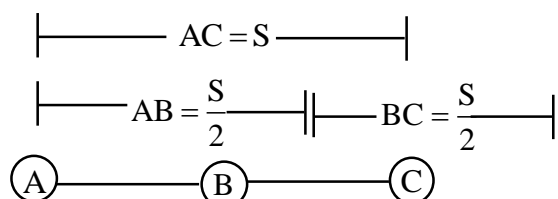


**Inchapter Exercise**

1.



Given  $V_{avg} = 90$

$$V_{AB} = 60$$

$$t_{AB} = \frac{S_{AB}}{V_{AB}}$$

$$t_{AB} = \frac{S/2}{60} = \frac{S}{120}$$

$$V_{BC} = ? = V \text{ let}$$

$$t_{BC} = \frac{S_{BC}}{V_{BC}} \rightarrow S/2$$

$$t_{BC} = \frac{S}{2V}$$

$$t_{AB} + t_{BC} = t_{AC}$$

$$\frac{S}{120} + \frac{S}{2V} = t \quad \text{_____ (1)}$$

$$\text{Also } V_{avg} = \frac{S}{t} \Rightarrow 90 = \frac{S}{t}$$

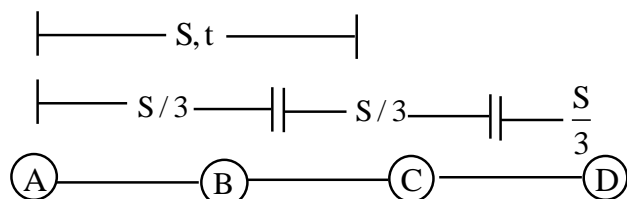
$$\Rightarrow t = \frac{S}{90} \quad \text{_____ (2)}$$

$$\Rightarrow t = \frac{S}{90} = \frac{S}{120} + \frac{S}{2V} \Rightarrow \frac{1}{90} = \frac{2V+120}{240V}$$

$$\Rightarrow 240V = 180V + 120 \times 90$$

$$60V = 120 \times 90 \Rightarrow V = 180$$

2.



$$V_B = u$$

$$t_{AB} = \frac{S_{AB}}{V_{AB}}$$

$$= \frac{S/3}{u}$$

$$t_{AB} = \frac{S}{3u}$$

$$V_{BC} = V$$

$$t_{BC} = \frac{S/3}{V}$$

$$t_{BC} = \frac{S}{3V}$$

$$V_{CD} = w$$

$$t_{CD} = \frac{S/3}{w}$$

$$t_{CD} = \frac{S}{3w}$$

$$t_{AD} = t_{AB} + t_{BC} + t_{CD}$$

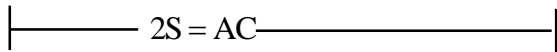
↓

$$t = \frac{S}{3u} + \frac{S}{3V} + \frac{S}{3w}$$

$$t = \frac{S [vw + uw + uv]}{3 uvw}$$

$$\text{Avg speed} = \frac{s}{t} = \frac{s}{\frac{s}{3} \left( \frac{vw + uw + uv}{uvw} \right)} = \frac{3uvw}{uv + uw + uv}$$

3.



$$V_{AB} = \frac{30\text{km}}{\text{hr}}$$

$$t_{AB} = \frac{S}{30}$$

$$V_{BC} = V$$

$$t_{BC} = \frac{S}{V}$$

$$t_{AC} = t_{AB} + t_{BC}$$

↓      ↓

$$10\text{hr} = \frac{S}{30} + \frac{S}{V} \quad \text{_____ (1)}$$

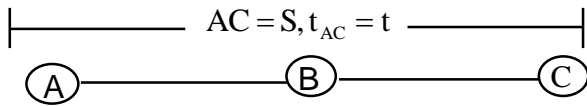
$$V_{\text{avg}} = \frac{S_{\text{total}}}{t_{\text{total}}} \Rightarrow 40 = \frac{2S}{10}$$

$$(40\text{km/hr given}) \Rightarrow S = 200 \quad \text{_____ (2)}$$

$$\Rightarrow 10 = \frac{200}{30} + \frac{200}{V} \Rightarrow \frac{200}{V} = 10 - \frac{20}{3}$$

$$\Rightarrow \frac{200}{V} = \frac{30-20}{3} \Rightarrow V = \frac{200 \times 3}{10} = 60 \text{ km/hr}$$

4. (a) half the time is covered with  $V_1$  and other half the time is covered with  $V_2$



$$t_{AB} = t/2$$

$$V_{AB} = V_1$$

$$S_{AB} = V_{AB} t_{AB}$$

$$= \frac{V_1 t}{2}$$

$$t_{BC} = t/2$$

$$V_{BC} = V_2$$

$$S_{BC} = V_{BC} t_{BC}$$

$$= \frac{V_2 t}{2}$$

$$S_{AC} = S_{AB} + S_{BC}$$

$$S = \frac{V_1 t}{2} + \frac{V_2 t}{2} = \left( \frac{V_1 + V_2}{2} \right) t$$

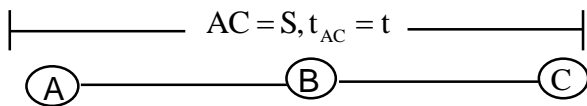
$$\text{Avg. speed} = \frac{S}{t} = \frac{\left( \frac{V_1 + V_2}{2} \right) t}{t} = \frac{V_1 + V_2}{2}$$

$$t = \frac{S}{2} \left[ \frac{V_2 + V_1}{V_1 V_2} \right]$$

$$\text{Avg. speed} = \frac{S}{t}$$

$$= \frac{S}{\frac{S}{2} \left[ \frac{V_2 + V_1}{V_1 V_2} \right]} = \frac{2V_1 V_2}{V_1 + V_2}$$

4. (b)



$$S_{AB} = S/2$$

$$V_{AB} = V_1$$

$$t_{AB} = \frac{S_{AB}}{V_{AB}} = \frac{S/2}{V_1} = \frac{S}{2V_1}$$

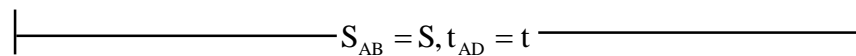
$$S_{BC} = S/2$$

$$V_{BC} = V_2$$

$$t_{BC} = \frac{S_{BC}}{V_{BC}} = \frac{S}{2V_2}$$

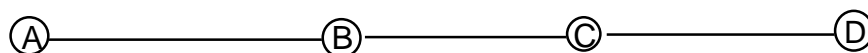
$$t = t_{AC} = t_{AB} + t_{BC} = \frac{S}{2V_1} + \frac{S}{2V_2}$$

4. (c)



$$S_{AB} = \frac{S}{3}$$

$$S_{BD} = \frac{2S}{3}, t_{BD} = t_1$$



$$\begin{array}{lll}
S_{AB} = S/3 & t_{BC} = \frac{t_1}{4} & t_{CD} = \frac{3t_1}{4} \\
V_{AB} = V_1 & V_{BC} = V_2 & V_{CD} = V_3 \\
t_{AB} = \frac{S_{AB}}{V_{AB}} = \frac{S}{3V_1} & S_{BC} = V_{BC}t_{BC} & S_{CD} = V_{CD}t_{CD} \\
& = \frac{V_2 t_1}{4} & = \frac{3V_3 t_1}{4}
\end{array}$$

$$\text{Total time} = t = t_{AD} = t_{AB} + t_{BD}$$

$$t = \frac{S}{3V_1} + \frac{8S}{3(V_2 + 3V_3)}$$

$$S_{BD} = S_{BC} + S_{CD}$$

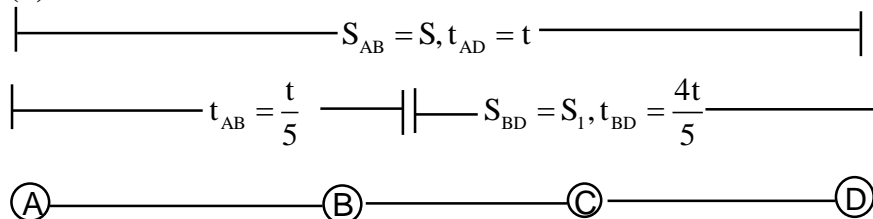
$$\frac{2S}{3} = \frac{V_2 t_1}{4} + \frac{3V_3 t_1}{4}$$

$$\text{On solving } t_1 = \frac{8S}{3[V_2 + 3V_3]}$$

$$t = \frac{S}{3} \left[ \frac{(V_2 + 3V_3) + 8V_1}{V_1(V_2 + 3V_3)} \right]$$

$$\begin{aligned}
\text{Avg speed} &= \frac{S}{t} = \frac{S}{\frac{S}{3} \left[ \frac{(V_2 + 3V_3) + 8V_1}{V_1(V_2 + 3V_3)} \right]} \\
&= \frac{3V_1(V_2 + 3V_3)}{V_2 + 3V_3 + 8V_1}
\end{aligned}$$

4. (d)



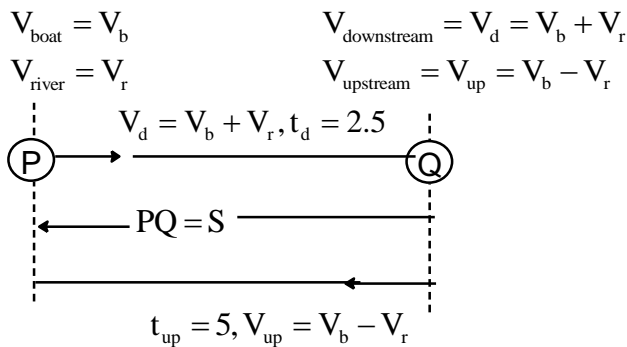
$$\begin{array}{lll}
V_{AB} = V_1 & S_{BC} = \frac{3S_1}{4} & S_{CD} = \frac{S_1}{4} \\
t_{AB} = t/5 & V_{BC} = V_2 & V_{CD} = V_3 \\
\Rightarrow S_{AB} = V_{AB}t_{AB} = \frac{V_1 t}{5} & t_{BC} = \frac{S_{BC}}{V_{BC}} = \frac{3S_1}{4V_2} & t_{CD} = \frac{S_{CD}}{V_{CD}} = \frac{S_1}{4V_3}
\end{array}$$

$$\begin{array}{ll}
S_{\text{Total}} = S_{AD} = S_{AB} + S_{BD} & t_{BD} = t_{BC} + t_{CD} \\
S = \frac{V_1 t}{5} + \frac{16V_2 V_3 t}{5[3V_3 + V_2]} & \frac{4t}{5} = \frac{3S_1}{4V_2} + \frac{S_1}{4V_3}
\end{array}$$

$$\begin{aligned}
S &= \frac{t}{5} \left[ \frac{V_1(3V_3 + V_2) + 16V_2 V_3}{(3V_3 + V_2)} \right] & \frac{4t}{5} &= \frac{S_1}{4} \left[ \frac{3V_3 + V_2}{V_2 V_3} \right] \\
\Rightarrow S_1 &= \frac{16V_2 V_3 t}{5(3V_3 + V_2)}
\end{aligned}$$

$$\begin{aligned}
\text{Average speed} &= \frac{S}{t} \\
&= \frac{\frac{t}{5} (V_1(3V_3 + V_2) + 16V_2 V_3)}{(3V_3 + V_2)} = \frac{3V_1 V_3 + V_1 V_2 + 16V_2 V_3}{5(3V_3 + V_2)}
\end{aligned}$$

5. Let



From downstream,  $S_d = V_d t_d$

$$\Rightarrow S = (V_b + V_r) 2.5 \quad \text{_____ (1)}$$

From upstream,  $S_{\text{up}} = V_{\text{up}} t_{\text{up}}$

$$S = (V_b - V_r) 5 \quad \text{_____ (2)}$$

$$\Rightarrow S[V_b + V_r] 2.5 = (V_b - V_r) 5$$

$$V_b + V_r = 2V_b - 2V_r \Rightarrow V_b = 3V_r$$

$$\text{As, } S = (V_b + V_r) 2.5 = (3V_r + V_r) 2.5 \Rightarrow S = 10V_r \quad \text{_____ (3)}$$

Due to monsoon

$$V'_r = 2V_r$$

$$\Rightarrow V'_D = V_b + V'_r = 3V_r + 2V_r$$

$$= 5V_r$$

From 3

$$S_d = V'_D t'_d$$

$$S = 5V_r t'_d \Rightarrow 10V_r = 5V_r t'_d$$

$$\Rightarrow t'_d = 2$$

Last

$$V'_{\text{up}} = V_b - V'_r = 3V_r - 2V_r$$

$$V'_{\text{up}} = V_r$$

$$S_{\text{up}} = V'_{\text{up}} t'_{\text{up}} \Rightarrow S = V_r t'_{\text{up}}$$

$$10V_r = V_r t'_{\text{up}}$$

$$\Rightarrow t'_{\text{up}} = 10$$

6.  $u = 0$

$$V = 180 \text{ km/hr} = 180 \times \frac{5}{18} = 50 \text{ m/s}$$

$$t = 25 \text{ sec}$$

$$a = \frac{V - u}{t} = \frac{50 - 0}{25} = 2 \text{ m/s}^2$$

$$S = \frac{V^2 - u^2}{2a} = \frac{50^2 - 0^2}{2 \times 2} = 625 \text{ m}$$

7.  $u = 126 \frac{\text{km}}{\text{hr}} = 126 \times \frac{5}{18} = 35 \text{ m/s}$

$$V = 0, S = 200 \text{ m}$$

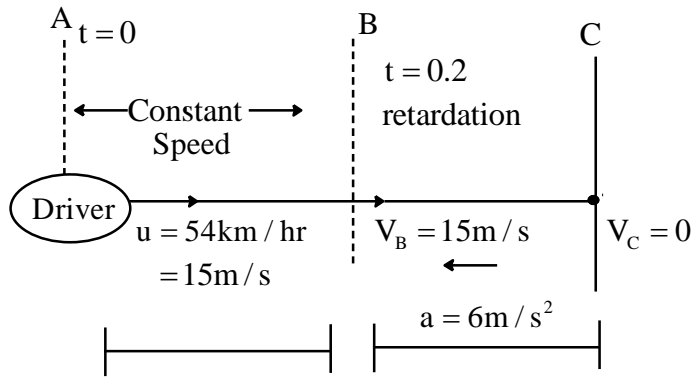
$$a = \frac{V^2 - u^2}{2S} = \frac{0^2 - (35)^2}{2 \times 200}$$

$$a = -\frac{1225}{400} = -3.0625 \leftarrow \text{Acceleration}$$

Retardation =  $+3.06 \text{ m/s}^2$

$$t = \frac{V - u}{a} = \frac{0 - 35}{-3.06}$$

8.



$$AB = S_{AB} = V_{AB}t$$

$$= 15 \times 0.2$$

$$= 3\text{m}$$

$$BC = S_{BC} = \frac{V_C^2 - V_A^2}{2}$$

$$= \frac{0^2 - 15^2}{2 \times -6}$$

$$= \frac{225}{12}$$

9.  $S_{7^{\text{th}}} = 20 = u + \frac{a}{2}[2(7) - 1]$

$$20 = u + \frac{13a}{2} \quad \text{_____ (1)}$$

$$S_{9^{\text{th}}} = 24 = u + \frac{a}{2}[2(9) - 1]$$

$$24 = u + \frac{17a}{2} \quad \text{_____ (2)}$$

From (1) and (2)

$$\Rightarrow a = 2 \Rightarrow u = 7$$

$$S_{15^{\text{th}}} = u + \frac{a}{2}[2(15) - 1] = 7 + \frac{2}{2}(29) = 36\text{m}$$

10.  $S_{2^{\text{nd}}} = 12$                        $S_{4^{\text{th}}} = 20\text{m}$

$$S_{2^{\text{nd}}} = u + a\left(2 - \frac{1}{2}\right) = 12$$

$$u + a\left[4 - \frac{1}{2}\right] = 20$$

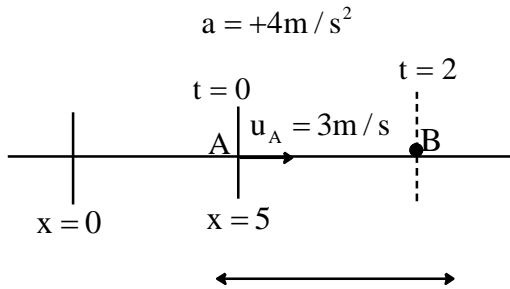
$$\therefore a = 4\text{m/s}^2, u = 6\text{m/s}$$

Distance covered in 4 sec after 5<sup>th</sup> second =  $S_a - S_5$

$$= \left(6 \times 9 + \frac{1}{2} \times 4 \times 9^2\right) - \left(6 \times 5 + \frac{1}{2} \times 4 \times 5^2\right)$$

$$= 216 - 80 = 136\text{m}$$

11.



