Answers and Solutions

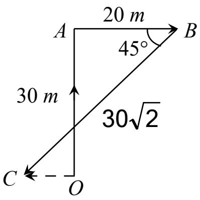
Distance and Displacement

1. (a) $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$ $\therefore r = \sqrt{x^2 + y^2 + z^2}$

$r = \sqrt{6^2 + 8^2 + 10^2} = 10\sqrt{2}\ m$

2. (a) $\vec{r} = 20\hat{i} + 10\hat{j}$ $\therefore r = \sqrt{20^2 + 10^2} = 22.5\ m$

3. (c) From figure, $\overrightarrow{OA} = 0\hat{i} + 30\hat{j}$, $\overrightarrow{AB} = 20\hat{i} + 0\hat{j}$



$\overrightarrow{BC} = -30\sqrt{2}\cos 45^o\hat{i} - 30\sqrt{2}\sin 45^o\hat{j} = -30\hat{i} - 30\hat{j}$

$\therefore$ Net displacement, $\overrightarrow{OC} = \overrightarrow{OA} + \overrightarrow{AB} + \overrightarrow{BC}$

$= -10\hat{i} + 0\hat{j}$

$|\overrightarrow{OC}| = 10\ m.$

4. (a) An aeroplane flies 400 *m* north and 300 *m* south so the net displacement is 100 *m* towards north.

Then it flies 1200 *m* upward so

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

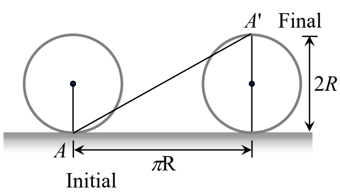
$= 1204\ m \simeq 1200\ m$

The option should be 1204 *m*, because this value mislead one into thinking that net displacement is in upward direction only.

5. (b) Total time of motion is 2 *min* 20 *sec* = 140 *sec*.

As time period of circular motion is 40 *sec* so in 140 *sec*. athlete will complete 3.5 revolution *i.e.,* He will be at diametrically opposite point *i.e.,* Displacement = 2*R*.

6. (c) Horizontal distance covered by the wheel in half revolution = πR.



So the displacement of the point which was initially in contact with ground = *AA'* = $\sqrt{(\pi R)^2 + (2R)^2}$

$= R\sqrt{\pi^2 + 4} = \sqrt{\pi^2 + 4}$ $(As\ R = 1m)$

Uniform Motion

1. (d) As the total distance is divided into two equal parts therefore distance averaged speed $= \frac{2v_1v_2}{v_1 + v_2}$

2. (d) $\frac{v_A}{v_B} = \frac{\tan\theta_A}{\tan\theta_B} = \frac{\tan 30°}{\tan 60°} = \frac{1/\sqrt{3}}{\sqrt{3}} = \frac{1}{3}$

3. (b) Distance average speed $= \frac{2v_1v_2}{v_1 + v_2} = \frac{2 \times 20 \times 30}{20 + 30}$

$= \frac{120}{5} = 24\ km/hr$

4. (b) Distance average speed $= \frac{2v_1v_2}{v_1 + v_2} = \frac{2 \times 2.5 \times 4}{2.5 + 4}$

$= \frac{200}{65} = \frac{40}{13}\ km/hr$

5. (c) Distance average speed $= \frac{2v_1v_2}{v_1 + v_2} = \frac{2 \times 30 \times 50}{30 + 50}$

$= \frac{75}{2} = 37.5\ km/hr$

6. (d) Average speed $= \frac{\text{Total distance}}{\text{Total time}} = \frac{x}{t_1 + t_2}$

$= \frac{x}{\frac{x/3}{v_1} + \frac{2x/3}{v_2}} = \frac{1}{\frac{1}{3 \times 20} + \frac{2}{3 \times 60}} = 36\ km/hr$

7. (a) Time average speed $= \frac{v_1 + v_2}{2} = \frac{80 + 40}{2} =$ $60\ km/hr$.

8. (b) Distance travelled by train in first 1 *hour* is 60 *km* and distance in next 1/2 *hour* is 20 *km*.

So Average speed $= \frac{\text{Total distance}}{\text{Total time}} = \frac{60 + 20}{3/2}$

$= 53.33\ km/hour$

9. (d)

10. (c) Total distance to be covered for crossing the bridge

= length of train + length of bridge

$= 150m + 850m = 1000m$

$\text{Time} = \frac{\text{Distance}}{\text{Velocity}} = \frac{1000}{45 \times \frac{5}{18}} = 80\ sec$

11. (c) Displacement of the particle will be zero because it comes back to its starting point

$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}} = \frac{30m}{10\ sec} = 3\ m/s$

12. (d) Velocity of particle $= \frac{\text{Total diplacement}}{\text{Total time}}$

$= \frac{\text{Diameter of circle}}{5} = \frac{2 \times 10}{5} = 4\ m/s$

13. (d) A man walks from his home to market with a speed of $5\ km/h$. Distance $= 2.5\ km$ and time $= \frac{d}{v} = \frac{2.5}{5} = \frac{1}{2} hr$.

and he returns back with speed of $7.5\ km/h$ in rest of time of 10 *minutes*.

Distance $= 7.5 \times \frac{10}{60} = 1.25\ km$

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

$= \frac{(2.5 + 1.25)km}{(40/60)hr} = \frac{45}{8} km/hr$.

14. (b) $\frac{|\text{Average velocity}|}{|\text{Average speed}|} = \frac{|\text{displacement}|}{|\text{distance}|} \le 1$

because displacement will either be equal or less than distance. It can never be greater than distance.

15. (b)

16. (d) Average speed $= \frac{\text{Total distance travelled}}{\text{Total time taken}}$

$= \frac{x}{\frac{2x/5}{v_1} + \frac{3x/5}{v_2}} = \frac{5v_1v_2}{3v_1 + 2v_2}$

17. (c) From given figure, it is clear that the net displacement is zero. So average velocity will be zero.

18. (c) Since displacement is always less than or equal to distance, but never greater than distance. Hence numerical ratio of displacement to the distance covered is always equal to or less than one.

19. (d) Length of train = 100 *m*

Velocity of train $= 45\ km/hr = 45 \times \frac{5}{18} = 12.5\ m/s$

Length of bridge = 1 *km* = 1000 *m*

$\therefore$ Total length covered by train = 1100 *m*

Time taken by train to cross the bridge $= \frac{1100}{12.5} = 88\ sec$

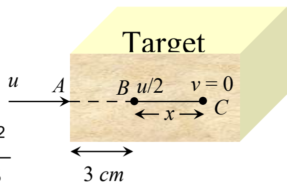
20. (b) Time average velocity $= \frac{v_1 + v_2 + v_3}{3}$

$= \frac{3 + 4 + 5}{3} = 4\ m/s$

21. (a) When the body is projected vertically upward then at the highest point its velocity is zero but acceleration is not equal to zero $(g = 9.8 m/s^2)$.

22. (b) Let initial velocity of the bullet = *u*

After penetrating 3 *cm* its velocity becomes $\frac{u}{2}$



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

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

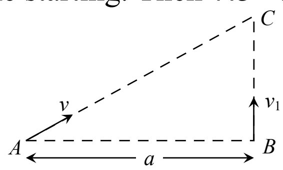
$\Rightarrow 6a = \frac{3u^2}{4} \Rightarrow a = \frac{u^2}{8}$

Let further it will penetrate through distance *x* and stops at point *C*.

For distance *BC*, $v = 0, u = u/2, s = x, a = u^2/8$

From $v^2 = u^2 - 2as \Rightarrow 0 = \left(\frac{u}{2}\right)^2 - 2\left(\frac{u^2}{8}\right).x \Rightarrow x = 1$ *cm*.

23. (b) Let two boys meet at point *C* after time '*t*' from the starting. Then $AC = vt$, $BC = v_1t$



$(AC)^2 = (AB)^2 + (BC)^2 \Rightarrow v^2t^2 = a^2 + v_1^2t^2$

By solving we get $t = \sqrt{\frac{a^2}{v^2 - v_1^2}}$

24. (c) $v_{av} = \frac{2v_1v_2}{v_1 + v_2} = \frac{2 \times 40 \times 60}{100} = 48 kmph$

Non-uniform Motion

1. (b) As $S = ut + \frac{1}{2}at^2 \therefore S_1 = \frac{1}{2}a(10)^2 = 50a$ .....(i)

As $v = u + at \therefore$ velocity acquired by particle in 10 *sec* $v = a \times 10$

For next 10 *sec* , $S_2 = (10a) \times 10 + \frac{1}{2}(a) \times (10)^2$

$S_2 = 150a$

.....(ii)

From (i) and (ii) $S_1 = S_2/3$

2. (c) Acceleration $= \frac{d^2x}{dt^2} = 2a_2$

3. (d) Velocity along *X*-axis $v_x = \frac{dx}{dt} = 2at$

Velocity along *Y*-axis $v_y = \frac{dy}{dt} = 2bt$

Magnitude of velocity of the particle,

$v = \sqrt{v_x^2 + v_y^2} = 2t\sqrt{a^2 + b^2}$

4. (a) $S = \int_0^3 v\,dt = \int_0^3 kt\,dt = \left[\frac{1}{2}kt^2\right]_0^3 = \frac{1}{2} \times 2 \times 9 = 9m$

5. (a) $S = kt^3 \therefore a = \frac{d^2S}{dt^2} = 6kt$ *i.e.* $a \propto t$

6. (a,c)

7. (a) From $S = ut + \frac{1}{2}at^2$

$S_1 = \frac{1}{2}a(P-1)^2$ and $S_2 = \frac{1}{2}aP^2$ $[As\, u = 0]$

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

$S_{(P^2-P+1)^{th}} = \frac{a}{2}\left[2(P^2 - P + 1) - 1\right] = \frac{a}{2}\left[2P^2 - 2P + 1\right]$

It is clear that $S_{(P^2-P+1)^{th}} = S_1 + S_2$

8. (d) $\vec{a} = \frac{\vec{F}}{m}$. If $\vec{F} = 0$ then $\vec{a} = 0$.

