_S - 10} \qquad 50\,V_S - 500 = 1000$$

$$50V_S = 1500 \quad \Rightarrow V_s = 30\text{ m/s}$$

20. (a) Relative velocity of combustion product of rocket w.r.t the motion of rocket

$$\overrightarrow{V_c} = +1200\,\text{m/s} \qquad \overrightarrow{V_r} = -200\,\text{m/s}$$

Velocity of vapours is V_V

$$\overrightarrow{V_c} = \overrightarrow{V_v} - \left(\overrightarrow{V_r}\right) \qquad 1200 = \overrightarrow{V_v} - (-200) \qquad \overrightarrow{V_v} = 1000\,\text{m/s}$$

21. (d) $P = mV, \quad K = \frac{1}{2}mV^2$

F = Mgh, All are mass dependent. So they would be different. But g = 9.8 m/s^2, which is constant on earth surface.

22. (d) Speed of child w.r.t. belt = 9 km/hr

Speed of belt = 4 km/hr

From ground frame

Speed = (9 + 4) = 13 km/hr

23. (b) $V_A = V_B$. Since, the motion is uniform. The velocity at each point is same so this velocity of A after coming back is also V_A, just the direction is reversed. Thus $V_A = V_B$.

24. (b) V_{Rel} = '0' as lines are parallel.

25. (d) Since u = 0 and we know that

$$a = \frac{\alpha\beta}{\alpha+\beta} \qquad \Rightarrow V = u + at = \left(\frac{\alpha\beta}{\alpha+\beta}\right)\times t$$

26. (a) Here, a = g – bv

When an object falls with constant speed v_c, its acceleration becomes zero.

$$\therefore\ g - bv_c = 0 \ \text{ or } \ v_c = \frac{g}{b}$$

27. (c) $v^2 = kr$ or $v = \sqrt{kr}$

$$\frac{dv}{dt} = \sqrt{k}\frac{1}{2}r^{-1/2}\frac{dr}{dt} = \sqrt{k}\frac{1}{2}r^{-1/2}.v$$

$$= \sqrt{k}\frac{1}{2}r^{-1/2}.\sqrt{k}r^{1/2} = \frac{k}{2}r^0$$

Velocity after 1 sec $= 0 + \frac{k}{2}r^0 \times 1 = \frac{k}{2}r^0$

28. (b,c,d) In this problem, we have to keep in mind the frame of the observer. Here we must be clear that we are considering the motion from the ground. Compared to velocity of trains (10 m/s) speed of ball is less (1 m/s). The speed of the ball before collision with side of train is 10 + 1 = 11 m/s.

Speed after collision with side of train = 10 –1 = 9 m/s.

As speed is changing after traveling 10 m and speed is 1 m/s hence, time duration of the changing speed is 10.

Since, the collision of the ball is perfectly elastic. There is no dissipation of energy hence, total momentum and kinetic energy are conserved.

Since, the train is moving with constant velocity hence, it will act as inertial frame of reference as that of Earth and acceleration will be same in both frames.

We should not confuse with non-inertial and inertial frame of reference. A frame of reference that is not accelerating will be inertial.

29. (a,d) Given, x = t – sin t

Velocity $v = \frac{dx}{dt} = \frac{d}{dt}[t - \sin t] - 1 - \cos t.$

As acceleration, a > 0 for all t > 0

Hence, x(t) > 0 for all t > 0

Velocity v = 1 – cos t

When, cos t = 1, velocity v = 0

V_{max} = 1 – (cos t)min = 1 – (– 1) = 2

V_{min} = 1 – (cos t)max = 1 –1 = 0

Hence, v lies between 0 and 2.

Acceleration $a = \frac{dx}{dt} = -\sin t$

When t = 0; x = 0, x = + 1, a = 0

When $t = \frac{\pi}{2}$; x = 1, v = 0, a = – 1

When t = π; x = 0, x = – 1, a = 1

When t = 2 π; x = 0: x = 0, a = 0

Multi-Concept Questions

1. (a) Point P is located on X-axis and to the right of origin 'O' at a distance of 360 m. Its position coordinate is P ≡ (+ 360, 0, 0). 'R' is located to the left of origin 'O' at a distance of 120 m, so its coordinate is R ≡ (– 120, 0, 0).