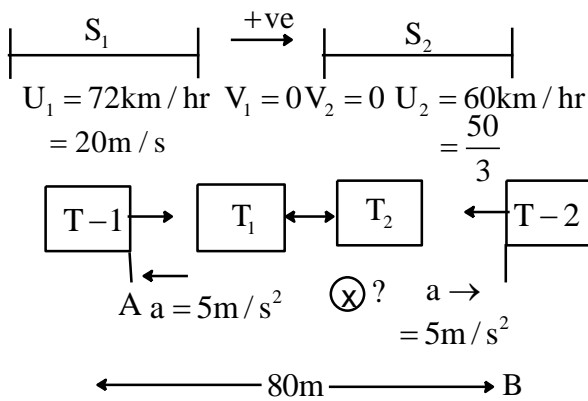
$$S_{AB} = 3(2) + \frac{1}{2}4(2)^2$$

$$S_{AB} = 14\text{m}$$

$$\text{Position} = 14 + 5 = 19$$

$$V_{AB} = 3 + 4(2) = 11\text{m/s}$$

12.



$$|\vec{S}_1| + x + |\vec{S}_2| = 80$$

$$S_1 = \frac{0^2 - (20)^2}{2(-5)} \quad \Rightarrow 40 + x + \left| \frac{-250}{9} \right| = 80$$

$$= 40\text{m} \quad x = \frac{110}{9}$$

$$S_2 = \frac{0^2 - (50/3)^2}{2(+5)} = \frac{-250}{9}$$

13. (i)  $h_{\max} = \frac{u^2}{2g} = \frac{98^2}{2 \times 9.8} = 490\text{m}$

(ii)  $t_a = \frac{u}{g} = \frac{98}{9.8} = 125^\circ$

(iii)  $v^2 = 98^2 - 2 \times 9.8 \times 196$   
 $\therefore v = 75.91$

(iv)  $v = 98\text{m/s}$

(v)  $T = \frac{2u}{g} = \frac{2 \times 98}{9.8} = 20\text{s}$

14. Assume  $\uparrow = +ve$

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

$$a = -9.8 \text{ m/s}^2$$

$$s = -h$$

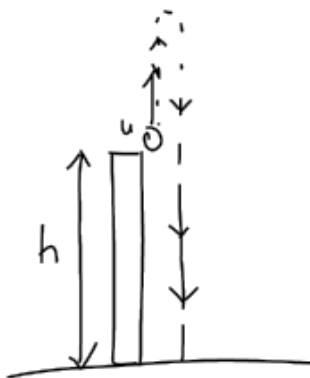
$$t = 6 \text{ sec}$$

$$\Rightarrow -h = 19.6 \times 6 + \frac{1}{2}(-9.8) \times (6)^2$$

$$-h = 19.6 \times 6 - 9.8 \times 18$$

$$h = 19.6 \times 3$$

$$= 58.8 \text{ m}$$



15.  $h_{\max} = \frac{u^2}{2g}, T = \frac{2u}{g} \quad \therefore T = 4 = \frac{2 \times u}{9.8}$

$$\therefore u = 19.6 \text{ m/s} \quad h_{\max} = \frac{19.6^2}{2 \times 9.8} = 19.6 \text{ m}$$

Height of body after 3 S =

$$S = 19.6 \times 3 - \frac{1}{2} \times 9.8 \times 3^2 = 14.7 \text{ m}$$

$$\text{Distance below highest point} = 19.6 - 14.7 = 4.9 \text{ m}$$

16. Taking downward positive

Packet is going up with 9.8 m/s at a height of 39.2 m when it was released

$$39.2 = -9.8 \times t + 4.9t^2$$

$$\therefore t = 4 \text{ s or } t = -2 \text{ s}, \quad \therefore t = 4 \text{ s}$$

$$\text{Also } v = -9.8 \times 9.8 \times 4 = 29.4 \text{ m/s}$$

17. For A,  $S_A = 20t - 4.9t^2$

$$\text{For B, } S_B = 4.9t^2 + 20t$$

$$S_A + S_B = 40 = 40t$$

$$\therefore t = 1 \text{ s}, S_A = 20 \times 1 - 4.9 \times 1^2 = 15.1 \text{ m}$$

18.  $u = 0, g = 9.8 \text{ m.s}^2$

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

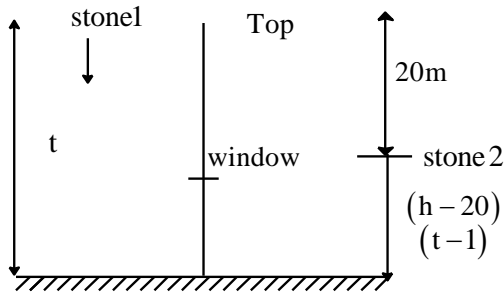
$$24.5 = 0 + 9.8 \left[ n - \frac{1}{2} \right]$$

$$n = 3$$

$$S = 0 \times 3 + \frac{1}{2} \times 9.8 \times 3^2 = 44.1 \text{ m}$$



19.



$$h = 0 \times t + \frac{1}{2} \times 0 \times t^2 \Rightarrow \text{for 1st stone}$$

$$t = \sqrt{\frac{h}{5}}$$

$$h - 20 = 0 \times t + \frac{1}{2} \times 0 \times (t-1)^2 \text{ for 2nd stone}$$

$$\therefore h = 20 = 5 \times \left[ \sqrt{\frac{h}{5}} - 1 \right]^2$$

$$\therefore h = 31.25\text{m}$$

20.  $u = 0, g = 10\text{m/s}^2, s = 45\text{m}, t = ?$

$$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 45}{10}} = 3$$

Time taken by sound to reach to of well =  $3.125 - 3 = 0.125\text{s}$

$$\text{Velocity of sound} = \frac{45}{0.125} = 360\text{m/s}$$

21. Safety depends on velocity of reaching ground.

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

$$V_e = \sqrt{2 \times 9.8 \times 2} = \sqrt{9.8 \times 4} \rightarrow \text{Earth}$$

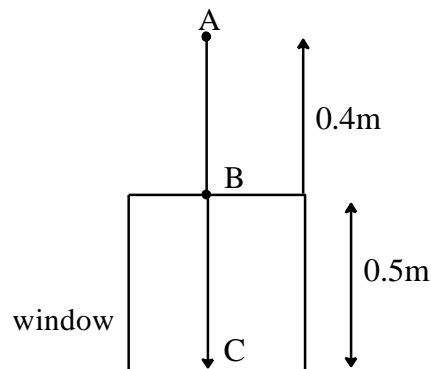
$$V_p = \sqrt{2 \times 1.96 \times h} \rightarrow \text{Planet}$$

$$V_e = V_p = \text{safe velocity}$$

$$\therefore \sqrt{9.8 \times 4} = \sqrt{2 \times 1.96 \times h}$$

$$\therefore h = 10\text{m}$$

22.



$$\text{For AB, } 0.4 = \frac{1}{2} \times 98 \times t_1^2, \therefore t_1 = 0.28\text{s}$$

$$\text{For AC, } 0.9 = \frac{1}{2} \times 9.8 \times t_2^2 \quad \therefore t_2 = 0.425\text{s}$$

Time to pass span of window  
 $= t_2 - t_1 = 0.425 - 0.28\text{s} = 0.145\text{s}$

23.  $y = u_y t + \frac{1}{2} g t^2 = 0 \times 3 + \frac{1}{2} \times 9.8 \times 3^2$   
 $= 44.1\text{m}$

Final vertical velocity  $v_y = 0 + 9.8 \times 3 = 29.4\text{m/s}$

Final horizontal velocity  $v_x = u$

Resultant velocity makes  $45^\circ$  with horizontal

$$\tan 45^\circ = \frac{v_y}{v_x}, \quad a = \frac{29.4}{u}$$

$$\therefore u = 29.4\text{m/s}$$

24.  $1000 = 0 \times t + \frac{1}{2} \times 9.8 \times t^2$

$$\therefore t = \sqrt{\frac{1000}{4.9}} = \frac{100}{7}\text{s}$$

Horizontal velocity of aeroplane

$$= 500\text{km/hr} = 500 \times \frac{5}{18} = \frac{1250}{9}\text{m/s}$$

Distance of missing

$$\text{Horizontal distance covered when it strikes ground} = \frac{1250}{9} \times \frac{100}{7} = 1984.13\text{m}$$

25. Horizontal velocity at any instant

$$V_x = u = 9.8\text{m/s}$$

$$V_y = 9.8 = 0 + 9.8t$$

$$\therefore t = 1\text{s}$$

26.  $\theta = 90 - 30 = 60^\circ$

$$u = \frac{u^2 \sin^2 \theta}{2g} = \frac{30^2 \sin^2 60}{2 \times 9.8} = 34.44\text{m}$$

$$T = \frac{2u \sin \theta}{g} = \frac{2 \times 30 \times \sin 60}{9.8} = 5.3\text{s}$$

$$R = \frac{u^2 \sin 2\theta}{g} = \frac{30^2 \sin 120}{9.8} = 79.53\text{m}$$

27.  $R_{\max} = \frac{u^2}{g} = 100\text{m}$

$$u^2 = 100g, u = \sqrt{100g}$$

$$h_{\max} = \frac{u^2}{2g} = \frac{100g}{2g} = 50\text{m}$$

$$28. \quad H = \frac{u^2 \sin^2 \theta}{2g} \therefore 25 = \frac{40^2 \sin^2 \theta}{2 \times 9.8}$$

$$\sin^2 \theta = 0.306, \therefore \sin \theta = \sqrt{0.306} = 0.554$$

$$\cos \theta = \sqrt{1 - \sin^2 \theta} = \sqrt{0.694} = \sqrt{0.694} = 0.833$$

$$R = \frac{u^2 \sin^2 \theta}{g} = \frac{2u^2 \sin \theta \cos \theta}{g} = \frac{2 \times 40^2 \times 0.554 \times 0.833}{9.8} = 150.7\text{m}$$

$$29. \quad 3000 = \frac{u^2 \sin 60}{g}$$

$$R_{\max} = \frac{u^2}{g} = \frac{3000 \times 2}{\sqrt{3}} = 2000\sqrt{3} < 5000\text{m}$$

$\therefore$  500m (5km) target cannot be hit.

$$30. \quad l^2 = \frac{u^2 \sin^2 \theta}{g} = \frac{2u^2 \sin \theta \cos \theta}{g}$$

$$4 \max = \frac{u^2 \sin^2 \theta}{2g}$$

Dividing  $\frac{H_{\max}}{12} = \frac{\tan \theta}{4}$

$$\therefore \tan \theta = \frac{4u}{12} = \frac{4 \times 10}{50} = 0.8$$

$$\theta = \tan^{-1}(0.8)$$

$$31. \quad \text{Here } H_{\max} = 19.6$$

$$\frac{R}{2} = 39.2 \quad \therefore R = 78.4$$

$$\frac{H_{\max}}{R} = \frac{1}{4} \tan \theta$$

$$\tan \theta = \frac{4H_{\max}}{R} = \frac{4 \times 19.6}{78.4} = 1$$

$$\theta = 45^\circ \Rightarrow R = \frac{u^2 \sin 90^\circ}{g} = 78.4$$

$$\Rightarrow u = 19.6\sqrt{2}\text{m/s}$$

$$32. \quad H = \frac{(39.2)^2 \times \sin^2 \theta}{2 \times 9.8}$$

$$H + 50 = \frac{(39.2)^2 \times \sin^2 (90 - \theta)}{2 \times 9.8} = \frac{(39.2)^2 \cos^2 \theta}{2 \times 9.8}$$

Adding  $24 + 50 = \frac{(39.2)^2}{2 \times 9.8} (\sin^2 \theta + \cos^2 \theta)$

$$24 + 50 = \frac{39.2^2}{19.6} = 78.4$$

$\therefore H = 14.2\text{m}$   
 $4 + 50 = 64.2\text{m}$

$$33. \quad R_1 = \frac{u^2 \sin^2 \theta}{g}, R_2 = \frac{4^2 \sin^2 (90 - \theta)}{g}$$

$$R_2 = \frac{u^2 \sin(180 - 2\theta)}{g} = \frac{u^2 \sin 2\theta}{g}$$

$$\therefore R_1 = R_2$$

$$H_1 = \frac{u^2 \sin^2 \theta}{2g} \quad H_2 = \frac{u^2 \sin^2 (90 - \theta)}{2g} = \frac{u^2 \cos^2 \theta}{2g}$$

$$H_1 + H_2 = \frac{u^2}{2g} (\sin^2 \theta + \cos^2 \theta) = \frac{u^2}{2g}, \text{ which is independent of } \theta.$$

$$34. \quad \theta = 90 - 30 = 60^\circ$$

$$u_x = u \cos 60 = 19.6$$

$$\therefore u = \frac{19.6}{\cos 60} = 39.2 \text{ m/s}$$

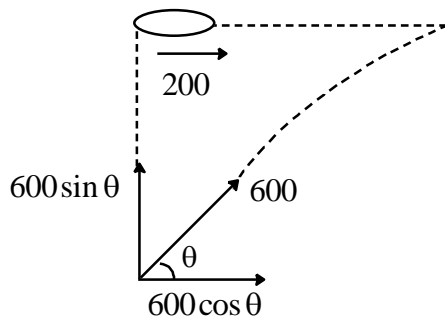
$$H_{\max} = \frac{u^2 \sin^2 \theta}{2g} = \frac{(39.2)^2}{2 \times 9.8} \times \left(\frac{\sqrt{3}}{2}\right)^2 = 58.8 \text{ m}$$

$$R = \frac{u^2 \sin^2 \theta}{g} = \frac{(39.2)^2 \times \sin 120}{9.8}$$

$$= \frac{(39.2)^2}{9.8} \times \frac{\sqrt{3}}{2} = 135.8 \text{ m}$$

$$35. \quad \text{Speed of plane} = 720 \text{ km/hr}$$

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



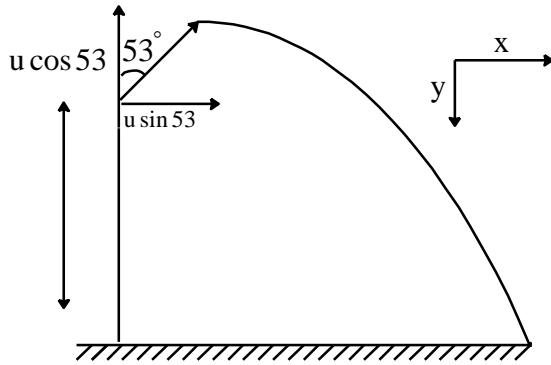
$$200 \times t = 600 \cos \theta t$$

$$\therefore \cos \theta = \frac{1}{3}, \theta = \cos^{-1} \left( \frac{1}{3} \right)$$

$$h_{\max} = \frac{u^2 \sin^2 \theta}{2g} = \frac{u^2 [1 - \cos^2 \theta]}{2 \times 10}$$

$$= 16000 \text{ m}$$

36.



$$800 = -u \cos 53 \times 20 - 5 \times 20^2$$

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

$$h_{\max} = 800 + \frac{100^2 \times \cos^2 53}{2 \times 10} = 980 \text{ m}$$

Horizontal distance travelled by bomb =  $u \times t$   
 $= u \sin 53 \times 20 = 100 \times 0.8 \times 20 = 1600 \text{ m}$

When bomb just strikes ground

$$v_y = u \sin 53 = 80 \text{ m/s}$$

$$v_y = -u \cos 53 + 10 \times 20 = 140$$

$$v = 80\hat{i} + 140\hat{j}$$

37.  $P_i = 10^{-3} \times 100 [20 \cos 30\hat{i} + 20 \sin 30\hat{j}]$

$$P_f = 10^{-3} \times 100 [20 \cos 30\hat{i}]$$

$$P_f - P_i = 10^{-3} \times 100 \times 20 \times \frac{1}{2} \hat{j} =$$

$$= 1\hat{j} \Rightarrow 1 \text{ kgm/s magnitude}$$

38.  $\vec{P}_f = m \left[ \frac{u}{\sqrt{2}} \hat{i} - \frac{v}{\sqrt{2}} \hat{j} \right]$

$$\vec{P}_i = m \left[ \frac{v}{\sqrt{2}} \hat{i} + \frac{v}{\sqrt{2}} \hat{j} \right]$$

$$\vec{P}_f - \vec{P}_i = -mv\sqrt{2}\hat{j} = mv\sqrt{2}$$

39. As the projectile returns back to the ground with the same speed so K.E. doesn't change between the point of projection and the point where the body strikes the ground.