9. (b) $v = 4t^3 - 2t$ (given) $\therefore a = \frac{dv}{dt} = 12t^2 - 2$

and $x = \int_0^t v\,dt = \int_0^t (4t^3 - 2t)\,dt = t^4 - t^2$

When particle is at 2*m* from the origin $t^4 - t^2 = 2$

$\Rightarrow t^4 - t^2 - 2 = 0$ $(t^2 - 2)(t^2 + 1) = 0 \Rightarrow t = \sqrt{2}$ sec

Acceleration at $t = \sqrt{2}$ sec given by,

$a = 12t^2 - 2 = 12 \times 2 - 2 = 22\, m/s^2$

10. (a) $\frac{dt}{dx} = 2\alpha x + \beta \Rightarrow v = \frac{1}{2\alpha x + \beta}$

$\because a = \frac{dv}{dt} = \frac{dv}{dx}.\frac{dx}{dt}$

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

$\therefore$ Retardation $= 2\alpha v^3$

11. (b) Let u_1, u_2, u_3 and u_4 be velocities at time $t = 0, t_1, (t_1 + t_2)$ and $(t_1 + t_2 + t_3)$ respectively and acceleration is a then $v_1 = \frac{u_1 + u_2}{2}, v_2 = \frac{u_2 + u_3}{2}$ and $v_3 = \frac{u_3 + u_4}{2}$

Also $u_2 = u_1 + at_1$, $u_3 = u_1 + a(t_1 + t_2)$

and $u_4 = u_1 + a(t_1 + t_2 + t_3)$

By solving, we get $\frac{v_1 - v_2}{v_2 - v_3} = \frac{(t_1 + t_2)}{(t_2 + t_3)}$

12. (c) Acceleration $a = \tan\theta$, where θ is the angle of tangent drawn on the graph with the time axis.

13. (b) If acceleration is variable (depends on time) then

$v = u + \int (f)\,dt = u + \int (a\,t)\,dt = u + \frac{a\,t^2}{2}$

14. (a) $S_n = u - \frac{a}{2}(2n-1) = 10 - \frac{2}{2}(2 \times 5 - 1) = 1$ *meter*

15. (b) From $v^2 = u^2 + 2aS \Rightarrow 0 = u^2 + 2aS$

$\Rightarrow a = \frac{-u^2}{2S} = \frac{-(20)^2}{2 \times 10} = -20 m/s^2$

16. (d) $v = u + at = 10 + 2 \times 4 = 18\, m/\text{sec}$

17. (c) If particle starts from rest and moves with constant acceleration then in successive equal interval of time the ratio of distance covered by it will be

$1:3:5:7$ .....$(2n-1)$

i.e. ratio of *x* and *y* will be $1:3$ *i.e.* $\frac{x}{y} = \frac{1}{3} \Rightarrow y = 3x$

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

$S_{5^{th}} = 7 + \frac{4}{2}[2 \times 5 - 1] = 7 + 18 = 25m.$

19. (c) Acceleration $a = \frac{dv}{dt} = 0.1 \times 2t = 0.2t$

Which is time dependent *i.e.* non-uniform acceleration.

20. (b) Constant velocity means constant speed as well as same direction throughout.

21. (a) Distance travelled in 4 *sec*

$24 = 4u + \frac{1}{2}a \times 16$ …(i)

Distance travelled in total 8 *sec*

$88 = 8u + \frac{1}{2}a \times 64$ …(ii)

After solving (i) and (ii), we get $u = 1$ *m/s.*

22. (c) $v_x = \frac{dx}{dt} = \frac{d}{dt}(3t^2 - 6t) = 6t - 6$. At $t = 1, v_x = 0$

$v_y = \frac{dy}{dt} = \frac{d}{dt}(t^2 - 2t) = 2t - 2$. At $t = 1, v_y = 0$

Hence $v = \sqrt{v_x^2 + v_y^2} = 0$

23. (a) Distance travelled in n^{th} second $= u + \frac{a}{2}(2n - 1)$

Distance travelled in 5^{th} second $= 0 + \frac{8}{2}(2 \times 5 - 1) = 36m$

24. (d) $v^2 = u^2 + 2as \Rightarrow (9000)^2 - (1000)^2 = 2 \times a \times 4$

$\Rightarrow a = 10^7 \, m/s^2$ Now $t = \frac{v - u}{a}$

$\Rightarrow t = \frac{9000 - 1000}{10^7} = 8 \times 10^{-4}$ sec

25. (c) Initial relative velocity $= v_1 - v_2$, Final relative velocity $= 0$

From $v^2 = u^2 - 2as \Rightarrow 0 = (v_1 - v_2)^2 - 2 \times a \times s$

$\Rightarrow s = \frac{(v_1 - v_2)^2}{2a}$

If the distance between two cars is 's' then collision will take place. To avoid collision

$d > s \therefore d > \frac{(v_1 - v_2)^2}{2a}$

where $d =$ actual initial distance between two cars.

26. (b) $v = u + at \Rightarrow -2 = 10 + a \times 4 \Rightarrow a = -3 m/sec^2$

27. (c) $S_x = u_x t + \frac{1}{2} a_x t^2 \Rightarrow S_x = \frac{1}{2} \times 6 \times 16 = 48 \, m$

$S_y = u_y t + \frac{1}{2} a_y t^2 \Rightarrow S_y = \frac{1}{2} \times 8 \times 16 = 64 \, m$

$S = \sqrt{S_x^2 + S_y^2} = 80m$

28. (d) $S \propto u^2$. If u becomes 3 times then S will become 9 times *i.e.* $9 \times 20 = 180m$

29. (c) $y = a + bt + ct^2 - dt^4$

$\therefore v = \frac{dy}{dt} = b + 2ct - 4dt^3$ and $a = \frac{dv}{dt} = 2c - 12dt^2$

Hence, at $t = 0$, $v_{\text{initial}} = b$ and $a_{\text{initial}} = 2c$.

30. (a) $S \propto u^2 \therefore \frac{S_1}{S_2} = \left(\frac{u_1}{u_2}\right)^2 \Rightarrow \frac{2}{S_2} = \frac{1}{4} \Rightarrow S_2 = 8 \, m$

31. (c) $t = \sqrt{\frac{2h}{(g + a)}} = \sqrt{\frac{2 \times 2.7}{(9.8 + 1.2)}} = \sqrt{\frac{5.4}{11}} = \sqrt{0.49} = 0.7 \sec$

As $u = 0$ and lift is moving upward with acceleration

32. (a) Displacement $x = 2t^2 + t + 5$

Velocity $= \frac{dx}{dt} = 4t + 1$

Acceleration $= \frac{d^2x}{dt^2} = 4$ *i.e.* independent of time

Hence acceleration $= 4 \, m/s^2$

33. (d) Both trains will travel a distance of 1 *km* before to come in rest. In this case by using $v^2 = u^2 + 2as$

$\Rightarrow 0 = (40)^2 + 2a \times 1000 \Rightarrow a = -0.8 \, m/s^2$

34. (a) $v = u + at \Rightarrow v = 0 + 5 \times 10 = 50 \, m/s$

35. (b) Let 'a' *be* the retardation of boggy then distance covered by it be S. If u is the initial velocity of boggy after detaching from train (*i.e.* uniform speed of train)

$v^2 = u^2 + 2as \Rightarrow 0 = u^2 - 2as \Rightarrow s_b = \frac{u^2}{2a}$

Time taken by boggy to stop

$v = u + at \Rightarrow 0 = u - at \Rightarrow t = \frac{u}{a}$

In this time t distance travelled by train $= s_t = ut = \frac{u^2}{a}$

Hence ratio $\frac{s_b}{s_t} = \frac{1}{2}$

36. (a) $S_n = u + \frac{a}{2}(2n - 1) = \frac{a}{2}(2n - 1)$ because $u = 0$

Hence $\frac{S_4}{S_3} = \frac{7}{5}$

37. (b) $v = u + \int a dt = u + \int (3t^2 + 2t + 2) dt$

$= u + \frac{3t^3}{3} + \frac{2t^2}{2} + 2t = u + t^3 + t^2 + 2t$

$= 2 + 8 + 4 + 4 = 18 \, m/s$ (As $t = 2$ *sec*)

38. (d) $v = \frac{ds}{dt} = 3t^2 - 12t + 3$ and $a = \frac{dv}{dt} = 6t - 12$

For $a = 0$, we have $t = 2$ and at $t = 2, v = -9 \, ms^{-1}$

39. (d)

40. (b) $a = \sqrt{a_x^2 + a_y^2} = \left[\left(\frac{d^2x}{dt^2}\right)^2 + \left(\frac{d^2y}{dt^2}\right)^2\right]^{\frac{1}{2}}$

Here $\frac{d^2y}{dt^2} = 0$. Hence $a = \frac{d^2x}{dt^2} = 8m/s^2$

41. (b) $F = m \times a$, If force is constant then $a \propto \frac{1}{m}$. So

If mass is doubled then acceleration becomes half.

42. (c) $S_n = u + \frac{a}{2}(2n-1) \Rightarrow 1.2 = 0 + \frac{a}{2}(2\times 6 - 1)$

$\Rightarrow a = \frac{1.2\times 2}{11} = 0.218\ m/s^2$

43. (b) Here $v = 144\ km/h = 40 m/s$

$v = u + at \Rightarrow 40 = 0 + 20\times a \Rightarrow a = 2\ m/s^2$

$\therefore s = \frac{1}{2}at^2 = \frac{1}{2}\times 2\times (20)^2 = 400\ m$

44. (c) $\frac{dx}{dt} = 2at - 3bt^2 \Rightarrow \frac{d^2x}{dt^2} = 2a - 6bt = 0 \Rightarrow t = \frac{a}{3b}$

45. (b) Stopping distance $= \frac{\text{Kinetic energy}}{\text{Retardins force}} = \frac{\frac{1}{2}mu^2}{F}$

If retarding force (F) and velocity (v) are equal then stopping distance $\propto m$ (mass of vehicle)

As $m_{car} < m_{truck}$ therefore car will cover less distance before coming to rest.