Distance from O to P = Path length OP = 360 m

path length from O to P and back to Q

= OP + PQ ⇒ 360 + 120 = 480 m

2. (b) Velocity when ball strikes the ground $V = \sqrt{2gh_1}$

$$V = \sqrt{2\times10\times10} = \sqrt{200}$$

Velocity of ball after rebound $V = \sqrt{2gh_2}$

$$V = \sqrt{2\times10\times2.5} = \sqrt{50}$$

Change in velocity / time

$$= \frac{\sqrt{50} - \left(-\sqrt{200}\right)}{0.01} = \frac{7.07 + 14.114}{0.01} = 2121.2\,\text{m/s}^2$$

3. (c) $S = u - \frac{a}{2}(2n-1)$ $\qquad 3 = 50 - \frac{10}{2}(2n-1)$

$3 = 50 - \left(\frac{20n}{2} - 5\right)$ $\qquad \Rightarrow 3 = 50 - 10n + 5$

$\Rightarrow 10n = 52$ $\qquad \Rightarrow n = 5.2$

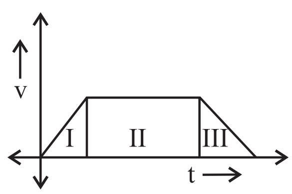
$S = 200 - \frac{10}{2}(2\times5.2 - 1) \Rightarrow 200 - 47 = 153$

4. (a) u = –30 m/s , t = 8 seconds

$h = ut + \frac{1}{2}gt^2$ $\qquad h = -30\times8 + \frac{1}{2}\times10\times64$

$= -240 + 64\times5$ $\qquad \Rightarrow h = 80$ m

5. (c)



For I → $S = ut + \frac{1}{2}at_1^2$ $\qquad$ u = O

$\therefore S = \frac{1}{2}at_1^2$ $\qquad \therefore V_0 = \sqrt{2Sf}$ [2aS = $V^2 - u^2$],

During II S_2 = 2 S

For II

$$15\,S - 3S \Rightarrow 12\,S = V_0\,t \Rightarrow S = \frac{V_0 t}{12} \Rightarrow S = \frac{\sqrt{2Sf}\,t}{12}$$

$$\Rightarrow S^2 = \frac{2Sft^2}{144} \Rightarrow S = \frac{f\,t^2}{72}$$

6. (d) $f = f_0 - \frac{f_0 t}{T}$

For $t = 0 \Rightarrow f = f_0$ $\quad S = \frac{1}{2} f_0 t^2 \quad V = \frac{S}{t} = \frac{1}{2} f_0 t$

7. (c) For walking $\quad$ For standing

$S = V_1\,t_1 \quad S = V_2\,t_2$

$\therefore V_1 = \frac{S}{t_1} \quad V_2 = \frac{S}{t_2}$

If she would walk on moving escalator.

$$S = (V_1 + V_2)T' \quad S = \left(\frac{1}{t_1} + \frac{1}{t_2}\right)ST' \quad \frac{1}{T'} = \frac{1}{t_1} + \frac{1}{t_2}$$

T′ – time taken by girl to reach on top on moving escalator while walking on it.

$$T' = \frac{t_1 t_2}{t_1 + t_2}$$

8. (a) Total time taken by bird $\Rightarrow t = \frac{D}{V} = \frac{36}{(27+18)} = \frac{36}{45} hr$

Distance travelled by bird

$S = V\,t \quad S = 36 \times \frac{36}{45} = \frac{1296}{45} = 28.8\ km$

9. (a) Distance traveled by stone in n time

$u = O \quad t = n \quad \therefore S = \frac{1}{2} gn^2$

Equating the distance traveled by both stones when one stone is overtaking the other.

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

$$t(u - gn) = \frac{1}{2}gn^2 \qquad t = \frac{1/2gn^2}{u - gn} \ldots(i)$$

t – time at which second stone is thrown down

$\therefore$ Distance traveled $S = ut + ½\,gt^2$ by second stone

$$S = t\left[u + \frac{1}{g}t\right] \qquad S = \frac{1}{2}gn^2 + gnt + 1/2gt^2$$

$$= \frac{g}{2}\left[n^2 + 2nt + t^2\right] = \frac{g}{2}[n+t]^2 \qquad = \frac{g}{2}\left[n + \frac{1/2gn^2}{u - gn}\right]^2$$

$$= \frac{g}{2}\left[\frac{nu - gn^2 + \frac{gn^2}{2}}{4 - gn}\right]^2$$

$$S = \frac{g}{2}\left[\frac{nu - \frac{gn^2}{2}}{(u - gn)}\right]^2 = \frac{g}{2}\left[\frac{n\left(u - g\frac{n}{2}\right)}{(u - gn)}\right]^2$$

10. (c) Distance traveled in T/3 seconds

$$S = \frac{1}{2} \times g \times \left(\frac{T}{3}\right)^2, S = \frac{T^2}{9 \times 2} g$$