40. At highest point,  $v_1 = u \cos \theta$  at  $y = \frac{h}{2} \text{ max}$ ,  $v_y^2 = u^2 \sin^2 \theta - 2g \frac{h_{\max}}{2}$

$$h_{\max} = \frac{u^2 \sin^2 \theta}{2g}$$

$$\therefore v_y^2 = u^2 \sin^2 \theta - \frac{2g}{2} \frac{u^2 \sin^2 \theta}{2g}$$

$$\therefore v_y = \frac{u \sin \theta}{\sqrt{2}}$$

Resultant velocity at  $y = \frac{h_{\max}}{2}$

$$v_2 = \sqrt{v_x^2 + v_y^2} = \sqrt{u^2 \cos^2 \theta + \frac{u^2 \sin^2 \theta}{2}}$$

$$\frac{v_1}{v_2} = \frac{\sqrt{2}}{\sqrt{5}} = \frac{u \cos \theta}{\sqrt{u^2 \cos^2 \theta + \frac{u^2 \sin^2 \theta}{2}}}$$

$$\therefore \frac{2}{5} = \frac{u^2 \cos^2 \theta}{u^2 \cos^2 \theta + u^2 \sin^2 \theta}$$

$$\therefore \tan^2 \theta = 3 \quad \therefore \tan \theta = \sqrt{3}$$

$$\theta = 60^\circ$$

41.  $V_{AB} = \vec{V}_\theta - \vec{V}_B = 10 - 6 = 4 \text{ m/s}$

$$V_{BA} = \vec{V}_B - \vec{V}_A = 6 - 10 = -4 \text{ m/s}$$

42.  $t = \frac{S_r}{V_r} = \frac{200 \text{ m}}{42 \times \frac{5}{18} + \frac{30 \times 5}{18}}$

$$= \frac{200 \text{ m}}{20 \text{ m/s}} = 10 \text{ s}$$

43. Let  $x$  be distance between drives of train A & guard of train B.  $u_B - u_A = 0$

$$\therefore a_r = 1, t = 50, u_r = 0$$

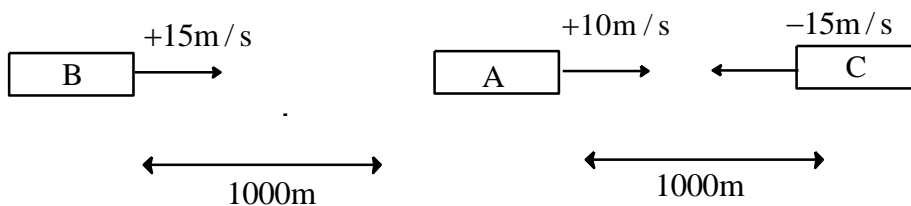
$$x = 0 \times t + \frac{1}{2} \times 1 \times 50^2 = 1250 \text{ m}$$

44. At instant B decides to overtake A,

$$V_A = +10 \text{ m/s}$$

$$V_B = +15 \text{ m/s}$$

$$V_C = -15 \text{ m/s}$$



$$V_{CA} = V_C - V_A = -15 - 10 = -25 \text{ m/s}$$

$$\text{Time C require to cross A} = \frac{1000 \text{ m}}{25} \left( \frac{S_r}{V_r} \right) = 40 \text{ s}$$

In order to avoid accident, B must overtake A in time less than 40 s

$$\therefore u_{BA} = 4B - 4A = 15 - 10 = 5 \text{ m/s}$$

$$S_{BA} = 100 \text{ m}$$

$$a_{BA} = a, t = 4 \text{ s}$$

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

$$1000 = 5 \times 40 + \frac{1}{2} \times a \times 40^2$$

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

45. Let  $v$  be full speed of man. He gets into train when his speed become equal to train.

$$v = 0 + at$$

$$\therefore v = 2t \quad \text{----- ex 1}$$

$$\text{Now } v \times t = 9 + \left( 0 \times t + \frac{1}{2} \times 2 \times t^2 \right) \quad \text{----- ex 2}$$

$$2t^2 = 9 + t^2$$

$$\therefore t^2 = 9, t = 3 \text{ s}$$

$$v = 3 \times 2 = 6 \text{ m/s}$$

$$s = 6 \times 3 = 18 \text{ m}$$

46.  $V_A = \frac{480}{8} = 60 \text{ km/hr}$ ,  $V_B = \frac{480}{12} = 40 \text{ km/hr}$

$$t = \frac{S_r}{V_r} = \frac{480}{100} = 4.8 \text{ hr}$$

A will have moved  $60 \times 4.8 = 288 \text{ km}$

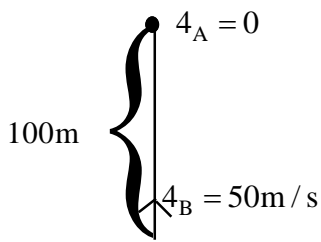
47.  $20 = \frac{200}{V_A - V_B}$ ,  $10 = \frac{200}{V_A + V_B}$

$$\therefore V_A = 15 \text{ m/s}, V_B = 5 \text{ m/s}$$

48. (a)  $S_{BA} = 100$ ,  $4_{BA} = 50$ ,

$$a_{BA} = 0 \therefore S = ut + \frac{1}{2} a t^2$$

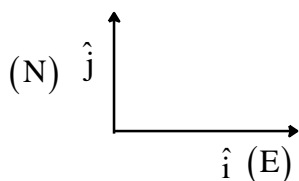
$$\therefore 100 = 50 \times t \therefore t = 2 \text{ s}$$



(b)  $S_{BA} = 100$ ,  $4_{BA} = 50 - (-25) = 75$ ,  $a \text{ \& } A = 0$

$$\therefore 100 = 75 \times t \therefore t = \frac{4}{3} \text{ s}$$

- 49.



$$\vec{V}_A = \vec{V}_B = \frac{V}{\sqrt{2}} \hat{i} + \frac{V}{\sqrt{2}} \hat{j} (\text{N}\epsilon)$$

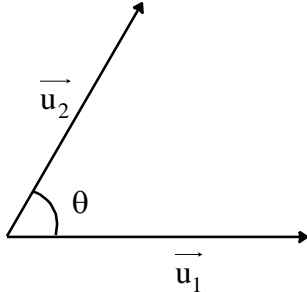
$$\vec{V}_B - \vec{V}_C = \frac{-V}{\sqrt{2}}\hat{i} + \frac{V}{\sqrt{2}}\hat{j} (N\omega)$$

$$\therefore \vec{V}_A - \vec{V}_C = V\sqrt{2}\hat{j}$$

$$\therefore \vec{V}_C - \vec{V}_A = -V\sqrt{2}\hat{j}$$

$$\therefore \vec{V}_{CA} \text{ is in } -\hat{j} \text{ i.e. south}$$

50.



$$|\vec{u}_1| = |\vec{u}_2| = v$$

$$\vec{u}_1 = v\hat{i} \qquad \vec{u}_2 = v \cos \theta \hat{i} + v \sin \theta \hat{j}$$

$$\Delta \vec{u} = \vec{u}_2 - \vec{u}_1 = \hat{i}(v \cos \theta - v) + v \sin \theta \hat{j}$$

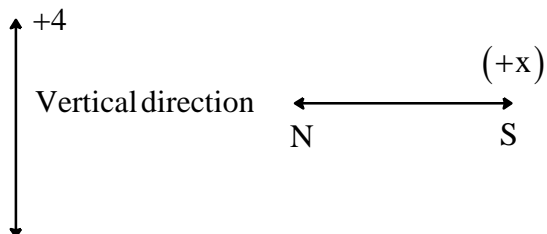
$$|\Delta \vec{u}| = \sqrt{(v \cos \theta - v)^2 + v^2 \sin^2 \theta}$$

$$= \sqrt{2v^2 - 2v^2 \cos \theta}$$

$$= v\sqrt{2}\sqrt{1 - \cos \theta}$$

$$|\Delta \vec{u}| = 2v \sin \frac{\theta}{2}$$

51.



Note-North south or east-west is not vertical direction

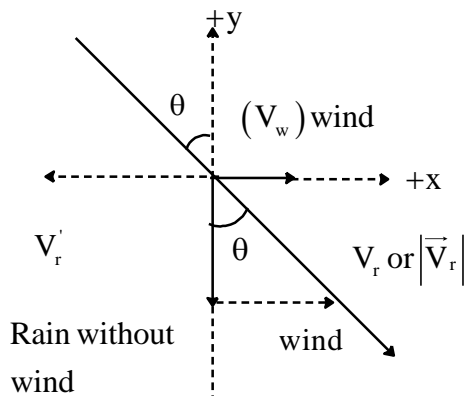
$$\text{Given } \vec{V}_r = -4\hat{j}, \vec{V}_w = 3\hat{i}$$

Last

$$\tan \theta = \frac{|\vec{V}_{rx}|}{|\vec{V}_{ry}|} = \frac{3}{4}$$

$$\Rightarrow \theta = 37^\circ$$



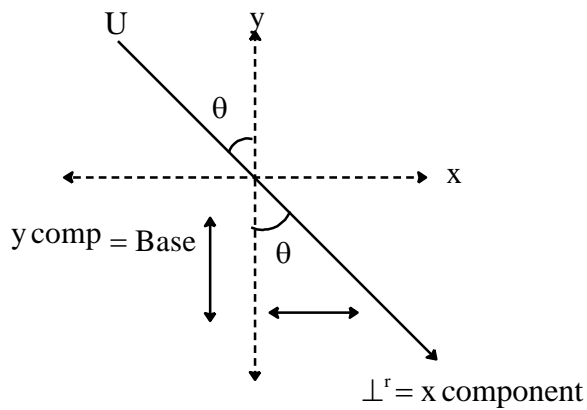


Rain without wind

Direction of rain  $\therefore$  of wind

Using  $\Delta$  law of vector  $\Rightarrow \vec{V}_r = \vec{V}_w + \vec{V}_r'$

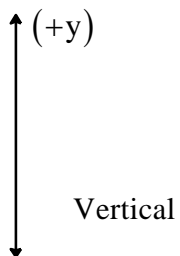
$$\vec{V}_r = 3\hat{i} - 4\hat{j}$$



4<sup>th</sup> Quad

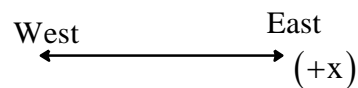
Rain is falling an angle  $\theta$  w.r.t. vertical

52.



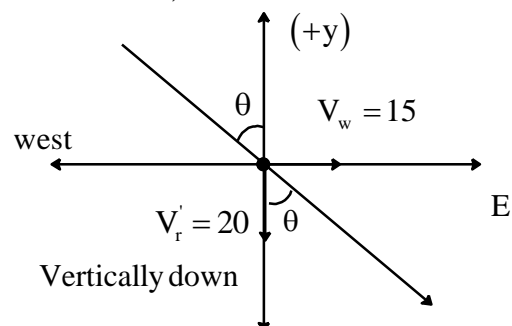
Rain is falling vertically down

$$\vec{V}_r = -20\hat{j}$$



Wind and man both are moving west to east with speed 15 m/s and 5 m/s respectively

$$\Rightarrow \vec{V}_w = 15\hat{i}, \vec{V}_m = 5\hat{i}$$



Direction of rain  $\therefore$  of wind, speed =  $V_r$

$$\Rightarrow \vec{V}_r = \vec{V}_w + \vec{V}_r' = 15\hat{i} - 20\hat{j}$$

$$\text{Also } \tan \theta = \frac{|\vec{V}_{rx}|}{|\vec{V}_{ry}|} = \frac{15}{20} \Rightarrow \theta = 37^\circ$$

↑

Rain will fall at an angle  $\theta$  wrt vertical wrt ground or stationary man

Rain wrt moving man

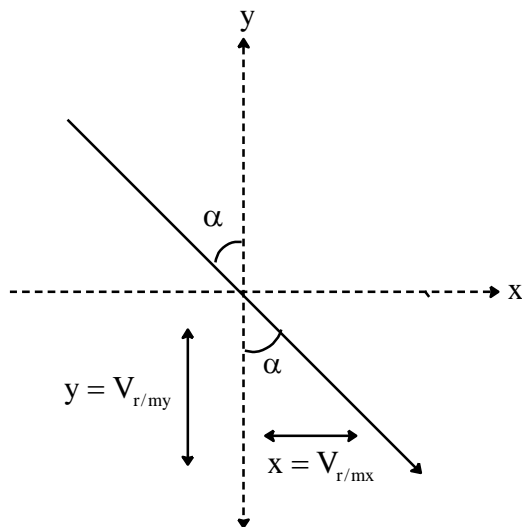
$$\vec{V}_{r/m} = \vec{V}_r - \vec{V}_m = (15\hat{i} - 20\hat{j}) - (5\hat{j})$$

$$\vec{V}_{r/m} = 10\hat{i} - 20\hat{j} \leftarrow 4^{\text{th}} \text{ quad}$$

$$\tan \alpha = \frac{|\vec{V}_{r/mx}|}{|\vec{V}_{r/my}|}$$

$$\tan \alpha = \frac{10}{20}$$

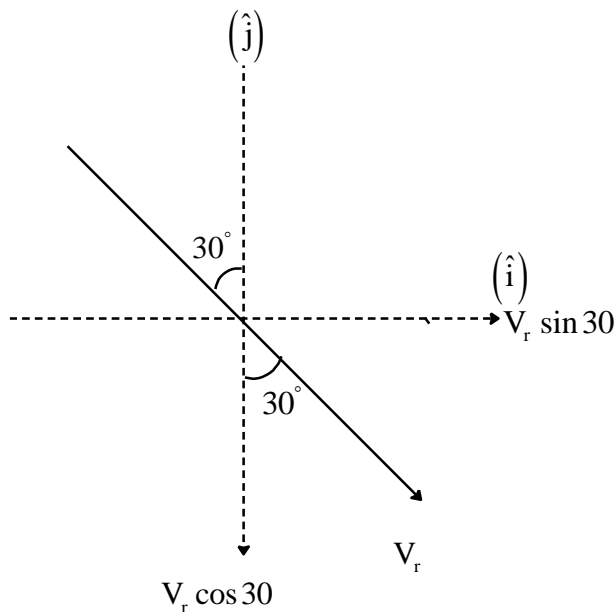
$$\alpha = \tan^{-1} \frac{1}{2}$$



$$\vec{V}_{r/m} = 10\hat{i} - 20\hat{j}$$

Direction of rain  
wrt moving man

53.