46. (d) $u = 72\ kmph = 20 m/s,\ v = 0$

By using $v^2 = u^2 - 2as \Rightarrow a = \frac{u^2}{2s}$

$= \frac{(20)^2}{2\times 200} = 1\ m/s^2$

47. (b) $v = \frac{ds}{dt} = 12t - 3t^2$

Velocity is zero for $t = 0$ and $t = 4$ sec

48. (a)

49. (b) Let A and B will meet after time t *sec*. it means the distance travelled by both will be equal.

$S_A = ut = 40t$ and $S_B = \frac{1}{2}at^2 = \frac{1}{2}\times 4\times t^2$

$S_A = S_B \Rightarrow 40t = \frac{1}{2}4t^2 \Rightarrow t = 20$ *sec*

50. (b) $x = a + bt^2,\ v = \frac{dx}{dt} = 2bt$

Instantaneous velocity $v = 2\times 3\times 3 = 18\ cm/\text{sec}$

51. (c) If the body starts from rest and moves with constant acceleration then the ratio of distances in consecutive equal time interval $S_1 : S_2 : S_3 = 1 : 3 : 5$

52. (c) $x = at + bt^2 - ct^3,\ a = \frac{d^2x}{dt^2} = 2b - 6ct$

53. (a) Let initial $(t = 0)$ velocity of particle $= u$

For first 5 *sec* motion $s_5 = 10$ *metre*

$s = ut + \frac{1}{2}at^2 \Rightarrow 10 = 5u + \frac{1}{2}a(5)^2$

$2u + 5a = 4$ …(i)

For first 8 *sec* of motion $s_8 = 20$ *metre*

$20 = 8u + \frac{1}{2}a(8)^2 \Rightarrow 2u + 8a = 5$ …(ii)

By solving $u = \frac{7}{6} m/s$ and $a = \frac{1}{3} m/s^2$

Now distance travelled by particle in Total 10 *sec*.

$s_{10} = u\times 10 + \frac{1}{2}a(10)^2$

By substituting the value of u and a we will get $s_{10} = 28.3\ m$

so the distance in last 2 sec $= s_{10} - s_8$

$= 28.3 - 20 = 8.3m$

54. (a) $s \propto t^2$ (given) $\therefore s = Kt^2$

Acceleration $a = \frac{d^2s}{dt^2} = 2k$ (constant)

It means the particle travels with uniform acceleration.

55. (c) Because acceleration is a vector quantity

56. (d) $u = at,\ x = \int u\,dt = \int at\,dt = \frac{at^2}{2}$

For $t = 4$ sec, $x = 8a$

57. (d) $3t = \sqrt{3x} + 6 \Rightarrow 3x = (3t-6)^2$

$\Rightarrow x = 3t^2 - 12t + 12$

$v = \frac{dx}{dt} = 6t - 12$, for $v = 0,\ t = 2$ sec

$x = 3(2)^2 - 12\times 2 + 12 = 0$

58. (d) $u = 0,\ S = 250m,\ t = 10$ sec

$S = ut + \frac{1}{2}at^2 \Rightarrow 250 = \frac{1}{2}a[10]^2 \Rightarrow a = 5 m/s^2$

So, $F = ma = 0.9\times 5 = 4.5 N$

59. (b) Time $= \frac{\text{Distance}}{\text{Average velocity}} = \frac{3.06}{0.34} = 9$ sec

Acceleration $= \frac{\text{Change in velocity}}{\text{Time}} = \frac{0.18}{9} = 0.02\ m/s^2$

60. (d) $s = 3t^3 + 7t^2 + 14t + 8\ m$

$a = \frac{d^2s}{dt^2} = 18t + 14$ at $t = 1$ sec $\Rightarrow a = 32 m/s^2$

61. (c) Instantaneous velocity $v = \frac{\Delta x}{\Delta t}$

By using the data from the table

$v_1 = \frac{0-(-2)}{1} = 2 m/s,\ v_2 = \frac{6-0}{1} = 6\ m/s$

$v_3 = \frac{16-6}{1} = 10\ m/s$

So, motion is non-uniform but accelerated.

62. (b) Only direction of displacement and velocity gets changed, acceleration is always directed vertically downward.

63. (b) $s = 2t^2 + 2t + 4,\ a = \frac{d^2s}{dt^2} = 4\ m/s^2$

64. (a) According to problem

Distance travelled by body *A* in 5^{th} *sec* and distance travelled by body *B* in 3^{rd} *sec*. of its motion are equal.

$0 + \frac{a_1}{2}(2\times 5 - 1) = 0 + \frac{a_2}{2}[2\times 3 - 1]$

$9a_1 = 5a_2 \Rightarrow \frac{a_1}{a_2} = \frac{5}{9}$

65. (d) $u = 200\ m/s,\ v = 100\ m/s,\ s = 0.1\ m$

$a = \frac{u^2 - v^2}{2s} = \frac{(200)^2 - (100)^2}{2\times 0.1} = 15\times 10^4\ m/s^2$

66. (b) $v = u + at = u + \left(\frac{F}{m}\right)t = 20 + \left(\frac{100}{5}\right)\times 10 = 220\ m/s$

67. (a) Velocity acquired by body in 10*sec*

$v = 0 + 2\times 10 = 20 m/s$

and distance travelled by it in 10 *sec*

$S_1 = \frac{1}{2}\times 2\times (10)^2 = 100\ m$

then it moves with constant velocity (20 *m/s*) for 30 sec

$S_2 = 20\times 30 = 600\ m$

After that due to retardation $(4m/s^2)$ it stops

$S_3 = \frac{v^2}{2a} = \frac{(20)^2}{2\times 4} = 50m$

Total distance travelled $S_1 + S_2 + S_3 = 750m$

68. (a) If a body starts from rest with acceleration α and then retards with retardation β and comes to rest. The total time taken for this journey is *t* and distance covered is *S* then

$S = \frac{1}{2}\frac{\alpha\beta t^2}{(\alpha+\beta)} = \frac{1}{2}\frac{5\times 10}{(5+10)}\times t^2$

$\Rightarrow\ 1500 = \frac{1}{2}\frac{5\times 10}{(5+10)}\times t^2 \ \Rightarrow\ t = 30\,\text{sec}.$

69. (a)

70. (d) $S \propto u^2$. Now speed is two times so distance will be four times $S = 4\times 6 = 24m$

71. (c) Let student will catch the bus after *t sec*. So it will cover distance *ut*.

Similarly distance travelled by the bus will be $\frac{1}{2}at^2$ for the given condition

$ut = 50 + \frac{1}{2}at^2 = 50 + \frac{t^2}{2} \qquad [a = 1\ m/s^2]$

$\Rightarrow u = \frac{50}{t} + \frac{t}{2}$

To find the minimum value of *u*

$\frac{du}{dt} = 0$, so we get $t = 10\,\text{sec}$, then $u = 10\ m/s$

72. (a) $\frac{1}{2}at^2 = vt \Rightarrow t = \frac{2v}{a}$

73. (a) The velocity of the particle is

$\frac{dx}{dt} = \frac{d}{dt}(2 - 5t + 6t^2) = (0 - 5 + 12t)$

For initial velocity $t = 0$, hence $v = -5\ m/s$.

74. (c) For First part,

u = 0, t = T and acceleration = *a*

$\therefore v = 0 + aT = aT$ and $S_1 = 0 + \frac{1}{2}aT^2 = \frac{1}{2}aT^2$

For Second part,

$u = aT,$ retardation=a_1, $v = 0$ and time taken = T_1 (let)

$\therefore 0 = u - a_1T_1 \Rightarrow aT = a_1T_1$

and from $v^2 = u^2 - 2aS_2 \Rightarrow S_2 = \frac{u^2}{2a_1} = \frac{1}{2}\frac{a^2T^2}{a_1}$

$S_2 = \frac{1}{2}aT\times T_1 \qquad \left(As\ a_1 = \frac{aT}{T_1}\right)$

$\therefore\ v_{av} = \frac{S_1 + S_2}{T + T_1} = \frac{\frac{1}{2}aT^2 + \frac{1}{2}aT\times T_1}{T + T_1}$

$= \frac{\frac{1}{2}aT(T + T_1)}{T + T_1} = \frac{1}{2}aT$

75. (c) *u* = 0, $v = 27.5\ m/s$ and *t* = 10 *sec*

$\therefore a = \frac{27.5 - 0}{10} = 2.75\ m/s^2$

Now, the distance traveled in next 10 *sec*,

$S = ut + \frac{1}{2}at^2 = 27.5\times 10 + \frac{1}{2}\times 2.75\times 100$

= 275 + 137.5 = 412.5 *m*

76. (c) $v = (180 - 16x)^{1/2}$

As $a = \frac{dv}{dt} = \frac{dv}{dx}.\frac{dx}{dt}$

$\therefore a = \frac{1}{2}(180 - 16x)^{-1/2}\times(-16)\left(\frac{dx}{dt}\right)$

$= -8\,(180 - 16x)^{-1/2}\times v$

$= -8\,(180 - 16x)^{-1/2}\times(180 - 16x)^{1/2} = -8\ m/s^2$

77. (d) $x \propto t^3\ \therefore\ x = Kt^3$

$\Rightarrow v = \frac{dx}{dt} = 3\,Kt^2$ and $a = \frac{dv}{dt} = 6\,Kt$

i.e. $a \propto t$

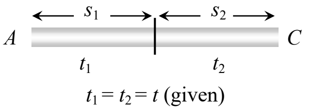
78. (a) $\because a = \frac{dv}{dt} = 2(t-1) \Rightarrow dv = 2(t-1)\,dt$

$\Rightarrow v = \int_0^5 2(t-1)dt = 2\left[\frac{t^2}{2} - t\right]_0^5 = 2\left[\frac{25}{2} - 5\right] = 15\ m/s$