Now $T = \sqrt{\frac{2h}{g}}$ $\qquad S = \frac{1}{18} \times \frac{2h}{g} \times g = \frac{h}{9}$

Distance from ground $= h - \frac{h}{9} = \frac{8h}{9}$

11. (a) Let the time taken for one third distance be t_1, then $t_1 = \frac{d}{3V_0}$, where d is the total length of the journey. Let the time taken for next 2d/3 distance be t_2, $\frac{2d}{3} = \frac{V_1 t_2}{2} + \frac{V_2 t_2}{2} = \frac{(V_1 + V_2)t_2}{2}$

$t_2 = \frac{4d}{3(V_1 + V_2)}$. Thus, the total time taken for the journey is $\frac{d}{3V_0} + \frac{4d}{3(V_1 + V_2)} = \frac{d(V_1 + V_2 + 12V_0)}{3V_0(V_1 + V_2)}$

Thus the average velocity $= \frac{\text{Total distance}}{\text{Total time}}$

$$V = \frac{d}{\frac{d(V_1 + V_2 + 12V_0)}{3V_0(V_1 + V_2)}} = \frac{3V_0(V_1 + V_2)}{(V_1 + V_2 + 12V_0)}$$

12. (c) Just to avoid collision, the speed of bike A should be equal or lesser than B, i.e., $u_A \le u_B$.

Now initial relative velocity of bike A with respect to B $= u_A - u_B$

And final relative velocity of A with respect to B ≤ zero.

Also the relative acceleration of A

w.r.t. B = – a – 0 $\quad$ = – a

Then, using $u^2 + 2as = v^2$ $\qquad (u_A - u_B)^2 - 2\alpha\,s \le 0$

or $\quad (u_A - u_B)^2 \le 2\alpha\,s \quad$ or $s \ge \frac{(u_A - u_B)^2}{2\alpha}$

13. (b) At t = 0 the first body starts moving with constant acceleration while the second body is already moving with certain constant speed. So the distance covered by the first body x_1 is smaller that covered by the second body x_2 i.e., $x_1 < x_2$ or $x_1 - x_2$ = negative till the first body attains the speed equal to that of second body. At that instant $x_1 = x_2$ or $x_1 - x_2 = 0$ and after that $x_1 > x_2$ i.e. $x_1 - x_2$ = positive and goes on increasing with increasing t.

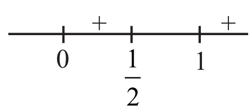
14. (b) $\vec{a}.\vec{v} < 0$ (condition of retardation)

$a = 2t - 1; \qquad v = t^2 - t$

$av < 0$

$(2t - 1)\ (t^2 - t) \quad < 0$

$(2t - 1)\ t\,(t - 1) \quad < 0$



$\frac{1}{2} < t < 1$

15. (d) Let u be initial velocity and a be the uniform acceleration

Average velocities in the intervals from-
0 to t_1 , t_1 to t_2 , t_2 to t_3 are

$$V_1 = \frac{u + u + at_1}{2} = u + \frac{at_1}{2} \;......(1)$$

$$V_2 = \frac{u + at_1 + u + a(t_1 + t_2)}{2} = u + at_1 + \frac{a}{2}t_2 \;......(2)$$

$$V_3 = \frac{u + a(t_1 + t_2 + t_3) + u + a(t_1 + t_2)}{2}$$

$$V_3 = u + at_1 + at_2 + \frac{a}{2}t_3 \;.....(3)$$

Subtracting (1) from (2), we get

$$V_2 - V_1 = u + at_1 + \frac{a}{2}t_2 - \left(u + \frac{a}{2}t_1\right)$$

$$= u + at_1 + \frac{a}{2}t_2 - u - \frac{a}{2}t_1$$

$$V_2 - V_1 = \frac{a}{2}t_1 + \frac{a}{2}t_2 \Rightarrow \frac{a}{2}(t_1 + t_2) \;......(4)$$

Similarly (2) from (3), we get

$$(V_3 - V_2) = \frac{a}{2}t_2 + \frac{a}{2}t_3 \Rightarrow \frac{a}{2}(t_2 + t_3) \;......(5)$$

Divide (4) by (5) we get

$$\frac{V_2 - V_1}{V_3 - V_2} = \frac{\frac{a}{2}(t_1 + t_2)}{\frac{a}{2}(t_2 + t_3)} = \frac{(t_1 + t_2)}{(t_2 + t_3)}$$