$$\Rightarrow \vec{V}_r = V_r \sin 30 \hat{i} - V_r \cos 30 \hat{j}$$

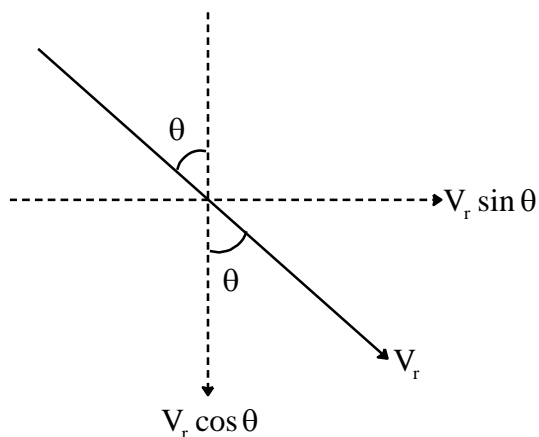
$$\vec{V}_m = 10 \hat{i}$$

$$\Rightarrow \vec{V}_{r/m} = \underbrace{(V_r \sin 30 - 10)}_{V_{r/mx}=0} \hat{i} - \underbrace{V_r \cos 30}_{V_{r/my}} \hat{j}$$

$\therefore$  Rain wrt man(moving) falls vertically

$$\Rightarrow V_r \sin 30 - 10 \Rightarrow V_r = 20$$

54.



$$\Rightarrow \vec{V}_r = V_r \sin \theta \hat{i} - V_r \cos \theta \hat{j}$$

$$\vec{V}_{m_1} = 8 \hat{i}$$

$$\text{Hence, } \vec{V}_{r/m_1} = \underbrace{(V_r \sin \theta - 8)}_{V_{r/m_2x}} \hat{i} - \underbrace{V_r \cos \theta}_{V_{r/m_2y}} \hat{j}$$

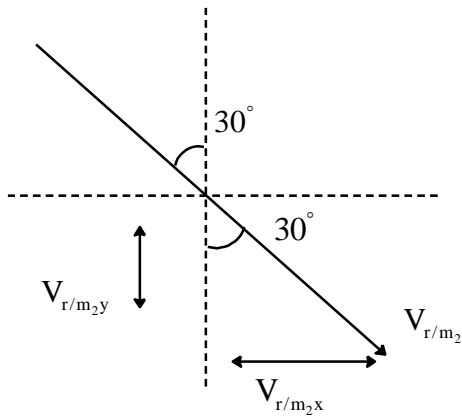
$$\vec{V}_{m_2} = 12 \hat{i} \Rightarrow \vec{V}_{r/m_2} = [V_r \sin \theta - 12] \hat{i} - V_r \cos \theta \hat{j}$$

Given  $\vec{V}_{r/m_1} \Rightarrow$  falls vertically

$$\Rightarrow V_{r/m_1x} = V_r \sin \theta - 8 = 0 \Rightarrow V_r \sin \theta = 8 \quad \text{_____ (1)}$$

Given  $\vec{V}_{r/m_2} \Rightarrow$  falls at  $30^\circ$  wrt vertical

$$\Rightarrow \tan 30^\circ = \left| \frac{V_{r/m_2x}}{V_{r/m_2y}} \right|$$



$$\Rightarrow \frac{1}{\sqrt{3}} = \left| \frac{V_r \sin \theta - 12}{V_r \cos \theta} \right| = 8 \quad \text{From equation (1)}$$

$$\frac{1}{\sqrt{3}} = \left| \frac{-4}{V_r \cos \theta} \right| \Rightarrow V_r \cos \theta = 4\sqrt{3} \quad \text{_____ (2)}$$

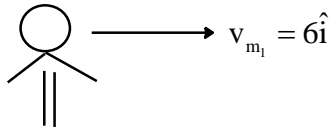
(1) and (2)

$$V_r^2 \sin^2 \theta + V_r^2 \cos^2 \theta = (8r^2 + (4\sqrt{3}))^2$$

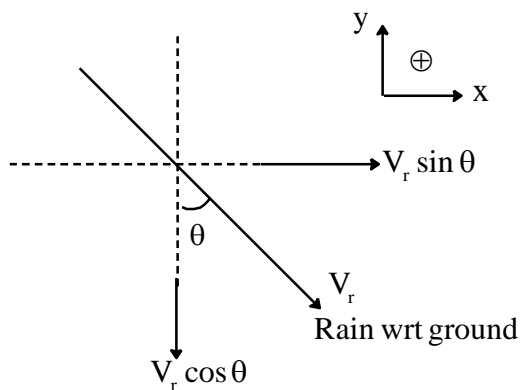
$$V_r^2 = 64 + 48 = 112$$

$$V_r = 4\sqrt{7}$$

55.



Case-I Rain wrt moving  $m_1$  falls vertically



$$\vec{V}_r = V_r \sin \theta \hat{i} - V_r \cos \theta \hat{j}$$

$$\vec{V}_{m_1} = 6\hat{i}$$

$$\Rightarrow \vec{V}_{r/m_1} = \underbrace{(V_r \sin \theta - 6)}_{V_{r/m_1x}} \hat{i} - \underbrace{V_r \cos \theta}_{V_{r/m_1y}} \hat{j}$$

It appears to fall vertically

$$\Rightarrow V_{r/m_1x} = 0$$

$$V_r \sin \theta - 6 = 0$$

$$\Rightarrow V_r \sin \theta = 6 \quad \text{_____ (1)}$$

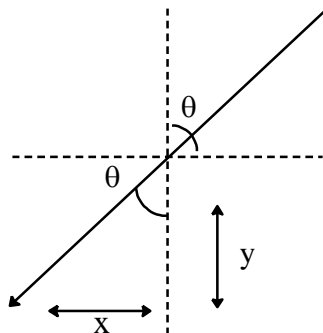
Case-2 Rain wrt moving man

$V_{m_2} = 12\hat{i}$  appears to fall at  $30^\circ$  wrt vertical.

$$\Rightarrow \vec{V}_{r/m_2} = \vec{V}_r - \vec{V}_{m_2}$$

$$= \underbrace{(V_r \sin \theta - 12)}_{V_{r/m_2x}} \hat{i} - \underbrace{V_r \cos \theta}_{V_{r/m_2y}} \hat{j}$$

$$\Rightarrow \tan \theta = \frac{x}{y} = \frac{|V_{r/m_2x}|}{|V_{r/m_2y}|}$$



In our case  $\theta = 30^\circ$

$$\Rightarrow \tan 30 = \frac{|V_r \sin \theta - 12|}{| -V_r \cos \theta |}$$

$$\downarrow \frac{1}{\sqrt{3}} = \frac{|6 - 12|}{V_r \cos \theta} (\because V_r \sin \theta = 6)$$

$$V_r \cos \theta = 6\sqrt{3} \quad \text{_____ (2)}$$

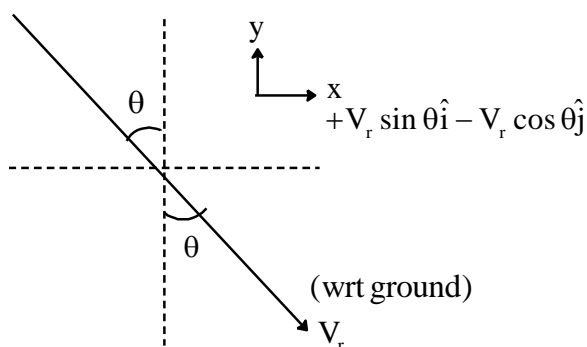
$\Rightarrow$  equation 1 and 2

$$V_r^2 \sin^2 \theta + V_r^2 \cos^2 \theta = (6)^2 + (6\sqrt{3})^2$$

$$V_r^2 (\sin^2 \theta + \cos^2 \theta) = 36 + 108$$

$$V_r^2 = 144 \Rightarrow V_r = 12$$

56.



Case-I  $V_{m_1} = V\hat{i} \Rightarrow \vec{V}_{r/m_1} = \underbrace{[V_r \sin \theta - V]}_{V_{r/m_1x}=0} \hat{i} - V_r \cos \theta \hat{j}$

$$V_r \sin \theta - V = 0$$

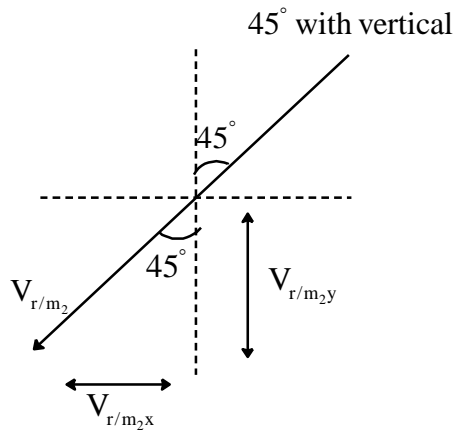
$$\text{Or } V_r \sin \theta = V \quad \text{_____ (1)}$$

Case-2

$$V_{m_2} = 2V\hat{i} \Rightarrow \vec{V}_{r/m_2} = [V_r \sin \theta - 2V] \hat{i} - V_r \cos \theta \hat{j}$$

$$\tan 45 = \frac{|V_r / m_2x|}{|V_r / m_2y|} = V \quad \text{_____ from equation (1)}$$

$$I = \left| \frac{V_r \sin \theta - 2V}{V_r \cos \theta} \right|$$



$$I = \left| \frac{V - 2V}{V_r \cos \theta} \right| \Rightarrow V_r \cos \theta = V \quad \text{--- (2)}$$

(1) and (2)

$$V_r^2 \sin^2 \theta + V_r^2 \cos^2 \theta = V^2 + V^2$$

$$V_r^2 + 2V^2 \Rightarrow V_r = V\sqrt{2}$$

$$\text{Also } \frac{V_r \sin \theta}{V_r \cos \theta} = \frac{V}{V} \Rightarrow \tan \theta = 1$$

$$\Rightarrow \theta = 45^\circ$$

Rain wrt ground

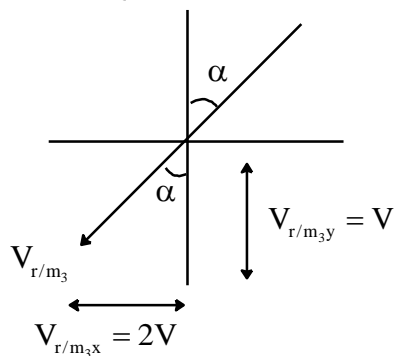
Case-3

$$\vec{V}_{m_3} = 3V\hat{i}, \vec{V}_r = V_r \sin \theta \hat{i} - V_r \cos \theta \hat{j}$$

$$= V\hat{i} - V\hat{j}$$

$$\Rightarrow \vec{V}_{r/m_3} = \underbrace{(V - 3V)\hat{i}}_{(V_{rx} - V_{m3x})\hat{i}} - \underbrace{V\hat{j}}_{(V_{ry} - V_{m3y})\hat{j}} = -2V\hat{i} - V\hat{j}$$

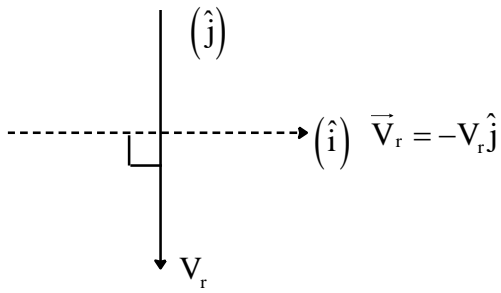
$$\underbrace{V_{r/m_3} = -2V\hat{i} - V\hat{j}}_{3^{\text{rd}} \text{ Quad}}$$



$$\tan \alpha = \frac{2V}{V} \Rightarrow \tan \alpha = 2$$

$$\alpha = \tan^{-1}(2)$$

57.

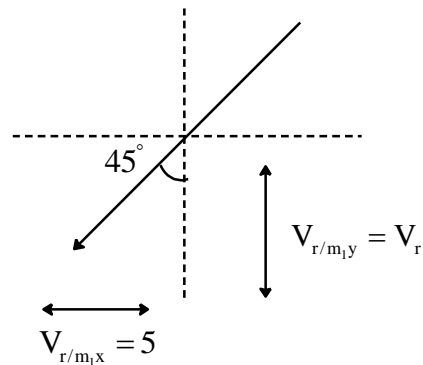


Case-I

$$\vec{V}_{m_1} = 5\hat{i} \Rightarrow \vec{V}_{r/m_1} = \underbrace{-5\hat{i}}_{3^{\text{rd}}} - V_r\hat{j}$$

$$\tan 45 = \frac{5}{V_r}$$

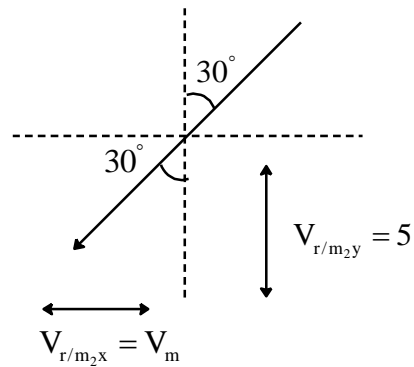
$$V_r = 5 \quad \text{----- (1)}$$



Case-2

$$V_{m_2} = V_m\hat{i}, \text{ As } \vec{V}_r = -V_r\hat{j} = -5\hat{j}$$

$$\Rightarrow \vec{V}_{r/m_2} = \underbrace{-V_m\hat{i}}_{3^{\text{rd}}} - 5\hat{j}$$



$$\tan 30 = \frac{V_m}{5} \Rightarrow V_m = \frac{5}{\sqrt{3}}$$

## JEE-Main Exercise

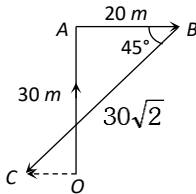
1. (a)

$$\vec{r} = x\hat{i} + y\hat{j} + z\hat{k} \quad \therefore r = \sqrt{x^2 + y^2 + z^2}$$

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

2. (c)

From figure,  $\vec{OA} = 0\vec{i} + 30\vec{j}$ ,  $\vec{AB} = 20\vec{i} + 0\vec{j}$



$$\vec{BC} = -30\sqrt{2} \cos 45^\circ \vec{i} - 30\sqrt{2} \sin 45^\circ \vec{j} = -30\vec{i} - 30\vec{j}$$

$$\therefore \text{Net displacement, } \vec{OC} = \vec{OA} + \vec{AB} + \vec{BC} = -10\vec{i} + 0\vec{j}$$

$$|\vec{OC}| = 10 \text{ m.}$$

3. (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 =  $2R$ .