79. (c) $\because S_1 = ut + \frac{1}{2}at^2$ .....(i)

and velocity after first t *sec*

$v = u + at$



Now, $S_2 = vt + \frac{1}{2}at^2$

$= (u + at)t + \frac{1}{2}at^2$ ..... (ii)

Equation (ii) – (i) $\Rightarrow S_2 - S_1 = at^2$

$\Rightarrow a = \frac{S_2 - S_1}{t^2} = \frac{65 - 40}{(5)^2} = 1\ m/s^2$

From equation (i), we get,

$S_1 = ut + \frac{1}{2}at^2 \Rightarrow 40 = 5u + \frac{1}{2} \times 1 \times 25$

$\Rightarrow 5u = 27.5 \ \therefore\ u = 5.5\ m/s$

80. (d) $S \propto u^2 \Rightarrow \frac{S_1}{S_2} = \left(\frac{1}{4}\right)^2 = \frac{1}{16}$

81. (d) $x = ae^{-\alpha t} + be^{\beta t}$

Velocity $v = \frac{dx}{dt} = \frac{d}{dt}(ae^{-\alpha t} + be^{\beta t})$

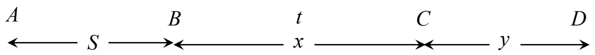
$= a.e^{-\alpha t}(-\alpha) + be^{\beta t}.\beta) = -a\alpha e^{-\alpha t} + b\beta e^{\beta t}$

Acceleration $= -a\alpha e^{-\alpha t}(-\alpha) + b\beta e^{bt}.\beta$

$= a\alpha^2 e^{-\alpha t} + b\beta^2 e^{\beta t}$

Acceleration is positive so velocity goes on increasing with time.

82. (c) Let car starts from point A from rest and moves up to point B with acceleration f



Velocity of car at point B, $v = \sqrt{2fS}$

[As $v^2 = u^2 + 2as$]

Car moves distance BC with this constant velocity in time t

$x = \sqrt{2fS}.t$ ......(i) [As $s = ut$]

So the velocity of car at point C also will be $\sqrt{2fs}$ and finally car stops after covering distance y.

Distance CD $\Rightarrow$ $y = \frac{(\sqrt{2fS})^2}{2(f/2)} = \frac{2fS}{f} = 2S$ ....(ii)

[As $v^2 = u^2 - 2as \Rightarrow s = u^2/2a$]

So, the total distance AD = $AB + BC + CD$ = $15S$ (given)

$\Rightarrow$ $S + x + 2S = 15S \Rightarrow x = 12S$

Substituting the value of x in equation (i) we get

$x = \sqrt{2fS}.t \Rightarrow 12S = \sqrt{2fS}.t \Rightarrow 144S^2 = 2fS.t^2$

$\Rightarrow S = \frac{1}{72}ft^2$.

83. (c) Let man will catch the bus after 't' *sec*. So he will cover distance ut.

Similarly distance travelled by the bus will be $\frac{1}{2}at^2$. For the given condition

$u\,t = 45 + \frac{1}{2}a\,t^2 = 45 + 1.25\,t^2$

[$As\ a = 2.5 m/s^2$]

$\Rightarrow u = \frac{45}{t} + 1.25\,t$

To find the minimum value of u

$\frac{du}{dt} = 0$ so we get $t = 6$ sec then,

$u = \frac{45}{6} + 1.25 \times 6 = 7.5 + 7.5 = 15 m/s$

84. (b) $x = 4(t-2) + a(t-2)^2$

At $t = 0, x = -8 + 4a = 4a - 8$

$v = \frac{dx}{dt} = 4 + 2a(t-2)$

At $t = 0,\ v = 4 - 4a = 4(1 - a)$

But acceleration, $a = \frac{d^2x}{dt^2} = 2a$

85. (a) Distance covered in 5th second,

$S_{5^{th}} = u + \frac{a}{2}(2n-1) = 0 + \frac{a}{2}(2 \times 5 - 1) = \frac{9a}{2}$

and distance covered in 5 second,

$S_5 = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2} \times a \times 25 = \frac{25a}{2}$

$\therefore \frac{S_{5^{th}}}{S_5} = \frac{9}{25}$

86. (d) The nature of the path is decided by the direction of velocity, and the direction of acceleration. The trajectory can be a straight line, circle or a parabola depending on these factors.

Relative Motion

1. (b) Time $= \frac{\text{Total length}}{\text{Relativevelocity}} = \frac{50+50}{10+15} = \frac{100}{25} = 4\ sec$

2. (d) Total distance $= 130 + 120 = 250\ m$

Relative velocity $= 30 - (-20) = 50\ m/s$

Hence $t = 250/50 = 5s$

3. (b) Relative velocity of bird *w.r.t* train $= 25 + 5 = 30\ m/s$

time taken by the bird to cross the train

$t = \frac{210}{30} = 7\ sec$

4. (a) Effective speed of the bullet

= speed of bullet + speed of police jeep

$= 180\ m/s + 45\ km/h = (180 + 12.5)\ m/s = 192.5\ m/s$

Speed of thief 's jeep $= 153 km/h = 42.5 m/s$

Velocity of bullet *w.r.t* thief 's car $= 192.5 - 42.5 = 150 m/s$

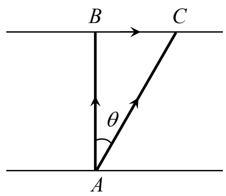
5. (c) Given $\overrightarrow{AB} =$ Velocity of boat= 8 *km/hr*

$\overrightarrow{AC} =$ Resultant velocity of boat = 10 *km/hr*

$\overrightarrow{BC} =$ Velocity of river

$= \sqrt{AC^2 - AB^2}$

$= \sqrt{(10)^2 - (8)^2} = 6\ km/hr$



6. (d) Relative velocity

$= 10 + 5 = 15\ m/sec$

$\therefore\ t = \frac{150}{15} = 10\ sec$

7. (b) The relative velocity of boat *w.r.t.* water

$= v_{boat} - v_{water} = (3\hat{i} + 4\hat{j}) - (-3\hat{i} - 4\hat{j}) = 6\hat{i} + 8\hat{j}$

8. (a) When two particles moves towards each other then $v_1 + v_2 = 6$ ...(i)

When these particles moves in the same direction then $v_1 - v_2 = 4$ ...(ii)

By solving $v_1 = 5$ and $v_2 = 1\ m/s$

9. (d) For the round trip he should cross perpendicular to the river $\therefore$ Time for trip to that side $= \frac{1 km}{4 km/hr} = 0.25 hr$

To come back, again he take 0.25 *hr* to cross the river.

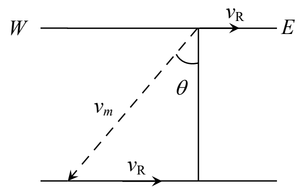
Total time is 30 min, he goes to the other bank and come back at the same point.

10. (c) Relativistic momentum $= \frac{m_0 v}{\sqrt{1 - v^2/c^2}}$

If velocity is doubled then the relativistic mass also increases. Thus value of linear momentum will be more than double.

11. (c) For shortest possible path man should swim with an angle (90+θ) with downstream.

From the fig,

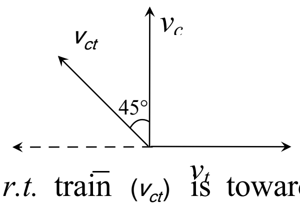


$\sin\theta = \frac{v_r}{v_m} = \frac{5}{10} = \frac{1}{2} \Rightarrow \therefore\ \theta = 30°$

So angle with downstream = $90° + 30° = 120°$

12. (b) $\overrightarrow{v_{ct}} = \overrightarrow{v_c} - \overrightarrow{v_t}$

$\overrightarrow{v_{ct}} = \overrightarrow{v_c} + (-\overrightarrow{v_t})$



Velocity of car *w.r.t.* train (v_{ct}) is towards West – North

13. (a) As the trains are moving in the same direction. So the initial relative speed $(v_1 - v_2)$ and by applying retardation final relative speed becomes zero.

From $v = u - at \Rightarrow 0 = (v_1 - v_2) - at \Rightarrow t = \frac{v_1 - v_2}{a}$

Motion Under Gravity

1. (c) $u = 12\ m/s,\ g = 9.8\ m/sec^2,\ t = 10$ sec

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

$= 12 \times 10 + \frac{1}{2} \times 9.8 \times 100 = 610 m$

2. (b) Velocity at the time of striking the floor,

$u = \sqrt{2gh_1} = \sqrt{2 \times 9.8 \times 10} = 14 m/s$

Velocity with which it rebounds.