16. (a) Given relation is $t = \alpha x^2 + \beta x$

Differentiating w.r.t x

$$\frac{dt}{dx} = \frac{d(\alpha x^2 + \beta x)}{dx}$$

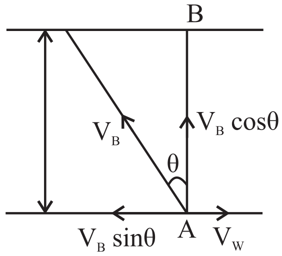
$$\frac{1}{v} = 2\alpha x + \beta \Rightarrow v = \frac{1}{2\alpha x + \beta}$$

Acceleration is $a = \frac{dv}{dt}$ (multiplying and divide by dx)

$$a = \frac{dv}{dt} \times \frac{dx}{dx} \Rightarrow \frac{dv}{dx} \cdot \frac{dx}{dt}$$

$$a = v.\frac{dv}{dx} \Rightarrow a = \frac{-v.2\alpha}{(2\alpha x + \beta)^2} = -2\alpha.v.v^2 \Rightarrow a = -2\alpha v^3$$

17. (d) $\sin\theta = \frac{V_W}{V_B}(V_B \sin\theta = V_W)$



$$\sin\theta = 0.707 = \frac{1}{\sqrt{2}} = \sin 45^0$$

Time taken to cross the river $t = \frac{D}{V_B \cos\theta}$

$$t = \frac{D}{V_B \cos 45^0} \Rightarrow t = \frac{D}{V_B \times \frac{1}{\sqrt{2}}} \Rightarrow t = \frac{\sqrt{2}D}{V_B}$$

18. (a) According to the equation

$$h = ut + \frac{1}{2}gt^2 \qquad h = \frac{1}{2}gt^2 \;......(1)$$

$$(h - 20) = 0 + \frac{1}{2}g(t-1)^2 \qquad (h - 20) = \frac{1}{2}g(t-1)^2 \;.......(2)$$

u = 0 in both case because stone s dropped from rest.

From the equation (1) and (2) we get

$$h = \frac{1}{2}gt^2 \qquad (h - 20) = \frac{1}{2}g(t-1)^2$$

$$h - (h - 20) = \frac{1}{2}gt^2 - \frac{1}{2}g(t-1)^2$$

$$h - h + 20 = \frac{1}{2}gt^2 - \frac{1}{2}gt^2 - \frac{1}{2}g + gt \qquad \Rightarrow 20 = gt - \frac{g}{2}$$

$\Rightarrow gt = 25 \quad (\because g = 10\ m/s^2) \quad \Rightarrow t = 2.5$ second

$$h = \frac{1}{2} \times 10 \times (2.5)^2$$

$$= 31.25\,m$$

19. (c) Average Acceleration $= \frac{\vec{v}_2 - \vec{v}_1}{\Delta t} = \frac{\text{Change in velocity}}{\text{Change in time}}$

When ball falls from height h_1 we get,

$$v_1^2 = u_1^2 + 2gh_1$$

$v_1 = \sqrt{2gh_1}$ ......(1) (u = 0 under free fall)

Similarly, when ball falls from height h_2 after striking the floor

But g = –g because after striking ball goes upward against the gravity.

$$v_2^2 = u_2^2 + 2(-g)h_2$$

(After contact $v_2 = 0$ at rest highest point, $u_2 = v_2$)

$$0 = v_2^2 - 2gh_2 \qquad v_2 = 2gh \Rightarrow v_2 = \sqrt{2gh_2} \;.....(2)$$

Average acceleration $= \frac{v_2 - v_1}{\Delta t}$

$= \frac{v_2 + v_1}{\Delta t}$ (v_1 = –ve)

Average acceleration $= \frac{\sqrt{2gh_2} + \sqrt{2gh_1}}{\Delta t}$

$$= \frac{\sqrt{2 \times 10 \times 2} + \sqrt{2 \times 10 \times 1.5}}{0.020}$$

$$\text{Average acceleration} = \frac{\sqrt{40}+\sqrt{30}}{0.020} = \frac{6.32+5.47}{0.020}$$

$$\text{Average acceleration} = \frac{11.79\times100}{2} = \frac{1179}{2}$$

$a_{av} = 589.5\ m/s^2$

20. (b) Given condition is $x = 20 + 14t - t^3$

Differentiating both side

$$\frac{dx}{dt} = \frac{d(20+14t-t^3)}{dt}$$

$V = 0 + 14 - 3t^2 \Rightarrow 0 = 0 + 14 - 3t^2$ (body comes to rest)

$-14 = -3t^2$

$$\left(\frac{14}{3}\right)^{1/2} = t \Rightarrow t = (4.66)^{1/2} \approx (5)^{1/2}$$