4. (1204)

An aeroplane flies 400 m north and 300 m south so the net displacement is 100 m towards north.

$$\text{Then it flies 1200 m upward so } r = \sqrt{(100)^2 + (1200)^2} \\ = 1204 \text{ m}$$

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

5. (b)

$$\text{Distance average speed} = \frac{2v_1v_2}{v_1 + v_2} = \frac{2 \times 2.5 \times 4}{2.5 + 4} \\ = \frac{200}{65} = \frac{40}{13} \text{ km/hr}$$

6. (d)

$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}} = \frac{x}{t_1 + t_2} \\ = \frac{x}{\frac{x/3}{v_1} + \frac{2x/3}{v_2}} = \frac{1}{\frac{1}{3 \times 20} + \frac{2}{3 \times 60}} = 36 \text{ km/hr}$$



7. (c)  
 Total distance to be covered for crossing the bridge  
 = length of train + length of bridge  
 = 150m + 850m = 1000m  

$$\text{Time} = \frac{\text{Distance}}{\text{Velocity}} = \frac{1000}{45 \times \frac{5}{18}} = 80 \text{ sec}$$
8. (c)  
 Displacement of the particle will be zero because it comes back to its starting point  

$$\text{Average speed} = \frac{\text{Total distance}}{\text{Total time}} = \frac{30\text{m}}{10 \text{ sec}} = 3 \text{ m/s}$$
9. (d)  

$$\text{Velocity of particle} = \frac{\text{Total displacement}}{\text{Total time}}$$

$$= \frac{\text{Diameter of circle}}{5} = \frac{2 \times 10}{5} = 4 \text{ m/s}$$
10. (d)  
 A man walks from his home to market with a speed of 5 km/h. Distance = 2.5 km and time  

$$= \frac{d}{v} = \frac{2.5}{5} = \frac{1}{2} \text{ hr}$$
 and he returns back with speed of 7.5 km/h in rest of time of 10 minutes.  

$$\text{Distance} = 7.5 \times \frac{10}{60} = 1.25 \text{ km}$$
  
 So, Average speed = 
$$\frac{\text{Total distance}}{\text{Total time}}$$

$$= \frac{(2.5 + 1.25)\text{km}}{(40/60)\text{hr}} = \frac{45}{8} \text{ km/hr}$$
11. (c)  
 From given figure, it is clear that the net displacement is zero. So average velocity will be zero.
12. (d)  
 Length of train = 100 m  
 Velocity of train = 45 km/hr =  $45 \times \frac{5}{18} = 12.5 \text{ m/s}$   
 Length of bridge = 1 km = 1000 m  
 $\therefore$  Total length covered by train = 1100 m  
 Time taken by train to cross the bridge =  $\frac{1100}{12.5} = 88 \text{ sec}$
13. (60)  

$$\text{Time average speed} = \frac{v_1 + v_2}{2} = \frac{80 + 40}{2} = 60 \text{ km/hr}$$

14. (53.33)

Distance travelled by train in first 1 hour is 60 km and distance in next 1/2 hour is 20 km.

$$\text{So Average speed} = \frac{\text{Total distance}}{\text{Total time}} = \frac{60+20}{3/2} = 53.33 \text{ km/hour}$$

15. (4)

$$\text{Time average velocity} = \frac{v_1 + v_2 + v_3}{3} = \frac{3+4+5}{3} = 4 \text{ m/s}$$

16. (1.0)

Let initial velocity of the bullet =  $u$

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

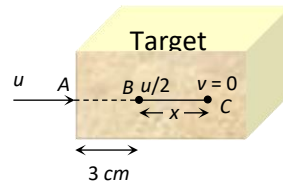
$$\text{From } v^2 = u^2 - 2as$$

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

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

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

$$\text{For distance } BC, v = 0, u = u/2, s = x, a = u^2/8$$



17. (a)

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

18. (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

$$\text{acceleration is } a \text{ then } v_1 = \frac{u_1+u_2}{2}, v_2 = \frac{u_2+u_3}{2} \text{ and } v_3 = \frac{u_3+u_4}{2}$$

$$\text{Also } u_2 = u_1 + at_1, u_3 = u_1 + a(t_1+t_2)$$

$$\text{and } u_4 = u_1 + a(t_1+t_2+t_3)$$

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

19. (d)

$$v = u + at = 10 + 2 \times 4 = 18 \text{ m/sec}$$

20. (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

$$1:3:5:7 \dots (2n-1)$$

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

21. (a)

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

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

22. (1)

Distance travelled in 4 sec

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

Distance travelled in total 8 sec

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

After solving (i) and (ii), we get  $u = 1\text{m/s}$ .

23. (180)

$S \propto u^2$ . If  $u$  becomes 3 times then  $S$  will become 9 times *i.e.*  $9 \times 20 = 180\text{m}$

24. (d)

Total distance =  $130 + 120 = 250\text{m}$

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

Hence  $t = 250 / 50 = 5\text{s}$

25. (b)

Relative velocity of bird *w.r.t* train =  $25 + 5 = 30\text{m/s}$

time taken by the bird to cross the train  $t = \frac{210}{30} = 7\text{sec}$

26. (d)

Relative velocity

=  $10 + 5 = 15\text{m/sec}$

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

27. (a)

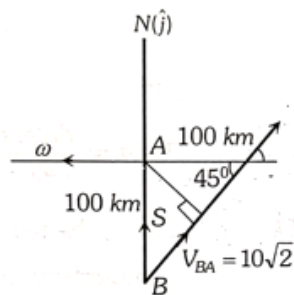
$$V_A = 10(-\hat{i})$$

$$V_B = 10(\hat{j})$$

$$V_{BA} = 10\hat{j} + 10\hat{i}$$

Time for shortest distance

$$= \frac{100/\sqrt{2}}{10\sqrt{2}} = 5.$$



28. (b)  
Velocity at the time of striking the floor,  
 $u = \sqrt{2gh_1} = \sqrt{2 \times 9.8 \times 10} = 14 \text{ m/s}$   
Velocity with which it rebounds.  
 $v = \sqrt{2gh_2} = \sqrt{2 \times 9.8 \times 2.5} = 7 \text{ m/s}$   
 $\therefore$  Change in velocity  $\Delta v = 7 - (-14) = 21 \text{ m/s}$   
 $\therefore$  Acceleration  $= \frac{\Delta v}{\Delta t} = \frac{21}{0.01} = 2100 \text{ m/s}^2$  (upwards)
29. (c)  
 $h = \frac{1}{2}gt^2 \Rightarrow t = \sqrt{2h/g}$   
 $t_a = \sqrt{\frac{2a}{g}}$  and  $t_b = \sqrt{\frac{2b}{g}} \Rightarrow \frac{t_a}{t_b} = \sqrt{\frac{a}{b}}$
30. (a)  
Time taken by first stone to reach the water surface from the bridge be  $t$ , then  
 $h = ut + \frac{1}{2}gt^2 \Rightarrow 44.1 = 0 \times t + \frac{1}{2} \times 9.8t^2$   
 $t = \sqrt{\frac{2 \times 44.1}{9.8}} = 3 \text{ sec}$   
Second stone is thrown 1 sec later and both strikes simultaneously.  
This means that the time left for second stone  $= 3 - 1 = 2 \text{ sec}$   
Hence  $44.1 = u \times 2 + \frac{1}{2} \times 9.8(2)^2$   
 $\Rightarrow 44.1 - 19.6 = 2u \Rightarrow u = 12.25 \text{ m/s}$
31. (d)  
The separation between the two bodies, two seconds after the release of second body  
 $= \frac{1}{2} \times 9.8[(3)^2 - (2)^2] = 24.5 \text{ m}$
32. (a)  
 $h = \frac{1}{2}gt^2 = \frac{1}{2} \times 10 \times (4)^2 = 80 \text{ m}$
33. (c)  
Force down the plane  $= mg \sin \theta$   
 $\therefore$  Acceleration down the plane  $= g \sin \theta$   
Since  $l = 0 + \frac{1}{2}g \sin \theta t^2$   
 $\therefore t^2 = \frac{2l}{g \sin \theta} = \frac{2h}{g \sin^2 \theta} \Rightarrow t = \frac{1}{\sin \theta} \sqrt{\frac{2h}{g}}$

34. (b)

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

35. (a)

Height travelled by ball (with balloon) in 2 sec

$$h_1 = \frac{1}{2} a t^2 = \frac{1}{2} \times 4.9 \times 2^2 = 9.8 \text{ m}$$

Velocity of the balloon after 2 sec

$$v = a t = 4.9 \times 2 = 9.8 \text{ m/s}$$

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

Let it move up to maximum height  $h_2$

$$v^2 = u^2 - 2gh_2 \Rightarrow 0 = (9.8)^2 - 2 \times (9.8) \times h_2 \therefore h_2 = 4.9 \text{ m}$$

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

36. (b)

Let  $h$  distance is covered in  $n$  sec

$$\Rightarrow h = \frac{1}{2} g n^2 \quad \dots \text{(i)}$$

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

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

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

37. (a)

Horizontal velocity of dropped packet =  $u$

Vertical velocity =  $\sqrt{2gh}$

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

38. (a)

$$S_n = u + \frac{g}{2} (2n-1); \text{ when } u = 0, S_1 : S_2 : S_3 = 1 : 3 : 5$$

39. (b)

It has lesser initial upward velocity.

40. (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

41. (a)  
Distance between the balls = Distance travelled by first ball in 3 seconds – Distance travelled by second ball in 2 seconds =  $\frac{1}{2}g(3)^2 - \frac{1}{2}g(2)^2 = 45 - 20 = 25\text{ m}$
42. (a)  
When the stone is released from the balloon. Its height  $h = \frac{1}{2}at^2 = \frac{1}{2} \times 1.25 \times (8)^2 = 40\text{ m}$  and velocity  
 $v = at = 1.25 \times 8 = 10\text{ m/s}$   
Time taken by the stone to reach the ground  
 $t = \frac{v}{g} \left[ 1 + \sqrt{1 + \frac{2gh}{v^2}} \right] = \frac{10}{10} \left[ 1 + \sqrt{1 + \frac{2 \times 10 \times 40}{(10)^2}} \right] = 4\text{ sec}$
43. (b)  
 $h_n = \frac{g}{2}(2n-1) \Rightarrow h_{5^{\text{th}}} = \frac{10}{2}(2 \times 5 - 1) = 45\text{ m}.$
44. (6)  
Time of flight =  $\frac{2u}{g} = \frac{2 \times 96}{32} = 6\text{ sec}$
45. (4)  
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  
 $\Rightarrow \frac{16}{2}g = \frac{1}{2}gt^2 \Rightarrow t = 4\text{ sec}$
46. (30)  
If  $u$  is the initial velocity then distance covered by it in 2 sec  
 $S = ut + \frac{1}{2}at^2 = u \times 2 + \frac{1}{2} \times 10 \times 4 = 2u + 20 \quad \dots(\text{i})$   
Now distance covered by it in 3<sup>rd</sup> sec  
 $S_{3^{\text{rd}}} = u + \frac{g}{2}(2 \times 3 - 1)10 = u + 25 \quad \dots(\text{ii})$   
From (i) and (ii),  $2u + 20 = u + 25 \Rightarrow u = 5$   
 $\therefore S = 2 \times 5 + 20 = 30\text{ m}$
47. (65)  
Speed of stone in a vertically upward direction is 20m/s.  
So for vertical downward motion we will consider  $u = -20\text{ m/s}$   
 $v^2 = u^2 + 2gh = (-20)^2 + 2 \times 9.8 \times 200 = 4320\text{ m/s} \quad \therefore v \approx 65\text{ m/s}.$
48. (80)

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.*  $H = 20 \times 4 = 80m$

49. (5)

The distance traveled in last second.

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

and distance traveled in first three second,

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

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

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

50. (200)

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

51. (c)

Due to constant velocity along horizontal and vertical downward force of gravity stone will hit the ground following parabolic path.

52. (c)

Because horizontal velocity is same for coin and the observer.  
So relative horizontal displacement will be zero.

53. (c)

Horizontal displacement of the bomb

AB = Horizontal velocity  $\times$  time available

$$AB = u \times \sqrt{\frac{2h}{g}} = 600 \times \frac{5}{18} \times \sqrt{\frac{2 \times 1960}{9.8}} = 3.33 \text{ Km.}$$

54. (b)

$$S = u \times \sqrt{\frac{2h}{g}} = 100 \times \sqrt{\frac{2 \times 490}{9.8}} = 1000m = 1 \text{ km}$$

55. (c)

56. (b)

The horizontal distance covered by bomb,

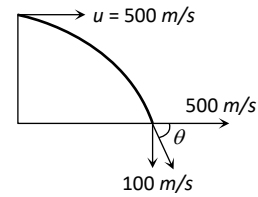
$$BC = v_H \times \sqrt{\frac{2h}{g}} = 150 \sqrt{\frac{2 \times 80}{10}} = 660m$$

57. (a)  
Horizontal component of velocity  $v_x = 500 \text{ m/s}$  and vertical components of velocity while striking the ground.

$$v_y = 0 + 10 \times 10 = 100 \text{ m/s}$$

$\therefore$  Angle with which it strikes the ground.

$$\theta = \tan^{-1}\left(\frac{v_y}{v_x}\right) = \tan^{-1}\left(\frac{100}{500}\right) = \tan^{-1}\left(\frac{1}{5}\right)$$

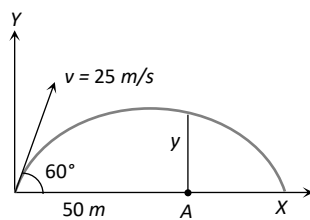


58. (a)  
Horizontal component of velocity

$$v_x = 25 \cos 60^\circ = 12.5 \text{ m/s}$$

Vertical component of velocity

$$v_y = 25 \sin 60^\circ = 12.5\sqrt{3} \text{ m/s}$$



Time to cover 50 m distance  $t = \frac{50}{12.5} = 4 \text{ sec}$

The vertical height  $y$  is given by

$$y = v_y t - \frac{1}{2} g t^2 = 12.5\sqrt{3} \times 4 - \frac{1}{2} \times 9.8 \times 16 = 8.2 \text{ m}$$

59. (a)  
For vertical upward motion  $h = ut - \frac{1}{2} g t^2$

$$5 = (25 \sin \theta) \times 2 - \frac{1}{2} \times 10 \times (2)^2$$

$$\Rightarrow 25 = 50 \sin \theta \Rightarrow \sin \theta = \frac{1}{2} \Rightarrow \theta = 30^\circ$$

60. (d)  
Acceleration through out the projectile motion remains constant and equal to  $g$ .

61. (c)  
Time of flight  $= \frac{2u \sin \theta}{g} = \frac{2 \times 50 \times \sin 30}{10} = 5 \text{ s}$

62. (c)  
Became vertical downward displacement of both (barrel and bullet) will be equal.

63. (b)  
 $R = \frac{u^2 \sin 2\theta}{g} = \frac{(500)^2 \times \sin 30^\circ}{10} = 12.5 \times 10^3 \text{ m}$



64. (a)

$$T = \frac{2u \sin \theta}{g} \Rightarrow u = \frac{T \times g}{2 \sin \theta} = \frac{2 \times 9.8}{2 \times \sin 30} = 19.6 \text{ m/s}$$

65. (a)

$$H = \frac{u^2 \sin^2 \theta}{2g} \text{ and } T = \frac{2u \sin \theta}{g}$$

So  $\frac{H}{T^2} = \frac{u^2 \sin^2 \theta / 2g}{4u^2 \sin^2 \theta / g^2} = \frac{g}{8} = \frac{5}{4}$

66. (a)  
For complementary angles range is same.