$v = \sqrt{2gh_2} = \sqrt{2 \times 9.8 \times 2.5} = 7\ m/s$

$\therefore$ Change in velocity $\Delta v = 7 - (-14) = 21 m/s$

$\therefore$ Acceleration $= \frac{\Delta v}{\Delta t} = \frac{21}{0.01} = 2100\ m/s^2$ (upwards)

3. (d) Let *t* be the time of flight of the first body after meeting, then $(t - 4)$ *sec* will be the time of flight of the second body. Since $h_1 = h_2$

$\therefore\ 98t - \frac{1}{2}gt^2 = 98(t-4) - \frac{1}{2}g(t-4)^2$

On solving, we get $t = 12$ *seconds*

4. (c) $h = \frac{1}{2}gt^2 \Rightarrow t = \sqrt{2h/g}$

$t_a = \sqrt{\frac{2a}{g}}$ and $t_b = \sqrt{\frac{2b}{g}} \Rightarrow \frac{t_a}{t_b} = \sqrt{\frac{a}{b}}$

5. (b) $\frac{1}{2}g(3)^2 = \frac{g}{2}(2n-1) \Rightarrow n = 5\ s$

6. (a) Time taken by first stone to reach the water surface from the bridge be t, then

$h = ut + \frac{1}{2}gt^2 \Rightarrow 44.1 = 0 \times t + \frac{1}{2} \times 9.8 t^2$

$t = \sqrt{\frac{2 \times 44.1}{9.8}} = 3\ sec$

Second stone is thrown 1 *sec* later and both strikes simultaneously. This means that the time left for second stone $= 3 - 1 = 2\ sec$

Hence $44.1 = u \times 2 + \frac{1}{2} 9.8 (2)^2$

$\Rightarrow 44.1 - 19.6 = 2u \Rightarrow u = 12.25\ m/s$

7. (a)

8. (b) Let the initial velocity of ball be u

Time of rise $t_1 = \frac{u}{g+a}$ and height reached $= \frac{u^2}{2(g+a)}$

Time of fall t_2 is given by

$\frac{1}{2}(g-a)t_2^2 = \frac{u^2}{2(g+a)}$

$\Rightarrow t_2 = \frac{u}{\sqrt{(g+a)(g-a)}} = \frac{u}{(g+a)}\sqrt{\frac{g+a}{g-a}}$

$\therefore t_2 > t_1$ because $\frac{1}{g+a} < \frac{1}{g-a}$

9. (c) Vertical component of velocities of both the balls are same and equal to zero. So $t = \sqrt{\frac{2h}{g}}$

10. (d) The separation between the two bodies, two seconds after the release of second body

$= \frac{1}{2} \times 9.8[(3)^2 - (2)^2] = 24.5\ m$

11. (b) Time of flight $= \frac{2u}{g} = \frac{2 \times 100}{10} = 20\ sec$

12. (a) $h = \frac{1}{2}gt^2 = \frac{1}{2} \times 10 \times (4)^2 = 80\ m$

13. (d) Let the body after time $t/2$ be at x from the top, then

$x = \frac{1}{2}g\frac{t^2}{4} = \frac{gt^2}{8}$ ...(i)

$h = \frac{1}{2}gt^2$ ...(ii)

Eliminate t from (i) and (ii), we get $x = \frac{h}{4}$

$\therefore$ Height of the body from the ground $= h - \frac{h}{4} = \frac{3h}{4}$

14. (b) By applying law of conservation of energy

$mgR = \frac{1}{2}mv^2 \Rightarrow v = \sqrt{2Rg}$

15. (c) Acceleration of body along AB is $g\cos\theta$

Distance travelled in time t *sec* $= AB = \frac{1}{2}(g\cos\theta)t^2$

From ΔABC, $AB = 2R\cos\theta$; $2R\cos\theta = \frac{1}{2}g\cos\theta t^2$

$\Rightarrow t^2 = \frac{4R}{g}$ or $t = 2\sqrt{\frac{R}{g}}$

16. (c) Force down the plane $= mg\sin\theta$

$\therefore$ Acceleration down the plane $= g\sin\theta$

Since $l = 0 + \frac{1}{2}g\sin\theta t^2$

$\therefore t^2 = \frac{2l}{g\sin\theta} = \frac{2h}{g\sin^2\theta} \Rightarrow t = \frac{1}{\sin\theta}\sqrt{\frac{2h}{g}}$

17. (a) $h = ut - \frac{1}{2}gt^2 \Rightarrow 96 = 80t - \frac{32}{2}t^2$

$\Rightarrow t^2 - 5t + 6 = 0 \Rightarrow t = 2\ sec$ or $3\ sec$

18. (b) $v = g \times t = 32 \times 1 = 32\ ft/\text{sec}$

19. (b) $v^2 = u^2 + 2gh \Rightarrow (3u)^2 = (-u)^2 + 2gh \Rightarrow h = \frac{4u^2}{g}$

20. (c) $t = \sqrt{\frac{2h}{g}}$ and h and g are same.

21. (b) Time of flight $= \frac{2u}{g} = \frac{2 \times 96}{32} = 6\ sec$

22. (c) Total distance $= \frac{1}{2}gt^2 = \frac{25}{2}g$

Distance moved in 3 *sec* $= \frac{9}{2}g$

Remaining distance $= \frac{16}{2}g$

If t is the time taken by the stone to reach the ground for the remaining distance then

$\Rightarrow \frac{16}{2}g = \frac{1}{2}gt^2 \Rightarrow t = 4\ \text{sec}$

23. (a) Height travelled by ball (with balloon) in 2 *sec*

$h_1 = \frac{1}{2}at^2 = \frac{1}{2} \times 4.9 \times 2^2 = 9.8\ m$

Velocity of the balloon after 2 sec

$v = at = 4.9 \times 2 = 9.8\ m/s$

Now if the ball is released from the balloon then it acquire same velocity in upward direction.

Let it move up to maximum height h_2

$v^2 = u^2 - 2gh_2 \Rightarrow$

$0 = (9.8)^2 - 2 \times (9.8) \times h_2 \therefore h_2 = 4.9m$

Greatest height above the ground reached by the ball $= h_1 + h_2 = 9.8 + 4.9 = 14.7\ m$

24. (b) Let h distance is covered in n sec

$\Rightarrow h = \frac{1}{2}gn^2$ ...(i)

Distance covered in n^{th} sec $= \frac{1}{2}g(2n-1)$

$\Rightarrow \frac{9h}{25} = \frac{g}{2}(2n-1)$ ...(ii)

From (i) and (ii), $h = 122.5\ m$

25. (c) $h = ut + \frac{1}{2}gt^2 \Rightarrow 81 = -12t + \frac{1}{2} \times 10 \times t^2 \Rightarrow t = 5.4\ sec$

26. (d) The initial velocity of aeroplane is horizontal, then the vertical component of velocity of packet will be zero.

So $t = \sqrt{\frac{2h}{g}}$

27. (b) Time taken by first drop to reach the ground

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

$\Rightarrow t = \sqrt{\frac{2 \times 5}{10}} = 1$ sec

As the water drops fall at regular intervals from a tap therefore time difference between any two drops $= \frac{1}{2}$ sec

In this given time, distance of second drop from the tap $= \frac{1}{2}g\left(\frac{1}{2}\right)^2 = \frac{5}{5} = 1.25\,m$

Its distance from the ground $= 5 - 1.25 = 3.75\ m$

28. (c) $h = ut + \frac{1}{2}gt^2$, $t = 3$ sec, $u = -4.9\ m/s$

$\Rightarrow h = -4.9 \times 3 + 4.9 \times 9 = 29.4\ m$

29. (a) Horizontal velocity of dropped packet $= u$

Vertical velocity $= \sqrt{2gh}$

$\therefore$ Resultant velocity at earth $= \sqrt{u^2 + 2gh}$

30. (d) Given $a = 19.6\ m/s^2 = 2g$

Resultant velocity of the rocket after 5 sec

$v = 2g \times 5 = 10g\ m/s$

Height achieved after 5 sec,

$h_1 = \frac{1}{2} \times 2g \times 25 = 245m$

On switching off the engine it goes up to height h_2 where its velocity becomes zero.

$0 = (10g)^2 - 2gh_2 \Rightarrow h_2 = 490m$

$\therefore$ Total height of rocket $= 245 + 490 = 735\ m$

31. (b) Bullet will take $\frac{100}{1000} = 0.1\,sec$ to reach target.

During this period vertical distance (downward)

travelled by the bullet $= \frac{1}{2}gt^2$

$= \frac{1}{2} \times 10 \times (0.1)^2\,m = 5\ cm$

So the gun should be aimed 5 cm above the target.

32. (a) $S_n = u + \frac{g}{2}(2n-1)$; when $u = 0$,

$S_1 : S_2 : S_3 = 1 : 3 : 5$

33. (b) It has lesser initial upward velocity.

34. (b) At maximum height velocity $v = 0$

We know that $v = u + at$, hence

$0 = u - gT \Rightarrow u = gT$

When $v = \frac{u}{2}$, then

$\frac{u}{2} = u - gt \Rightarrow gt = \frac{u}{2} \Rightarrow gt = \frac{gT}{2} \Rightarrow t = \frac{T}{2}$

Hence at $t = \frac{T}{2}$, it acquires velocity $\frac{u}{2}$

35. (a) If u is the initial velocity then distance covered by it in 2 sec

$S = ut + \frac{1}{2}at^2 = u \times 2 + \frac{1}{2} \times 10 \times 4 = 2u + 20$ ...(i)

Now distance covered by it in 3rd sec

$S_{3^{rd}} = u + \frac{g}{2}(2 \times 3 - 1)10 = u + 25$ ...(ii)

From(i) and (ii), $2u + 20 = u + 25 \Rightarrow u = 5$

$\therefore S = 2 \times 5 + 20 = 30\ m$

36. (c) For first case $v^2 - 0^2 = 2gh \Rightarrow (3)^2 = 2gh$

For second case

$v^2 = (-u)^2 + 2gh = 4^2 + 3^2 \therefore v = 5km/h$

37. (b) The time of fall is independent of the mass.

38. (c) $h_{n^{th}} = u - \frac{g}{2}(2n-1)$

$h_{5^{th}} = u - \frac{10}{2}(2 \times 5 - 1) = u - 45$

$h_{6^{th}} = u - \frac{10}{2}(2 \times 6 - 1) = u - 55$

Given $h_{5^{th}} = 2 \times h_{6^{th}}$. By solving we get $u = 65\ m/s$

39. (b) $S = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2}at^2$

Hence $t \propto \sqrt{S}$ *i.e.,* if S becomes one-fourth then t will become half *i.e.,* 2 *sec*

40. (a) Distance between the balls = Distance travelled by first ball in 3 seconds –Distance travelled by second ball in 2 seconds = $\frac{1}{2}g(3)^2 - \frac{1}{2}g(2)^2 = 45 - 20 = 25\ m$

41. (b) Speed of stone in a vertically upward direction is 4.9 *m/s*. So for vertical downward motion we will consider $u = -4.9\ m/s$

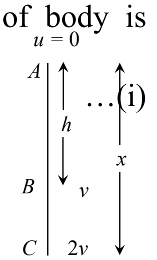
$h = ut + \frac{1}{2}gt^2 = -4.9 \times 2 + \frac{1}{2} \times 9.8 \times (2)^2 = 9.8\ m$

42. (b) Speed of stone in a vertically upward direction is 20*m/s*. So for vertical downward motion we will consider $u = -20\ m/s$

$v^2 = u^2 + 2gh = (-20)^2 + 2 \times 9.8 \times 200 = 4320\ m/s$

$\therefore v \tilde{-} 65\ m/s.$

43. (b) Let at point A initial velocity of body is equal to zero



for path AB : $v^2 = 0 + 2gh$

for path AC : $(2v)^2 = 0 + 2gx$

$4v^2 = 2gx$ ...(ii)

Solving (i) and (ii) $x = 4h$

44. (b) For one dimensional motion along a plane

$S = ut + \frac{1}{2}at^2 \Rightarrow 9.8 = 0 + \frac{1}{2}\ g\sin 30^o\ t^2 \Rightarrow t = 2\,\text{sec}$

45. (d) Body reaches the point of projection with same velocity.