NEET Past 10 Year Questions

1. (b) ***NCERT (XI) Ch - 3, Pg. 43***

Between t = 0 to t = 1 s

$v = u + at \Rightarrow 6 = 0 + a \times 1$

$a = 6\ m/s^2$

$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}}$$

$$= \frac{3X}{3} = X\ m/s$$

$$\text{where } X = 0 + \frac{1}{2}\times6\times(1)^2 = 3m$$

$\therefore$ Average speed = 3m/s

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

$$= \frac{X}{3} = \frac{3}{3} = 1\ m/s$$

2. (b) ***NCERT (XI) Ch - 3, Pg. 42***

V_1 = Preeti's velocity

V_2 = Escalator's velocity

$$t = \frac{\text{distance}}{\text{speed}} \Rightarrow t = \frac{\ell}{V_1+V_2}$$

$$= \frac{\ell}{\frac{\ell}{t_1}+\frac{\ell}{t_2}} = \frac{t_1t_2}{t_2+t}$$

3. (b) ***NCERT (XI) Ch - 3, Pg. 43***

$x = 5t - 2t^2$ $\qquad$ $y = 10t$

$v = \frac{dx}{dt} = 5 - 4t$ $\qquad$ $v = \frac{dy}{dt} = 10$

$a_x = \frac{dv}{dt} = -4\ ms^{-2}$ $\qquad$ $a_y = 0$

$a = -4m/s^2$

4. (b) ***NCERT (XI) Ch - 3, Pg. 42***

$X_p(t) = at + bt^2$ $\qquad$ $X_Q(t) = ft - t^2$

$V_p = a + 2bt$ $\qquad$ $V_Q = f - 2t$

as $V_p = V_Q$

$a + 2bt = f - 2t$

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

5. (c) ***NCERT (XI) Ch - 3, Pg. 47***

$v = At + Bt^2$

$$\frac{dx}{dt} = At + Bt^2$$

$$\int_0^x dx = \int_1^2 (At+Bt^2)dt$$

$$x = \frac{A}{2}(2^2-1^2) + \frac{B}{3}(2^3-1^3) = \frac{3A}{2} + \frac{7B}{3}$$

6. (a) ***NCERT (XI) Ch - 3, Pg. 45***

$v = \beta x^{-2n}$

So, $\frac{dv}{dx} = -2n\beta x^{-2n-1}$

Now $a = v\frac{dv}{dx} = (\beta x^{-2n})(-2n\beta x^{-2n-1})$

$\Rightarrow a = -2n\beta^2 x^{-4n-1}$

7. (c) ***NCERT (XI) Ch - 3, Pg. 47-48***

$AB = h_1 = \frac{1}{2}g(5)^2 \Rightarrow h_1 = 125\ m \quad (\because \mu = 0)$

$h_2 = BC = \frac{1}{2}g\,[10^2 - 5^2] \Rightarrow h_2 = 375\ m$

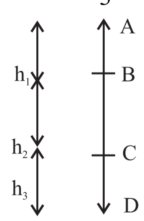
$h_3 = CD = \frac{1}{2}g\,[15^2 - 10^2]$

$h_3 = 625\ m$

$h_1 : h_2 : h_3$

$125 : 375 : 625 = 1 : 3 : 5$

$$\Rightarrow h_1 = \frac{h_2}{3} = \frac{h_3}{5}$$



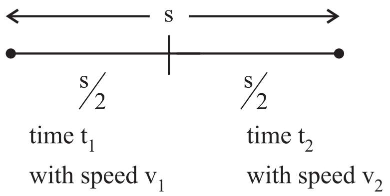
8. (d) ***NCERT (XI) Ch - 3, Pg. 45***

$$v = \frac{dx}{dt} = 0 + 12 - 3t^2 = 0 \quad \Rightarrow t = 2s$$

At t = 2 s

Retardation $= -\frac{dv}{dt} = -(-6t) = 12\ ms^{-2}$

9. (b) ***NCERT (XI) Ch - 3, Pg. 42***



Av. Speed $= \frac{\text{Total distance}}{\text{Total time taken}}$

$$= \frac{s}{t_1 + t_2} = \frac{s}{\frac{s}{2v_1} + \frac{s}{2v_2}} = \frac{2v_1v_2}{v_1 + v_2}$$

$$\left(\because t_1 = \frac{s}{2v_1} \Rightarrow t_2 = \frac{s}{2v_2}\right)$$

10. (b) ***NCERT (XI) Ch - 3, Pg. 48***

u = 0

$v^2 - u^2 = 2gh \Rightarrow v^2 - 0 = 2gh$

$v = \sqrt{2gh} \Rightarrow v = 20$ m/s