67. (d)

$$R = 4H \cot \theta, \text{ if } R = 4\sqrt{3}H \text{ then } \cot \theta = \sqrt{3} \Rightarrow \theta = 30^\circ$$

68. (c)

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

According to problem  $\frac{u_1^2 \sin^2 45^\circ}{2g} = \frac{u_2^2 \sin^2 60^\circ}{2g}$

$$\Rightarrow \frac{u_1^2}{u_2^2} = \frac{\sin^2 60^\circ}{\sin^2 45^\circ} \Rightarrow \frac{u_1}{u_2} = \frac{\sqrt{3}/2}{1/\sqrt{2}} = \sqrt{\frac{3}{2}}$$

69. (45)

$$R = 4H \cot \theta, \text{ if } R = 4H \text{ then } \cot \theta = 1 \Rightarrow \theta = 45^\circ$$

70. (200)

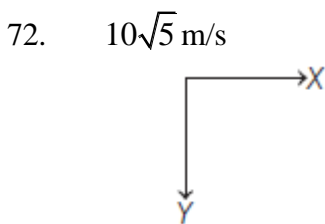
$$R = \frac{u^2 \sin 2\theta}{g} = R \propto u^2. \text{ So if the speed of projection doubled, the range will become four times,}$$

*i.e.*,  $4 \times 50 = 200 \text{ m}$

71. (5)

$$\frac{2u \sin \theta}{g} = 2 \text{ sec} \Rightarrow u \sin \theta = 10$$

$$\therefore H = \frac{u^2 \sin^2 \theta}{2g} = \frac{100}{2g} = 5 \text{ m}$$



$$\mathbf{v}_{\text{person}} = 10 \hat{i}$$

$$\mathbf{v}_{\text{rain, person}} = 20 \hat{j}$$

$$\mathbf{v}_{\text{rain, person}} = \mathbf{v}_{\text{rain}} - \mathbf{v}_{\text{person}}$$

$$\Rightarrow 20\hat{\mathbf{j}} = \mathbf{v}_{\text{rain}} - 10\hat{\mathbf{i}}$$

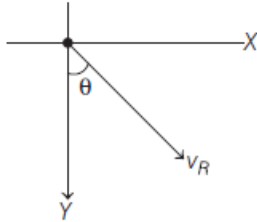
$$\Rightarrow \mathbf{v}_{\text{rain}} = 10\hat{\mathbf{i}} + 20\hat{\mathbf{j}}$$

$$|\mathbf{v}_{\text{rain}}| = 10\sqrt{5} \text{ m/s}$$

73.  $2\sqrt{2}$  km/h,  $45^\circ$  with vertically away from the man.

$$\mathbf{v}_M = (2 \text{ km/h})\hat{\mathbf{i}}$$

$$\mathbf{v}_R = v_R \sin \theta \hat{\mathbf{i}} + v_R \cos \theta \hat{\mathbf{j}}$$



$$\mathbf{v}_{RM} = \mathbf{v}_R - \mathbf{v}_M$$

$$= (v_R \sin \theta - 2)\hat{\mathbf{i}} + v_R \cos \theta \hat{\mathbf{j}}$$

Since, rain appears to fall vertically,

$$v_R \sin \theta - 2 = 0$$

$$\Rightarrow v_R \sin \theta = 2$$

$$\mathbf{v}_M = 4\hat{\mathbf{i}}$$

$$\mathbf{v}_R = 2\hat{\mathbf{i}} + v_R \cos \theta \hat{\mathbf{j}}$$

$$\mathbf{v}_{RM} = -2\hat{\mathbf{i}} + v_R \cos \theta \hat{\mathbf{j}}$$

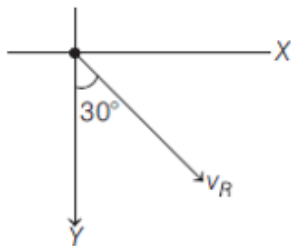
$$\tan \phi = \frac{v_R \cos \theta}{2} = 1$$

$$\Rightarrow v_R \cos \theta = 2$$

$$\mathbf{v}_R = 2\hat{\mathbf{i}} + 2\hat{\mathbf{j}}$$

$$= 2\sqrt{2} \text{ km/h, at } 45^\circ \text{ with vertical}$$

74. 20 km/h



$$\mathbf{v}_R = v_R \sin 30^\circ \hat{\mathbf{i}} + v_R \cos 30^\circ \hat{\mathbf{j}}$$

$$\mathbf{v}_M = 10\hat{\mathbf{i}}$$

$$\mathbf{v}_{RM} = \mathbf{v}_R - \mathbf{v}_M$$

$$= (v_R \sin 30^\circ - 10)\hat{\mathbf{i}} + v_R \cos 30^\circ \hat{\mathbf{j}}$$

Since, rain appears to fall vertically

$$v_R \sin 30^\circ - 10 = 0$$

$$\Rightarrow v_R = 20 \text{ km/h}$$

**Inchapter Exercise**

1.  $x = 4t^2 - 15t + 25$

$$v = \frac{du}{dt} = 8t - 15$$

$$9 = -\frac{dv}{dt} = 8$$

At  $t = 0$ ,  $x = 25\text{m}$ ,  $v = -15\text{m/s}$ ,  $a = 8\text{m/s}^2$

$$v = 0 \text{ means } 8t - 15 = 0 \therefore t = \frac{15}{8} = 1.875\text{s}$$

Acceleration does not depend on time. So, it is constant

2.  $v = 2t^2 + 5$

$$t_1 = 2\text{s}, v_1 = 12 \text{ cm/s}, t_2 = 4\text{s}, v_2 = 37 \text{ cm/s}$$

$$\text{Change in velocity} = v_2 - v_1 = 37 - 13 = 24 \text{ cm/s}$$

$$\text{(ii) Avg. acceleration} = \frac{v_2 - v_1}{t_2 - t_1} = \frac{37 - 13}{4 - 2} = 12 \text{ cm/s}^2$$

(iii) Instantaneous acceleration

$$A_{\text{ar}} = \frac{dv}{dt} = \frac{d}{dt}(2t^2 + 5) = 4t$$

$$t = 4\text{s}, a = 16 \text{ cm/s}^2$$

3.  $t = \sqrt{x} + 3, \sqrt{x} = t - 3$

$$x = (t - 3)^2 = t^2 - 6t + 9$$

$$v = \frac{du}{dt} = 2t - 6$$

$$v = 0 \Rightarrow 2t - 6 = 0, \therefore t = 3\text{s}$$

$$x = (t - 3)^2, \text{ at } t = 3\text{s}, x = 0$$

4.  $x = 2 - 5t + 6t^2$

$$v = \frac{du}{dt} = -5 + 12t$$

5.  $v = \frac{du}{dt} = 8 + 14t$

$$A = 14$$

$$\text{At } t = 2\text{s}, v = 8 + 14 \times 2 = 36 \text{ m/s}$$

$$A = 14$$

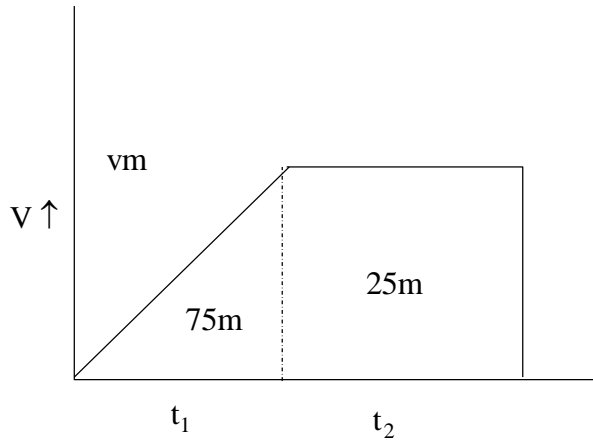
6.  $v = \frac{du}{dt} = 180 + 100t, a = 100$

$$\text{At } t = 0, v = 180,$$

$$\text{At } t = 4\text{s}, v = 580$$

$$\text{At } t = 4\text{s}, a = 100$$

7.



$$a = \frac{v_m}{t_1} = 1\text{m/s}^2$$

$$v_m = t_1$$

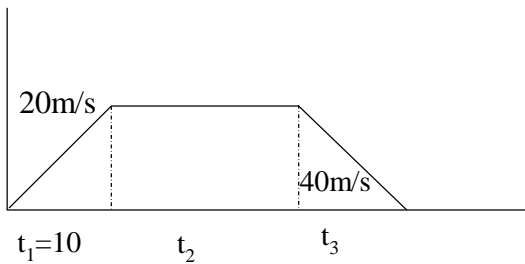
$$\frac{1}{2} v_m t_2 = 75$$

$$v_m t_1 = 150 \therefore v_m = t_1 = \sqrt{150} = 5\sqrt{6}$$

Now, for 1<sup>st</sup> 50m  $a = 1\text{m/s}^2$

$$5a = \frac{1}{2} \times 1 \times t^2 \quad t = 10$$

8.



$$\frac{1}{2} \times 20 \times t_1 = 40$$

$$t_3 = 4$$

Now ans under graph

$$\frac{(2t^2 + 14)}{2} \times 20 = 640$$

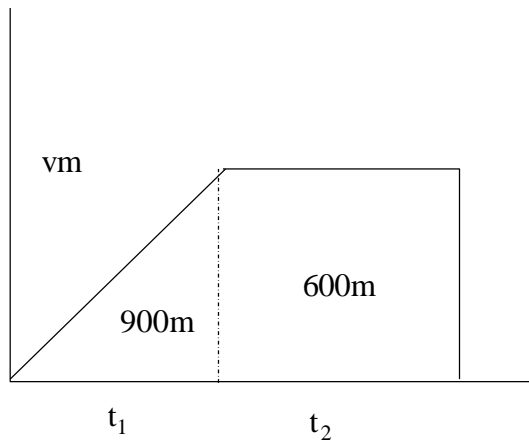
$$\therefore t_2 = 25$$

$$\text{Total time} = 10 + 25 + 4 = 39\text{s}$$

$$\text{Accel} \frac{20}{10} = 2\text{m/s}^2$$

$$= \frac{20}{4} = 5\text{m/s}^2$$

9.

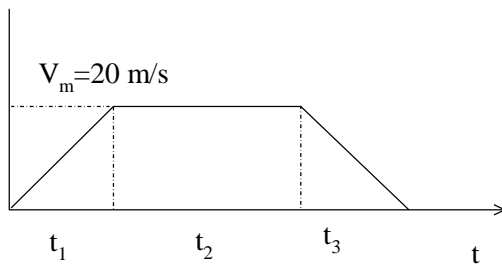


$$2 = \frac{V_m}{t_1}, \frac{1}{2} V_m t_1 = 900$$

$$\therefore t_1 = 30s, V_m = 60m/s \quad v_m t_2 \therefore t_2 = 10s, a = \frac{V_m}{t_1} = 2m$$

Now, at centre of track  $S = 750$  and motion : uniformly

10.



$$0.1 = \frac{20}{t_1} \therefore t_1 = 200s$$

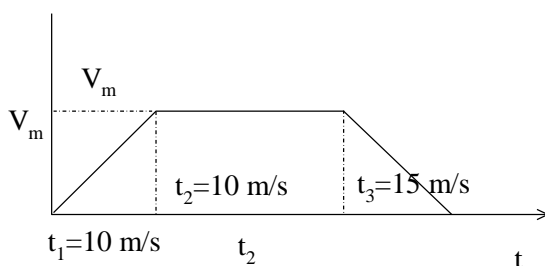
$$0.2 = \frac{V_m}{t_1}, t_3 = \frac{20}{0.2} = 100s$$

$$\text{Now } 5000 = \left[ \frac{2t_2 + 200 + 100}{2} \right] \times 20$$

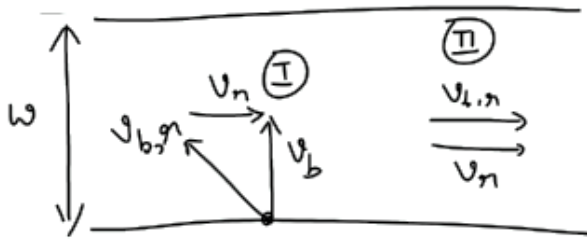
$$t_2 = 1000$$

$$\therefore t_1 + t_2 + t_3 = 400s$$

11.



12.

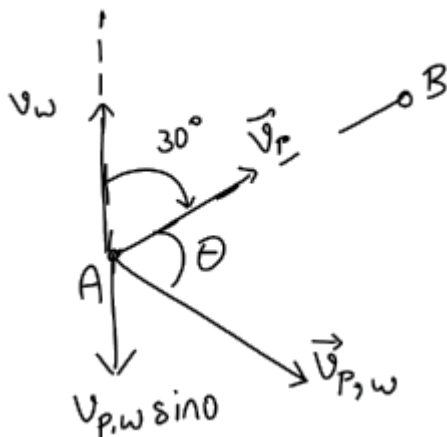


(I)  $(v_b)t_1 = \omega$   
 $\sqrt{(v_{h,r})^2 + (v_r)^2} t_1 = \omega$   
 $\sqrt{v^2 - u^2} t_1 = \omega \quad \dots (1)$

(II)  $(v_r + v_{h,r})t_2 = \omega$   
 $(v + u)t_2 = \omega \quad \dots (2)$

(1) / (2)  $\Rightarrow \frac{t_1}{t_2} = \sqrt{\frac{v+u}{v-u}}$

13.



$v_{p,w} \sin \theta = v_\omega$   
 $\Rightarrow \sin \theta = \frac{1}{15}$

14.  $\omega = 400 \text{ m}$

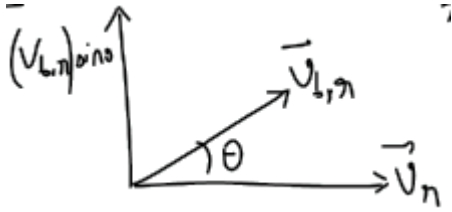
$v_r = 2 \text{ m/s}$

$v_{b,r} = 10 \text{ m/s}$

(a)  $t_{\min} = \frac{\omega}{v_{b,r}} = 40 \text{ s}$

(b)  $\text{drift} = (v_r)t = 80 \text{ m}$

15. (a)  $t = \frac{\omega}{v_{b,r} \sin \theta} = \frac{0.5 \text{ km}}{3 \text{ km/hr} \sin \theta} = \frac{10}{\sin \theta} \text{ mins}$



(b)  $t_{\min} = 10 \text{ mins}$

16.  $\omega = 0.5 \text{ km}$   
 $v_r = 5 \text{ km/hr}$   
 $v_{b,r} = 3 \text{ km/hr}$

For min drift  $\Rightarrow \sin \theta = \frac{v_{b,r}}{v_r} = \frac{3}{5} \Rightarrow \theta = 37^\circ$

$\because v_r > v_{b,r}$

Zero drift not possible.

Min. drift  $= \left( v_r - v_{b,r} \sin \theta \right) \frac{\omega}{v_{b,r} \cos \theta} = \frac{2}{3} \text{ km}$



## **JEE-Main Exercise**

1. (c)

Acceleration  $= \frac{d^2x}{dt^2} = 2a_2$

2. (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,

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

3. (c)

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

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

$$\begin{aligned} \therefore a &= \frac{1}{2}(180-16x)^{-1/2} \times (-16) \left( \frac{dx}{dt} \right) \\ &= -8(180-16x)^{-1/2} \times v \\ &= -8(180-16x)^{-1/2} \times (180-16x)^{1/2} = -8 \text{ m/s}^2 \end{aligned}$$

4. (c)

$$\text{Acceleration } a = \frac{dv}{dt} = 0.1 \times 2t = 0.2t$$

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

5. (c)

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

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

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

6. (c)

$$y = a + bt + ct^2 - dt^4$$

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

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

7. (b)

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

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

8. (c)

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

9. (b)

$$\text{Time} = \frac{\text{Distance}}{\text{Average speed}} = \frac{3.06}{0.34} = 9 \text{ sec}$$

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



10. (d)

$$s = 3t^3 + 7t^2 + 14t + 8 \text{ m}$$

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

11. (22)

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

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

$$\text{When particle is at } 2 \text{ m from the origin } t^4 - t^2 = 2$$

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

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

$$a = 12t^2 - 2 = 12 \times 2 - 2 = 22 \text{ m/s}^2$$

12. (18)

$$v = u + \int a \, dt = u + \int (3t^2 + 2t + 2) \, dt$$

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

$$= 2 + 8 + 4 + 4 = 18 \text{ m/s} \quad (\text{As } t = 2 \text{ sec})$$

13. (0)

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

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

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

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

14. (45)

$$a = 6t + 4$$

$$\Rightarrow \frac{dv}{dt} = 6t + 4 \Rightarrow \int_0^v dv = \int_0^v (6t + 4) \, dt$$

$$\Rightarrow [v]_0^v = [3t^2 + 4t]_0^t$$

$$\Rightarrow v - 0 = 3t^2 + 4t$$

$$\Rightarrow v = 3t^2 + 4t$$

$$v = \frac{dx}{dt} = 3t^2 + 4t$$

$$\Rightarrow \int_0^x dx = \int_0^t (3t^2 + 4t) \, dt$$

$$\Rightarrow [x]_0^x = (t^3 + 2t^2)_0^t$$

$$\Rightarrow x - 0 = t^3 + 2t^2$$

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

$$\text{At } t = 3, x = 45$$

15. (4)

$$\frac{dv}{dt} = -\frac{1}{30}v^2$$

$$\Rightarrow \int_5^v v^{-2} dv = -\frac{1}{30} \int_0^t dt$$

$$\Rightarrow \left[ -\frac{1}{v} \right]_5^v = -\frac{1}{30} [t]_0^t$$

$$\Rightarrow \frac{1}{v} - \frac{1}{5} = \frac{t}{30}$$

$$\Rightarrow \frac{1}{v} = \frac{t}{30} + \frac{1}{5}$$

$$\Rightarrow v = \frac{30}{t+6}$$

$$\text{When } v = 3 \Rightarrow \frac{30}{t+6} = 3$$

$$t + 6 = 10$$

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

16. (3)

$$s = \sqrt{at^2 + bt + c}$$

$$v = \frac{ds}{dt} = \frac{2at + b}{\sqrt{at^2 + bt + c}}$$

$$\text{Acceleration} = \frac{dv}{dt}$$

$$\Rightarrow \text{Acceleration} = \frac{(\sqrt{at^2 + bt + c})(2a) - (2at + b)(2at + b)}{(2\sqrt{at^2 + bt + c})^2}$$

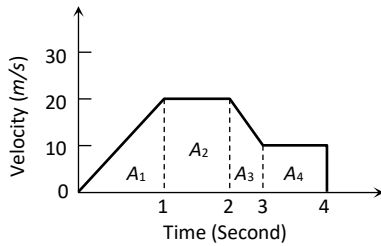
$$\Rightarrow \text{Acceleration} = \frac{4a(at^2 + bt + c) - (2at + b)^2}{2(at^2 + bt + c)^{3/2}}$$

$$\Rightarrow \text{Acceleration} = \frac{4ac - b^2}{(\sqrt{at^2 + bt + c})^3} = (4ac - b^2)s^{-3}$$

$$\text{Acceleration} \propto s^{-3}$$

17. (b)

Distance = Area under  $v-t$  graph =  $A_1 + A_2 + A_3 + A_4$



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

$$= 10 + 20 + 15 + 10 = 55 \text{ m}$$

18. (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.