46. (d) Time of flight $T = \frac{2u}{g} = 4\ \text{sec} \Rightarrow u = 20\ m/s$

47. (b) $t = \sqrt{\frac{2h}{g}} \Rightarrow \frac{t_1}{t_2} = \sqrt{\frac{h_1}{h_2}}$

48. (b) Time of ascent = Time of descent = 5 *sec*

49. (b) Time of ascent $= \frac{u}{g} = 6\ \text{sec} \Rightarrow u = 60\ m/s$

Distance in first second

$h_{\text{first}} = 60 - \frac{g}{2}(2 \times 1 - 1) = 55\ m$

Distance in seventh second will be equal to the distance in first second of vertical downward motion $h_{\text{seventh}} = \frac{g}{2}(2 \times 1 - 1) = 5\ m \Rightarrow$

$h_{\text{first}} / h_{\text{seventh}} = 11:1$

50. (b) Let particle thrown with velocity u and its maximum height is H then $H = \frac{u^2}{2g}$

When particle is at a height $H/2$, then its speed is 10 *m/s*

From equation $v^2 = u^2 - 2gh$

$(10)^2 = u^2 - 2g\left(\frac{H}{2}\right) = u^2 - 2g\frac{u^2}{4g} \Rightarrow u^2 = 200$

Maximum height $\Rightarrow H = \frac{u^2}{2g} = \frac{200}{2 \times 10} = 10\ m$

51. (c) Mass does not affect on maximum height.

$H = \frac{u^2}{2g} \Rightarrow H \propto u^2$, So if velocity is doubled then height will become four times. *i.e.* $H = 20 \times 4 = 80m$

52. (a) When the stone is released from the balloon. Its height $h = \frac{1}{2}at^2 = \frac{1}{2} \times 1.25 \times (8)^2 = 40\ m$ and velocity

$v = at = 1.25 \times 8 = 10\ m/s$

Time taken by the stone to reach the ground

$t = \frac{v}{g}\left[1 + \sqrt{1 + \frac{2gh}{v^2}}\right] = \frac{10}{10}\left[1 + \sqrt{1 + \frac{2 \times 10 \times 40}{(10)^2}}\right] = 4$ *sec*

53. (d) At highest point $v = 0$ and $H_{\max} = \frac{u^2}{2g}$

54. (d) $u = \sqrt{2gh} = \sqrt{2 \times 10 \times 20} = 20\ m/s$

and $T = \frac{2u}{g} = \frac{2 \times 20}{10} = 4$ *sec*

55. (d) If t_1 and t_2 are the time, when body is at the same height then, $h = \frac{1}{2}gt_1t_2$

$= \frac{1}{2} \times g \times 2 \times 10 = 10\ g$

56. (c) Speed of the object at reaching the ground $v = \sqrt{2gh}$

If heights are equal then velocity will also be equal.

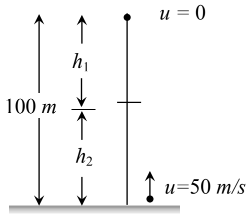
57. (b) $S_{3^{rd}} = 10 + \frac{10}{2}(2 \times 3 - 1) = 35\ m$

$S_{2^{nd}} = 10 + \frac{10}{2}(2 \times 2 - 1) = 25m \Rightarrow \frac{S_{3^{rd}}}{S_{2^{nd}}} = \frac{7}{5}$

58. (c) $v^2 = u^2 + 2gh \Rightarrow v = \sqrt{u^2 + 2gh}$

so for both the cases velocity will be equal.

59. (b) $h_1 = \frac{1}{2}gt^2$, $h_2 = 50t - \frac{1}{2}gt^2$



Given $h_1 + h_2 = 100m \Rightarrow 50t = 100 \Rightarrow t = 2$ sec

60. (b) $H_{max} = \frac{u^2}{2g} = \frac{19.6 \times 19.6}{2 \times 9.8} = 19.6\ m$

61. (c) Maximum height of ball = 5 *m*

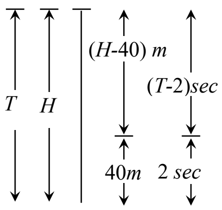
So velocity of projection $\Rightarrow u = \sqrt{2gh}$ $= 10\ m/s$

Time interval between two balls (time of ascent)

$= \frac{u}{g} = 1\ sec = \frac{1}{60}\ min.$

So number of ball thrown per min. = 60

62. (b) Let height of minaret is *H* and body take time *T* to fall from top to bottom.



$H = \frac{1}{2}gT^2$ …(i)

In last 2 *sec*. body travels distance of 40*meter* so in $(T-2)$ *sec* distance travelled $= (H-40)\ m$.

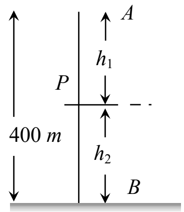
$(H-40) = \frac{1}{2}g(T-2)^2$ …(ii)

By solving (i) and (ii) $T = 3$ *sec* and $H = 45\ m$.

63. (c) $S_n \propto (2n-1)$. In equal time interval of 2 *seconds*

Ratio of distance $= 1 : 3 : 5$

64. (c) Let both balls meet at point *P* after time *t*.



The distance travelled by ball *A*, $h_1 = \frac{1}{2}gt^2$

The distance travelled by ball *B*, $h_2 = ut - \frac{1}{2}gt^2$

$h_1 + h_2 = 400\ m \Rightarrow ut = 400,\ t = 400/50 = 8\ sec$

$\therefore\ h_1 = 320\ m$ and $h_2 = 80\ m$

65. (a) $t = \sqrt{\frac{2h}{g}} \Rightarrow \frac{t_1}{t_2} = \sqrt{\frac{h_1}{h_2}} = \sqrt{\frac{1}{2}} = \frac{1}{\sqrt{2}}$

66. (a) $H_{max} = \frac{u^2}{2g} \Rightarrow H_{max} \propto \frac{1}{g}$

On planet *B* value of *g* is $1/9$ times to that of *A*. So value of H_{max} will become 9 times *i.e.* $2 \times 9 = 18$ *metre*

67. (b) $h_n = \frac{g}{2}(2n-1) \Rightarrow h_{5^{th}} = \frac{10}{2}(2 \times 5 - 1) = 45\ m.$

68. (a) $h_{max} = \frac{u^2}{2g} = \frac{(15)^2}{2 \times 10} = 11.25\ m.$

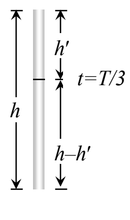
69. (b) For stone to be dropped from rising balloon of velocity 29 *m/s.*

$u = -29\ m/s,\ t = 10\ sec.$

$\therefore h = -29 \times 10 + \frac{1}{2} \times 9.8 \times 100$

$= -290 + 490 = 200\ m.$

70. (c) $\because\ h = ut + \frac{1}{2}gt^2 \Rightarrow h = \frac{1}{2}gT^2$



After $\frac{T}{3}$ seconds, the position of ball,

$h' = 0 + \frac{1}{2}g\left(\frac{T}{3}\right)^2 = \frac{1}{2} \times \frac{g}{9} \times T^2$

$h' = \frac{1}{2} \times \frac{g}{9} \times T^2 = \frac{h}{9}\ m$ from top

∴ Position of ball from ground $= h - \frac{h}{9} = \frac{8h}{9} m$.

71. (c) Since acceleration due to gravity is independent of mass, hence time is also independent of mass (or density) of object.

72. (c) When packet is released from the balloon, it acquires the velocity of balloon of value 12 *m/s*. Hence velocity of packet after 2 *sec*, will be

$v = u + gt = 12 - 9.8 \times 2 = -7.6$ *m/s*.

73. (b) The distance traveled in last second.

$S_{Last} = u + \frac{g}{2}(2t-1) = \frac{1}{2} \times 9.8(2t-1) = 4.9(2t-1)$

and distance traveled in first three second,

$S_{Three} = 0 + \frac{1}{2} \times 9.8 \times 9 = 44.1\ m$

According to problem $S_{Last} = S_{Three}$

$\Rightarrow 4.9(2t-1) = 44.1 \Rightarrow 2t - 1 = 9 \Rightarrow t = 5\ sec.$

74. (c) Net acceleration of a body when thrown upward

= acceleration of body – acceleration due to gravity

$= a - g$

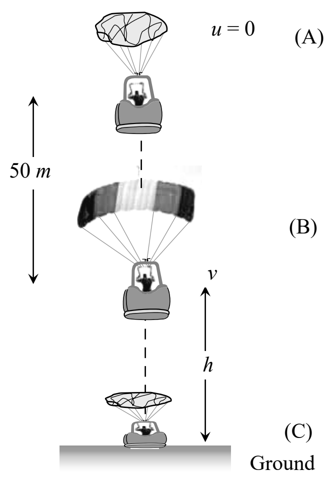
75. (b) The given condition is possible only when body is at its highest position after 5 seconds

It means time of ascent = 5 *sec*

and time of flight $T = \frac{2u}{g} = 10 \Rightarrow u = 50\ m/s$

76. (b) $H_{max} \propto u^2$, It body projected with double velocity then maximum height will become four times *i.e.* 200 *m*.