19. (a)

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

20. (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.

21. (c)

$$v^2 = u^2 + 2aS, \text{ If } u = 0 \text{ then } v^2 \propto S$$

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

22. (a)

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

23. (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.

24. (c)

From given  $a-t$  graph it is clear that acceleration is increasing at constant rate

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

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

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

*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.

25. (c)

In first instant you will apply  $v = \tan \theta$  and say,  $v = \tan 30^\circ = \frac{1}{\sqrt{3}} \text{ m/s}$ .

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

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

Now  $v = \tan 60^\circ = \sqrt{3}$

26. (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

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

27. (0)

Since total displacement is zero, hence average velocity is also zero.

28. (B)

$$\sqrt{v_{MR}^2 - v_M^2} = \frac{1 \text{ km}}{\frac{1}{4} \text{ h}}$$

$$\Rightarrow \sqrt{5^2 - v_R^2} = 4$$

$$\Rightarrow v_R = 3 \text{ km/h}$$

29. (B)

$$v_{MR} \cos \theta = v_R$$

$$\frac{T_1}{T_2} = \frac{\frac{d}{v_{MR}}}{\frac{d}{(v_{MR}) \sin \theta}} = \sin \theta$$

30. (C)

$$t = \frac{d}{v_{MR} \sin \theta}$$

$$\Rightarrow v_{MR} \sin \theta = \frac{60}{6} = 10 \text{ m/s}$$

$$\tan \phi = \frac{v_{MR} \sin \theta}{v_R + v_{MR} \cos \theta}$$

$$\Rightarrow \tan 45^\circ = \frac{10}{5 + v_{MR} \cos \theta}$$

$$\Rightarrow v_{MR} \cos \theta = 5$$

$$v_{MR} = \sqrt{10^2 + 5^2} = 5\sqrt{5} \text{ m/s}$$

31. (B)

$$v_{MR} = (4.5 \text{ km/h}) \hat{\mathbf{j}}$$

$$\mathbf{v}_R = (6 \text{ km/h}) \hat{\mathbf{i}}$$

$$\mathbf{v}_M = \mathbf{v}_{MR} + \mathbf{v}_R = (4.5 \hat{\mathbf{j}} + 6 \hat{\mathbf{i}}) \text{ km/h}$$

$$v_M = \left( \sqrt{(4.5)^2 + 6^2} \right) \text{ km/h} = \frac{15}{2} \text{ km/h}$$

$$= \frac{15}{2} \times \frac{5}{18} \text{ m/s}$$

32. (B)

$$V_{MR} = 5 \text{ m/s}$$

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

$$t = \frac{d}{\sqrt{v_{MR}^2 - V_R^2}} = \frac{480}{3} = 160 \text{ s}$$

33. (d)

For the round trip he should cross perpendicular to the river

$$\therefore \text{Time for trip to that side} = \frac{1 \text{ km}}{4 \text{ km/hr}} = 0.25 \text{ hr}$$

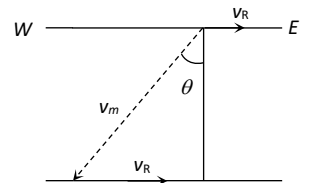
To come back, again he take 0.25 hr to cross the river.

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

34. (c)

For shortest possible path man should swim with an angle  $(90 + \theta)$  with downstream.

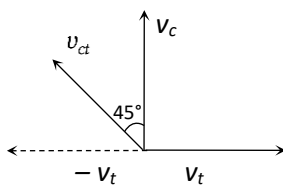
$$\text{From the fig, } \sin \theta = \frac{v_r}{v_m} = \frac{5}{10} = \frac{1}{2} \Rightarrow \therefore \theta = 30^\circ$$



35. (b)

$$\vec{v}_c = \vec{v}_c - \vec{v}_t$$

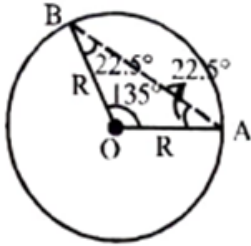
$$\vec{v}_c = \vec{v}_c + (-\vec{v}_t)$$



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

## PYQ : JEE-Main

1. (b)



From  $\triangle AOB$

$$\frac{AB}{\sin 135} = \frac{OB}{\sin 22.5}$$

$$AB = \frac{\sin 135}{\sin 22.5} OB$$

$$= \frac{\sin(135)}{\sin(22.5)} \frac{\text{arc}(AB)}{\frac{3\pi}{4}} = \frac{\sin(45)}{\sin(22.5)} \times \frac{60 \times 4}{3\pi} = 47\text{m}$$

2. (b)

Given,  $v = b\sqrt{x}$  or  $\frac{dx}{dt} = bx^{1/2}$

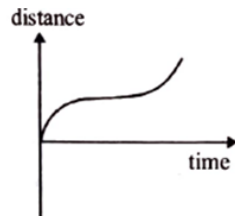
Or  $\int_0^x x^{-1/2} dx = \int_0^t b dt \Rightarrow \frac{x^{1/2}}{1/2} = bt \Rightarrow x = \frac{b^2 t^2}{4}$

Differentiating w.r.t. time, we get

$$\frac{dx}{dt} = \frac{b^2 2t}{4} \text{ or } v = \frac{b^2 \tau}{2} \quad (t = \tau)$$

3. (b)

Graphs in option (c) position-time and option (a) velocity- position are corresponding to velocity-time graph option (d) and its distance-time graph is as given below. Hence distance-time graph option (b) is incorrect.



4. (b)

We have,  $\vec{r} = 3t\hat{i} + 5t^3\hat{j} + 7\hat{k}$

So,  $\frac{d^2\vec{r}}{dt^2} = 30t\hat{j}$

At  $t = 1 \Rightarrow \boxed{\frac{d^2\vec{r}}{dt^2} = 30\hat{j}} \Rightarrow \vec{a} = 30\hat{j}$

5. (a)  
At  $t = 20\text{sec}$

$$V_H = at = 5 \times 20 = 100\text{m/s}$$

At  $t = 1\text{sec}$

[ $\because$  After falling there is not acceleration in horizontal direction]

$$V_v = (0 + g \times 1) = 10 \times 1 = 10\text{m/s}$$

$$\text{So, } \vec{V} = 100\hat{i} - 10\hat{j}$$



6. (c)  
Time of fall of packet

$$t = \sqrt{\frac{2h}{g}}, x = \sqrt{\frac{2h}{g}}v$$

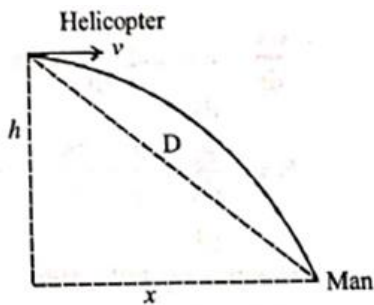
Horizontal range ( $x$ ) = time  $\times$  horizontal component of velocity ( $v$ )

$\therefore$  Required distance

$$D = \sqrt{x^2 + h^2}$$

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

$$\text{Or, } D = \sqrt{\frac{2hv^2}{g} + h^2}$$



7. (b)  
Given:  $\vec{u} = 5\hat{j}\text{m/s}$

Acceleration,  $\vec{a} = 10\hat{i} + 4\hat{j}$  and final coordinate  $(20, y_0)$  in time  $t$ .

$$S_x = u_x t + \frac{1}{2} a_x t^2 \quad [\because u_x = 0]$$

$$\Rightarrow 20 = 0 + \frac{1}{2} \times 10 \times t^2 \Rightarrow t = 2\text{s}$$

$$S_y = u_y \times t + \frac{1}{2} a_y t^2$$

$$y_0 = 5 \times 2 + \frac{1}{2} 4 \times 2^2 = 18\text{m}$$

8. (d)

Given, Position vector,

$$\vec{r} = \cos \omega t \hat{i} + \sin \omega t \hat{j}$$

$$\text{Velocity, } \vec{v} = \frac{d\vec{r}}{dt} = \omega(-\sin \omega t \hat{i} + \cos \omega t \hat{j})$$

Acceleration,

$$\vec{a} = \frac{d\vec{v}}{dt} = -\omega^2 (\cos \omega t \hat{i} + \sin \omega t \hat{j})$$

$$\vec{a} = -\omega^2 \vec{r}$$

$\therefore \vec{a}$  is antiparallel to  $\vec{r}$

Also  $\vec{v} \cdot \vec{r} = 0 \therefore \vec{v} \perp \vec{r}$

Thus, the particle is performing uniform circular motion.

9. (d)

$$\vec{r} = 15t^2 \hat{i} + (4 - 20t^2) \hat{j}$$

$$\vec{v} = \frac{d\vec{r}}{dt} = 30t \hat{i} - 40t \hat{j}$$

$$\text{Acceleration, } \vec{a} = \frac{d\vec{v}}{dt} = 30 \hat{i} - 40 \hat{j}$$

$$\therefore a = \sqrt{30^2 + 40^2} = 50$$

10. (c)

From given equation,

$$\vec{V} = K(y \hat{i} + x \hat{j})$$

$$\frac{dx}{dt} = Ky \quad \text{and} \quad \frac{dy}{dt} = Kx$$

$$\text{Now } \frac{\frac{dy}{dt}}{\frac{dx}{dt}} = \frac{x}{y} = \frac{dy}{dx} \Rightarrow y dy = x dx$$

Integrating both side

$$y^2 = x^2 + c$$

11. (d)

Equation of trajectory of projectile

$$y = x \tan \theta - \frac{1}{2} \frac{gx^2}{u^2 \cos^2 \theta} = x \tan 45^\circ - \frac{1}{2} \frac{10x^2}{u^2 \cos^2 45^\circ}$$



$$\Rightarrow y = x - \frac{10x^2}{2u^2\left(\frac{1}{2}\right)} \Rightarrow 10 = 20 - \frac{(10)(100)}{u^2} \Rightarrow u = 20$$

$$\text{Time period, } T = \frac{2u \sin \theta}{g} = \frac{(2)(20)}{\sqrt{2}(10)} = 2\sqrt{2}$$

$$\vec{v} = u \cos \theta \hat{i} + (\mu \sin \theta - gt) \hat{j} = \left[ 10\sqrt{2} \hat{i} + (10\sqrt{2} - 10\sqrt{2}) \hat{j} \right]$$

$$\text{Momentum } \vec{P} = M\vec{v} = 100\sqrt{2} \hat{i} + (100\sqrt{2} - 200) \hat{j}$$

12. (c)

Projection speed is  $v$ .

$$R_1 = \frac{v^2 \sin(90^\circ)}{g}; R_2 = \frac{v^2 \sin(60^\circ)}{g}$$

$$\therefore \frac{R_1}{R_2} = \frac{2}{\sqrt{3}}$$

13. (d)

As range and maximum height are equal

$$R = H$$

$$\Rightarrow \frac{2v_x - v_y}{g} = \frac{v_y^2}{2g},$$

$$\Rightarrow v_x = \frac{v_y}{4} \Rightarrow u \cos \theta = \frac{u \sin \theta}{4} \Rightarrow \tan \theta = 4$$

14. (c)

$$\text{As, } H_{\max} = \frac{u^2 \sin^2 \theta}{2g} \Rightarrow u^2 \propto \frac{1}{\sin^2 \theta}$$

$$\Rightarrow u \propto \frac{1}{\sin \theta} \Rightarrow \frac{\sin \theta_2}{\sin \theta_1} = \frac{u_1}{u_2}$$

$$\Rightarrow \sin \theta_1 = \frac{u_2}{u_1} \times \sin \theta_2 = \frac{\sqrt{2}}{\sqrt{3}} \times \frac{\sqrt{3}}{2} = \frac{1}{\sqrt{2}}$$

$$\text{So, } \theta_1 = \sin^{-1}\left(\frac{1}{\sqrt{2}}\right) = 45^\circ$$

15. (a)

$$R = \frac{u^2 \sin 2\theta}{g}$$

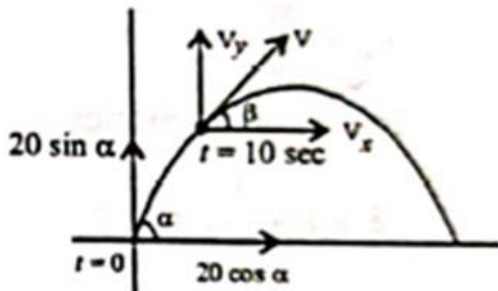
$$\text{For, } R = R_{\max}$$

$$\sin 2\theta = 1 \Rightarrow 2\theta = \frac{\pi}{2}$$

$$\theta = \frac{\pi}{4}, \text{ So } R_{\max} = \frac{u^2}{g} = 100\text{m}$$

$$\text{So, } H = \frac{u^2 \sin^2\left(\frac{\pi}{4}\right)}{2g} = \frac{u^2 \times \frac{1}{2}}{2g} = \frac{u^2}{4g} = \frac{100}{4} = 25\text{m}$$

16. (b)



$$v_x = 20 \cos \alpha [\because a_x = 0]$$

$$v_y = 20 \sin \alpha - g \times t [\because a_y = -g]$$

$$= 20 \sin \alpha - 10 \times 10$$

$$= 20 \sin \alpha - 100$$

$$\text{So, } \tan \beta = \frac{v_y}{v_x} = \frac{20 \sin \alpha - 100}{20 \cos \alpha} = \tan \alpha - 5 \sec \alpha$$

17. (a)

We know that if range is same for two angle of projection, then these angles must be complementary. Let first angle of projection be ' $\theta$ ' then second will be  $(90 - \theta)$

$$\therefore h_1 = \frac{u^2 \sin^2 \theta}{2g} \text{ and } h_2 = \frac{u^2 \sin^2 (90 - \theta)}{2g} = \frac{u^2 \cos^2 \theta}{2g}$$

$$\therefore h_1 h_2 = \frac{u^2 \sin^2 \theta}{2g} \cdot \frac{u^2 \cos^2 \theta}{2g}, \text{ So, reason is correct}$$

$$\Rightarrow \sqrt{h_1 h_2} = \frac{u^2 \sin \theta \cos \theta}{2g} \Rightarrow 4\sqrt{h_1 h_2} = \frac{4u^2 \sin \theta \cos \theta}{2g}$$

$$\Rightarrow 4\sqrt{h_1 h_2} = \frac{u^2 (2 \sin \theta \cos \theta)}{g} \Rightarrow 4\sqrt{h_1 h_2} = \frac{u^2 \sin^2 \theta}{g} = R$$

So, assertion is correct

18. (d)

At maximum height inclination with horizontal becomes zero

$$\text{So, } t = \frac{u \sin \theta}{g} \Rightarrow u = \frac{gt}{\sin \theta} \quad \dots(i)$$

$$\text{Now, } R = u \cos \theta \times T \Rightarrow R = u \cos \theta \times 2t$$

$$\Rightarrow \cos \theta = \frac{R}{2ut} \Rightarrow \cos \theta = \frac{R \sin \theta}{\sin \theta} \quad [\text{From (i)}]$$

$$\Rightarrow \tan \theta = \frac{2gt^2}{R} \Rightarrow \tan \theta = \frac{20t^2}{R} \Rightarrow \cot \theta = \frac{R}{20t^2}$$

19. (b)  
For projectile motion,

$$\text{Range } R = \frac{u^2 \sin 2\theta}{g}$$

As range is same for angle of projection  $\theta$  and  $90-\theta$ . So, range is same for  $42^\circ$  and  $48^\circ$ .

$$\text{Height in projectile motion, } H = \frac{u^2 \sin^2 \theta}{2g} \Rightarrow H \propto \sin^2 \theta$$

So H is higher for  $48^\circ$  than H for  $42^\circ$

20. (d)  
Given:  $y = \alpha x - \beta x^2$

For maximum height, maximum value of y

$$\frac{dy}{dx} = 0 \Rightarrow \frac{d(\alpha x - \beta x^2)}{dx} = 0 \Rightarrow \alpha - 2\beta x = 0$$

$$\therefore x = \frac{\alpha}{2\beta}$$

$$\therefore y = \alpha \left( \frac{\alpha}{2\beta} \right) - \beta \left( \frac{\alpha^2}{4\beta^2} \right) \Rightarrow \left( \frac{\alpha^2}{2\beta} \right) - \left( \frac{\alpha^2}{4\beta} \right) \Rightarrow \frac{\alpha^2}{4\beta}$$

$$\text{So, } H_{\max} = \frac{\alpha^2}{4\beta}$$

Hence option (D) is correct answer.