77. (a) After bailing out from point *A* parachutist falls freely under gravity. The velocity acquired by it will '*v*'



From $v^2 = u^2 + 2as = 0 + 2 \times 9.8 \times 50 = 980$

[As $u = 0$, $a = 9.8 m/s^2$, $s = 50\ m$]

At point *B*, parachute opens and it moves with retardation of $2\ m/s^2$ and reach at ground (Point *C*) with velocity of $3 m/s$

For the part '*BC*' by applying the equation $v^2 = u^2 + 2as$

$v = 3m/s,\ u = \sqrt{980} m/s,\ a = -2m/s^2,\ s = h$

$\Rightarrow (3)^2 = (\sqrt{980})^2 + 2 \times (-2) \times h \Rightarrow 9 = 980 - 4h$

$\Rightarrow h = \frac{980 - 9}{4} = \frac{971}{4} = 242.7 \simeq 243\ m.$

So, the total height by which parachutist bail out $= 50 + 243 = 293\ m.$

78. (a)

79. (c)

80. (a) $H_{max} \propto u^2\ \therefore u \propto \sqrt{H_{max}}$

i.e. to triple the maximum height, ball should be thrown with velocity $\sqrt{3}\,u$.

81. (a)

Critical Thinking Questions

1. (a) If t_1 and $2t_2$ are the time taken by particle to cover first and second half distance respectively.

$t_1 = \frac{x/2}{3} = \frac{x}{6}$ …(i)

$x_1 = 4.5\ t_2$ and $x_2 = 7.5\ t_2$

So, $x_1 + x_2 = \frac{x}{2} \Rightarrow 4.5t_2 + 7.5t_2 = \frac{x}{2}$

$t_2 = \frac{x}{24}$ …(ii)

Total time $t = t_1 + 2t_2 = \frac{x}{6} + \frac{x}{12} = \frac{x}{4}$

So, average speed $= 4\ m/sec.$

2. (c) $\frac{dv}{dt}=bt \Rightarrow dv=bt\,dt \Rightarrow v=\frac{bt^2}{2}+K_1$

At $t=0,\ v=v_0 \Rightarrow K_1=v_0$

We get $v=\frac{1}{2}bt^2+v_0$

Again $\frac{dx}{dt}=\frac{1}{2}bt^2+v_0 \Rightarrow x=\frac{1}{2}\frac{bt^3}{3}+v_0t+K_2$

At $t=0,\ x=0 \Rightarrow K_2=0$

$\therefore\ x=\frac{1}{6}bt^3+v_0t$

3. (a,b,d) $\frac{dv}{dt}=6-3v \Rightarrow \frac{dv}{6-3v}=dt$

Integrating both sides, $\int\frac{dv}{6-3v}=\int dt$

$\Rightarrow \frac{\log_e(6-3v)}{-3}=t+K_1$

$\Rightarrow \log_e(6-3v)=-3t+K_2$ …(i)

At $t=0,\ v=0\ \therefore\ \log_e 6=K_2$

Substituting the value of K_2 in equation (i)

$\log_e(6-3v)=-3t+\log_e 6$

$\Rightarrow \log_e\left(\frac{6-3v}{6}\right)=-3t \Rightarrow e^{-3t}=\frac{6-3v}{6}$

$\Rightarrow 6-3v=6e^{-3t} \Rightarrow 3v=6(1-e^{-3t})$

$\Rightarrow v=2(1-e^{-3t})$

$\therefore\ v_{\text{trminal}}=2\ m/s$ (When $t=\infty$)

Acceleration $a=\frac{dv}{dt}=\frac{d}{dt}\left[2(1-e^{-3t})\right]=6e^{-3t}$

Initial acceleration $=6\ m/s^2$.

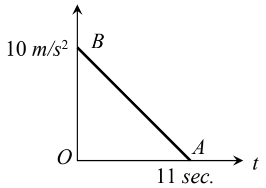
4. (a,d) The body starts from rest at $x=0$ and then again comes to rest at $x=1$. It means initially acceleration is positive and then negative.

So we can conclude that α can not remains positive for all *t* in the interval $0\le t\le 1$ *i.e.* α must change sign during the motion.

5. (b) The area under acceleration time graph gives change in velocity. As acceleration is zero at the end of 11 *sec*

i.e. $v_{\max}=$ Area of ΔOAB

$=\frac{1}{2}\times 11\times 10=55\ m/s$



6. (d) Let the car accelerate at rate α for time t_1 then maximum velocity attained, $v=0+\alpha t_1=\alpha t_1$

Now, the car decelerates at a rate β for time $(t-t_1)$ and finally comes to rest. Then,

$0=v-\beta(t-t_1) \Rightarrow 0=\alpha t_1-\beta t+\beta t_1$

$\Rightarrow t_1=\frac{\beta}{\alpha+\beta}t$

$\therefore\ v=\frac{\alpha\beta}{\alpha+\beta}t$

7. (c) If a stone is dropped from height *h*

then $h=\frac{1}{2}gt^2$ …(i)

If a stone is thrown upward with velocity *u* then

$h=-u\,t_1+\frac{1}{2}g\,t_1^2$ …(ii)

If a stone is thrown downward with velocity *u* then

$h=ut_2+\frac{1}{2}gt_2^2$ …(iii)

From (i) (ii) and (iii) we get

$-ut_1+\frac{1}{2}gt_1^2=\frac{1}{2}gt^2$ …(iv)

$ut_2+\frac{1}{2}gt_2^2=\frac{1}{2}gt^2$ …(v)

Dividing (iv) and (v) we get

$\therefore\ \frac{-ut_1}{ut_2}=\frac{\frac{1}{2}g(t^2-t_1^2)}{\frac{1}{2}g(t^2-t_2^2)}$

or $-\frac{t_1}{t_2}=\frac{t^2-t_1^2}{t^2-t_2^2}$

By solving $t=\sqrt{t_1t_2}$

8. (c) Since direction of *v* is opposite to the direction of *g* and *h* so from equation of motion

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

$\Rightarrow gt^2-2vt-2h=0$

$\Rightarrow t=\frac{2v\pm\sqrt{4v^2+8gh}}{2g}$

$\Rightarrow t=\frac{v}{g}\left[1+\sqrt{1+\frac{2gh}{v^2}}\right]$

9. (c) $h=ut+\frac{1}{2}gt^2 \Rightarrow 1=0\times t_1+\frac{1}{2}gt_1^2 \Rightarrow t_1=\sqrt{2/g}$

Velocity after travelling 1*m* distance

$v^2 = u^2 + 2gh \Rightarrow v^2 = (0)^2 + 2g \times 1 \Rightarrow v = \sqrt{2g}$

For second 1 meter distance

$1 = \sqrt{2g} \times t_2 + \frac{1}{2} g t_2^2 \Rightarrow g t_2^2 + 2\sqrt{2g} t_2 - 2 = 0$

$t_2 = \frac{-2\sqrt{2g} \pm \sqrt{8g + 8g}}{2g} = \frac{-\sqrt{2} \pm 2}{\sqrt{g}}$

Taking +ve sign $t_2 = (2 - \sqrt{2}) / \sqrt{g}$

$\therefore \frac{t_1}{t_2} = \frac{\sqrt{2/g}}{(2 - \sqrt{2})/\sqrt{g}} = \frac{1}{\sqrt{2} - 1}$ and so on.

10. (d) Interval of ball throw = 2 *sec.*

If we want that minimum three (more than two) ball remain in air then time of flight of first ball must be greater than 4 *sec.*

$T > 4\ sec$

$\frac{2u}{g} > 4\ sec \Rightarrow u > 19.6\ m/s$

for *u* =19.6. First ball will just strike the ground(in sky)

Second ball will be at highest point (in sky)

Third ball will be at point of projection or at ground (not in sky)

11. (a) The distance covered by the ball during the last *t* seconds of its upward motion = Distance covered by it in first *t* seconds of its downward motion

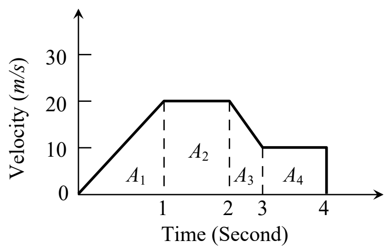
From $h = ut + \frac{1}{2} g t^2$

$h = \frac{1}{2} g t^2$ [*As u* = 0 for it downward motion]

12. (c)

Graphical Questions

1. (b) Distance = Area under *v* – *t* graph $= A_1 + A_2 + A_3 + A_4$



$= \frac{1}{2} \times 1 \times 20 + (20 \times 1) + \frac{1}{2}(20 + 10) \times 1 + (10 \times 1)$

$= 10 + 20 + 15 + 10 = 55\ m$

2. (a) The slope of displacement-time graph goes on decreasing, it means the velocity is decreasing *i.e.* It's motion is retarded and finally slope becomes zero *i.e.* particle stops.

3. (d) In the positive region the velocity decreases linearly (during rise) and in the negative region velocity increases linearly (during fall) and the direction is opposite to each other during rise and fall, hence fall is shown in the negative region.

4. (b) Region *OA* shows that graph bending toward time axis *i.e.* acceleration is negative.

Region *AB* shows that graph is parallel to time axis *i.e.* velocity is zero. Hence acceleration is zero.

Region *BC* shows that graph is bending towards displacement axis *i.e.* acceleration is positive.

Region *CD* shows that graph having constant slope *i.e.* velocity is constant. Hence acceleration is zero.

5. (d) Maximum acceleration means maximum change in velocity in minimum time interval.

In time interval $t = 30$ to $t = 40$ sec

$a = \frac{\Delta v}{\Delta t} = \frac{80 - 20}{40 - 30} = \frac{60}{10} = 6\ cm/sec^2$

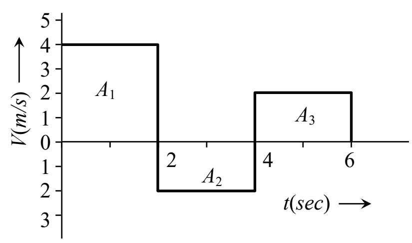
6. (c) In part *cd* displacement-time graph shows constant slope *i.e.* velocity is constant. It means no acceleration or no force is acting on the body.

7. (d) Up to time t_1 slope of the graph is constant and after t_1 slope is zero *i.e.* the body travel with constant speed up to time t_1 and then stops.

8. (c) Area of trapezium $= \frac{1}{2} \times 3.6 \times (12 + 8) = 36.0\ m$

9. (a) Displacement = Summation of all the area with sign

$= (A_1) + (-A_2) + (A_3) = (2 \times 4) + (-2 \times 2) + (2 \times 2)$



$\therefore$ Displacement = 8 *m*

Distance =Summation of all the areas without sign

$= |A_1| + |-A_2| + |A_3| = |8| + |-4| + |4| = 8 + 4 + 4$

$\therefore$ Distance = 16 *m*.

10. (b) Between time interval 20 *sec* to 40 *sec*, there is non-zero acceleration and retardation. Hence distance travelled during this interval

= Area between time interval 20 *sec* to 40 *sec*

$= \frac{1}{2} \times 20 \times 3 + 20 \times 1$ = 30 + 20 = 50 *m*.

11. (c)

12. (b) $\frac{(S)_{(last\,2s)}}{(S)_{7s}} = \frac{\frac{1}{2} \times 2 \times 10}{\frac{1}{2} \times 2 \times 10 + 2 \times 10 + \frac{1}{2} \times 2 \times 10} = \frac{1}{4}$

13. (a) Distance = Area covered between graph and displacement axis $= \frac{1}{2}(30 + 10)10 = 200\ meter$.

14. (d) Because acceleration due to gravity is constant so the slope of line will be constant *i.e.* velocity time curve for a body projected vertically upwards is straight line.

15. (d) Slope of displacement time graph is negative only at point *E*.

16. (c) $v^2 = u^2 + 2aS$, If $u = 0$ then $v^2 \propto S$

i.e. graph should be parabola symmetric to displacement axis.

17. (a) This graph shows uniform motion because line having a constant slope.

18. (a) For the given condition initial height $h = d$ and velocity of the ball is zero. When the ball moves downward its velocity increases and it will be maximum when the ball hits the ground & just after the collision it becomes half and in opposite direction. As the ball moves upward its velocity again decreases and becomes zero at height $d/2$. This explanation match with graph (*A*).

19. (a) We know that the velocity of body is given by the slope of displacement – time graph. So it is clear that initially slope of the graph is positive and after some time it becomes zero (corresponding to the peak of graph) and then it will becomes negative.

20. (b) Maximum acceleration will be represented by *CD* part of the graph

Acceleration $= \frac{dv}{dt} = \frac{(60 - 20)}{0.25} = 160\ km/h^2$

21. (d)

22. (c) For upward motion

Effective acceleration $= -(g + a)$

and for downward motion

Effective acceleration $= (g - a)$

But both are constants. So the slope of speed-time graph will be constant.

23. (a) Since slope of graph remains constant for velocity-time graph.

24. (b) Other graph shows more than one velocity of the particle at single instant of time which is not practically possible.

25. (a) Slope of velocity-time graph measures acceleration. For graph (a) slope is zero. Hence $a = 0$ *i.e.* motion is uniform.

26. (c) From acceleration time graph, acceleration is constant for first part of motion so, for this part velocity of body increases uniformly with time and as *a* = 0 then the velocity becomes constant. Then again increased because of constant acceleration.

27. (a) Given line have positive intercept but negative slope. So its equation can be written as

$v = -mx + v_0$ .....(i) [where $m = \tan\theta = \frac{v_0}{x_0}$]

By differentiating with respect to time we get $\frac{dv}{dt} = -m\frac{dx}{dt} = -mv$

Now substituting the value of *v* from eq. (i) we get $\frac{dv}{dt} = -m[-mx + v_0] = m^2x - mv_0$ $\therefore$

$a = m^2x - mv_0$

i.e. the graph between *a* and *x* should have positive slope but negative intercept on *a*-axis. So graph (a) is correct.

28. (c) From given $a-t$ graph it is clear that acceleration is increasing at constant rate

$\therefore \frac{da}{dt}=k$ (constant) $\Rightarrow$ $a=kt$ (by integration)

$\Rightarrow \frac{dv}{dt}=kt \Rightarrow dv=ktdt$

$\Rightarrow \int dv=k\int tdt \Rightarrow v=\frac{kt^2}{2}$

i.e. v is dependent on time parabolically and parabola is symmetric about v-axis.

and suddenly acceleration becomes zero. *i.e*. velocity becomes constant.

Hence (c) is most probable graph.

29. (c) In first instant you will apply $\upsilon=\tan\theta$ and say, $\upsilon=\tan 30^o=\frac{1}{\sqrt{3}}$ *m*/*s*.

But it is wrong because formula $\upsilon=\tan\theta$ is valid when angle is measured with time axis.

Here angle is taken from displacement axis. So angle from time axis $=90^o-30^o=60^o$

Now $\upsilon=\tan 60^o=\sqrt{3}$

30. (a) Since total displacement is zero, hence average velocity is also zero.

Assertion and Reason

1. (a) When body going vertically upwards, reaches at the highest point, then it is momentarily at rest and it then reverses its direction. At the highest point of motion, its velocity is zero but its acceleration is equal to acceleration due to gravity.

2. (a) As motion is governed by force of gravity and acceleration due to gravity (g) is independent of mass of object.

3. (a) As distance being a scalar quantity is always positive but displacement being a vector may be positive, zero and negative depending on situation.

4. (a) As displacement is either smaller or equal to distance but never be greater than distance.

5. (a) Since velocity is a vector quantity, hence as its direction changes keeping magnitude constant, velocity is said to be changed. But for constant speed in equal time interval distance travelled should be equal.

6. (d) Speed can never be negative because it is a scalar quantity.

7. (c) Negative slope of position time graph represents that the body is moving towards the negative direction and if the slope of the graph decrease with time then it represents the decrease in speed *i.e.* retardation in motion.

8. (b) A body having positive acceleration can be associated with slowing down, as time rate of change of velocity decreases, but velocity increases with time, from graph it is clear that slope with time axis decreases, but velocity increases with time.

9. (b) A body having negative acceleration can be associated with a speeding up, if object moves along negative *X*-direction with increasing speed.

10. (e) It is not necessary that an object moving under uniform acceleration have straight path. *eg*. projectile motion.

11. (a) Motion of rocket is based on action reaction phenomena and is governed by rate of fuel burning causing the change in momentum of ejected gas.

12. (a) When a body moves on a straight path in one direction value of distance & displacement remains same so that average speed equals the average velocity for a given time interval.

13. (a) Position-time graph for a stationary object is a straight line parallel to time axis showing that no change in position with time.

14. (a) Since slope of displacement-time graph measures velocity of an object.

15. (e) For distance-time graph, a straight line inclined to time axis measures uniform speed for which acceleration is zero and for uniformly accelerated motion $S \propto t^2$.

16. (e) As per definition, acceleration is the rate of change of velocity, *i.e.* $\vec{a} = \frac{d\vec{v}}{dt}$.

If velocity is constant $d\vec{v}/dt = 0, \ \therefore \vec{a} = 0$.

Therefore, if a body has constant velocity it cannot have non zero acceleration.

17. (a) A body has no relative motion with respect to itself. Hence if a frame of reference of the body is fixed, then the body will be always at relative rest in this frame of reference.

18. (c) The displacement is the shortest distance between initial and final position. When final position of a body coincides with its initial position, displacement is zero, but the distance travelled is not zero.

19. (d) Equation of motion can be applied if the acceleration is in opposite direction to that of velocity and uniform motion mean the acceleration is zero.

20. (e) As velocity is a vector quantity, its value changes with change in direction. Therefore when a bus takes a turn from north to east its velocity will also change.

21. (b) When two bodies are moving in opposite direction, relative velocity between them is equal to sum of the velocity of bodies. But if the bodies are moving in same direction their relative velocity is equal to difference in velocity of the bodies.

22. (d) The displacement of a body moving in straight line is given by, $s = ut + \frac{1}{2}at^2$. This is a equation of a parabola, not straight line. Therefore the displacement-time graph is a parabola. The displacement time graph will be straight line, if acceleration of body is zero or body moving with uniform velocity.

23. (c) In uniform motion the object moves with uniform velocity, the magnitude of its velocity at different instant *i.e.* at $t = 0$, $t = 1sec$, $t = 2sec$,.... will always be constant. Thus velocity-time graph for an object in uniform motion along a straight path is a straight line parallel to time axis.

24. (e) The uniform motion of a body means that the body is moving with constant velocity, but if the direction of motion is changing (such as in uniform circular motion), its velocity changes and thus acceleration is produced in uniform motion.

25. (e) When a body falling freely, only gravitational force acts on it in vertically downward direction. Due to this downward acceleration the velocity of a body increases and will be maximum when the body touches the ground.

26. (a) According to definition,displacement = velocity × time Since displacement is a vector quantity so its value is equal to the vector sum of the area under velocity-time graph.

27. (e) If the position-time graph of a body moving uniformly in a straight line parallel to position axis, it means that the position of body is changing at constant time. The statement is abrupt and shows that the velocity of body is infinite.

28. (b) Average speed = Total distance /Total time

Time average speed $= \frac{v_1 + v_2 + v_3 + ...}{n}$

29. (c) An object is said to be in uniform motion if it undergoes equal displacement in equal intervals of time.

$$\therefore v_{av} = \frac{s_1 + s_2 + s_3 + ...}{t_1 + t_2 + t_3 + ...} = \frac{s + s + s + ...}{t + t + t + ...} = \frac{ns}{nt} = \frac{s}{t}$$

and $v_{ins} = \frac{s}{t}$.

Thus, in uniform motion average and instantaneous velocities have same value and body moves with constant velocity.

30. (e) Speedometer measures instantaneous speed of automobile.