21. (a)  
Using principal of conservation of linear momentum for horizontal motion, we have

$$2mv_x = mu + mu \cos 60^\circ$$

$$v_x = \frac{3u}{4}$$

For vertical motion

$$h = 0 + \frac{1}{2}gT^2 \Rightarrow T = \sqrt{\frac{2h}{g}}$$

Let R is the horizontal distance travelled by the body.

$$R = v_x T + \frac{1}{2}(0)(T)^2 \text{ (For horizontal motion)}$$

$$R = v_x T = \frac{3u}{4} \times \sqrt{\frac{2h}{g}} \Rightarrow R = \frac{3\sqrt{3}u^2}{8g}$$

22. (c)  
Given,  $y = 2x - 9x^2$

On comparing with,

$$y = x \tan \theta - \frac{gx^2}{2u^2 \cos^2 \theta},$$

We have,

$$\tan \theta = 2 \text{ or } \cos \theta = \frac{1}{\sqrt{5}}$$

$$\text{And } \frac{g}{2u^2 \cos^2 \theta} = 9 \text{ or } \frac{10}{2u^2 (1/\sqrt{5})^2} = 9$$

$$\therefore u = 5/3 \text{ m/s}$$

23. (d)

R will be same for  $\theta$  and  $90^\circ - \theta$

Time of flights:

$$t_1 = \frac{2u \sin \theta}{g} \text{ and}$$

$$t_2 = \frac{2u \sin(90^\circ - \theta)}{g} = \frac{2u \cos \theta}{g}$$

$$\text{Now, } t_1 t_2 = \left( \frac{2u \sin \theta}{g} \right) \left( \frac{2u \cos \theta}{g} \right) = \frac{2}{g} \left( \frac{u^2 \sin 2\theta}{g} \right) = \frac{2R}{g}$$

24. (a)

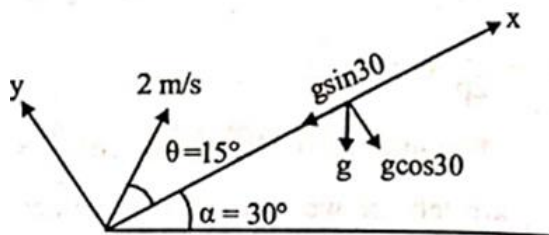
On an inclined plane, time of flight (T) is given by

$$T = \frac{2u \sin \theta}{g \cos \alpha}$$

Substituting the values, we get

$$T = \frac{(2)(2 \sin 15^\circ)}{g \cos 30^\circ} = \frac{4 \sin 15^\circ}{10 \cos 30^\circ}$$

$$\text{Distance, } S = (2 \cos 15^\circ) T - \frac{1}{2} g \sin 30^\circ (T)^2$$



$$= (2 \cos 15^\circ) \frac{4 \sin 15^\circ}{10 \cos 30^\circ} - \left( \frac{1}{2} \times 10 \sin 30^\circ \right) \frac{16 \sin^2 15^\circ}{100 \cos^2 30^\circ}$$

$$= \frac{16\sqrt{3} - 16}{60} \approx 0.1952 \approx 20 \text{ cm}$$

25. (a)

$$\text{As we know, range } R = \frac{u^2 \sin 2\theta}{g}$$

$$\text{And, area } A = \pi R^2$$

$$\therefore A \propto R^2 \text{ or, } A \propto u^4$$

$$\therefore \frac{A_1}{A_2} = \frac{u_1^4}{u_2^4} = \left[ \frac{1}{2} \right]^4 = \frac{1}{16}$$

26. (b)

Given,  $t = \sqrt{x} + 4$

$$\Rightarrow x = (t-4)^2 = t^2 - 8t + 16$$

$$\Rightarrow \frac{dx}{dt} = 2t - 8 \Rightarrow \left. \frac{dx}{dt} \right|_{t=4} = 2 \times 4 - 8 = 0$$

27. (c)

Let initial velocity of bullet =  $u$

Final velocity of bullet =  $\frac{u}{3}$

Distance travelled by bullet,  $s = 4\text{cm}$

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

$$\Rightarrow \left( \frac{u}{3} \right)^2 = u^2 - 2a(4) \Rightarrow a = \frac{8u^2}{9(8)} = \frac{u^2}{9}$$

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

$$0 = v^2 - 2a(4+x)$$

$$\Rightarrow v^2 = 2 \left( \frac{u^2}{9} \right) (4+x) \Rightarrow 4.5 = 4+x \Rightarrow x = 0.5$$

28. (c)

In 't' sec,  $S = 10\text{m}$

$$\text{So, } 10 = \frac{1}{2}at^2 \quad \dots\dots(i)$$

In next, 't' sec, suppose body travel  $S'$  distance

$$\text{Then, } 10 + S' = \frac{1}{2}a(2t)^2 \quad \dots\dots(ii)$$

Dividing (ii) by (i), we get

$$\Rightarrow \frac{10+S'}{10} = 4 \Rightarrow 10+S' = 40 \Rightarrow S' = 30\text{m}$$

29. (d)

For bus P

$$x_p(t) = \alpha t + \beta t^2$$

$$V_p(t) = \alpha + 2\beta t \quad \left[ \because V_p = \frac{dx_p}{dt} \right]$$

For bus Q

$$x_q(t) = \int t - t^2$$

$$V_q(t) = f - 2t \left[ \because V_q = \frac{dx_q}{dt} \right]$$

$$\text{As, } V_p(t) = V_q(t) \Rightarrow \alpha + 2\beta t = f - 2t$$

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

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

30. (b)

We have given,

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

$$\Rightarrow \frac{ds}{dt} = \alpha t + \beta t^2 \Rightarrow \int_{s_1}^{s_2} ds = \int_1^2 (\alpha t + \beta t^2) dt$$

$$\Rightarrow s_2 - s_1 = \left[ \frac{\alpha t^2}{2} + \frac{\beta t^3}{3} \right]_1^2$$

As particle is moving in a straight line,

$\therefore$  Distance = Displacement

$$\therefore \text{Distance} = \left[ \frac{\alpha [4-1]}{2} + \frac{\beta [8-1]}{3} \right] = \frac{3\alpha}{2} + \frac{7\beta}{3}$$

31. (c)

For time interval  $t_1$

$$v_1 = u_1 + a_1 t$$

$$\Rightarrow v_1 = at_1 \quad [\because u_1 = 0]$$

For time interval  $t_2$

$$v_2 = u_2 + (-a_2 t_2) \text{ or, } 0 = v_1 - a_2 t_2 \Rightarrow v_1 = a_2 t_2$$

$$\therefore a_1 t_1 = a_2 t_2 \text{ or, } \frac{t_1}{t_2} = \frac{a_2}{a_1}$$

32. (b)

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

$$\text{Velocity, } v = \frac{dx}{dt} = \frac{d}{dt} (at + bt^2 - ct^3)$$

$$= a + 2bt - 3ct^2$$

$$\text{Acceleration, } \frac{dv}{dt} = \frac{d}{dt} (a + 2bt - 3ct^2)$$

$$\text{Or } 0 = 2b - 3c \times 2t \quad \therefore t = \left( \frac{b}{3c} \right)$$

$$\text{and } v = a + 2b\left(\frac{b}{3c}\right) - 3c\left(\frac{b}{3c}\right)^2 = \left(a + \frac{b^2}{3c}\right)$$

33. (d)

For constant acceleration, there is straight line parallel to t-axis on  $\vec{a} - t$

34. (d)

Position of the particle,

$S =$  area under graph (time  $t=0$  to 5s)

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

35. (b)

$$\text{Here, } s = \frac{v^2}{2a} \Rightarrow s \propto v^2$$

$$\Rightarrow s_2 = s_1 \left(\frac{v_2}{v_1}\right)^2 \Rightarrow s_2 = 40 \left(\frac{80}{40}\right)^2 \Rightarrow s_2 = 160\text{m}$$

36. (c)

$$\text{Using equation, } a = \frac{v-u}{t} \text{ and } S = ut + \frac{1}{2}at^2$$

$$\begin{aligned} \text{Distance travelled by car in 15 sec} &= \frac{1}{2} \left(\frac{45}{15}\right) (15)^2 \\ &= \frac{675}{2} \text{m} \end{aligned}$$

$$\text{Distance travelled by scooter in 15 seconds} = 30 \times 15 = 450$$

( $\because$  distance = speed  $\times$  time)

$$\text{Difference between distance travelled by car and scooter in 15 sec, } 450 - 337.5 = 112.5\text{m}$$

Let car catches scooter in time  $t$ ;

$$\begin{aligned} \frac{675}{2} + 45(t-15) &= 30t \Rightarrow 337.5 + 45t - 675 = 30t \Rightarrow 15t = 337.5 \\ \Rightarrow t &= 22.5\text{sec} \end{aligned}$$

37. (a)

Let the car turn of the highway at a distance 'x' from the point M. So,  $RM = x$

And if speed of car in field is  $v$ , then time taken by the car to cover the distance  $QR = QM - x$  on the highway.

$$t_1 = \frac{QM - x}{2v} \quad \dots\dots(i)$$

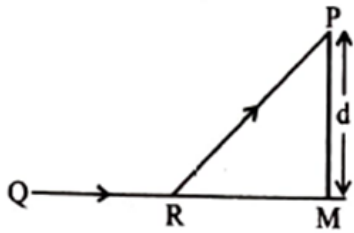
Time taken to travel the distance 'RP' in the field

$$t_2 = \frac{\sqrt{d^2 + x^2}}{v} \quad \dots\dots(ii)$$

Total time elapsed to move the car from Q to P

$$t = t_1 + t_2 = \frac{QM - x}{2v} + \frac{\sqrt{d^2 + x^2}}{v}$$

For 't' to be minimum  $\frac{dt}{dx} = 0$



$$\frac{1}{v} \left[ -\frac{1}{2} + \frac{x}{\sqrt{d^2 + x^2}} \right] = 0$$

$$\text{Or } x = \frac{d}{\sqrt{2^2 - 1}} = \frac{d}{\sqrt{3}}$$

38. (c)

Let L be the length of escalator. Speed of man wrt escalator  $= \frac{L}{t_1} = V_1$

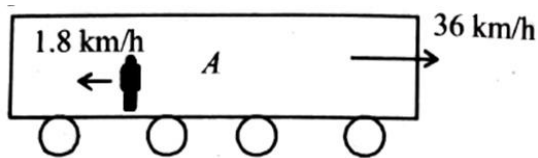
Speed of escalator  $= \frac{L}{t_2} = V_2$

Time taken when escalator is moving and man is also walking on it

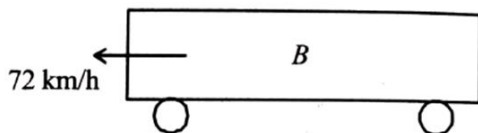
$$= t = \frac{L}{v_1 + v_2} \Rightarrow \frac{1}{t} = \frac{v_1 + v_2}{L} = \frac{1}{t_1} + \frac{1}{t_2} \Rightarrow t = \frac{t_1 t_2}{t_1 + t_2}$$

39. (a)

According to question, train A and B are running on parallel tracks in the opposite direction.



$$V_A = 36 \text{ km/h} = 10 \text{ m/s}$$



$$V_B = -72 \text{ km/h} = -20 \text{ m/s}; V_{MA} = -1.8 \text{ km/h} = -0.5 \text{ m/s}$$

$$V_{\text{man},B} = V_{\text{man},A} + V_{A,B}$$

$$= V_{\text{man},A} + V_A - V_B = -0.5 + 10 - (-20)$$

$$= -0.5 + 30 = 29.5 \text{ m/s}$$

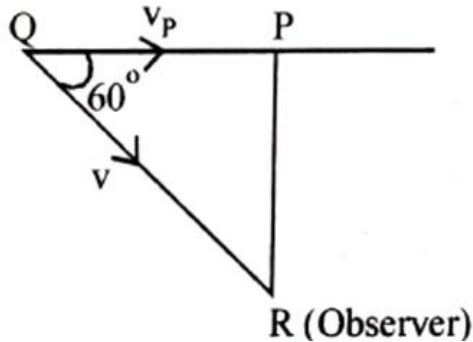
40. (a)



$$t_1 = \frac{(60+120)/1000 \text{ km}}{80-30}$$

$$t_2 = \frac{(60+120)/1000 \text{ km}}{80+30} \therefore \frac{t_1}{t_2} = \frac{11}{5}$$

41. (d)

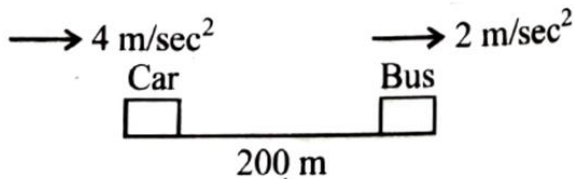


Distance,  $PQ = v_P \times t$  (Distance = speed  $\times$  time)

Distance,  $QR = v \cdot t$

$$\cos 60^\circ = \frac{PQ}{QR}; \frac{1}{2} = \frac{v_P \times t}{v \cdot t} \Rightarrow v_P = \frac{v}{2}$$

42. (c)



Given,  $u_C = u_B = 0, a_C = 4 \text{ m/s}^2, a_B = 2 \text{ m/s}^2$

Hence relative acceleration,  $a_{CB} = 2 \text{ m/sec}^2$

Now, we know,  $s = ut + \frac{1}{2}at^2 \Rightarrow 200 = \frac{1}{2} \times 2t^2 [\because u = 0]$

Hence, the car will catch up with the bust after time

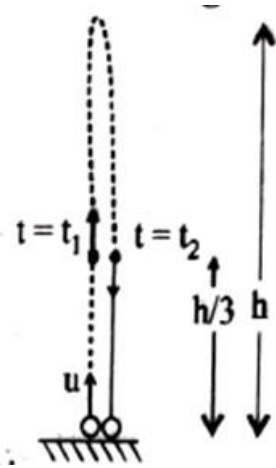
$$t = 10\sqrt{2} \text{ second}$$

43. (b)

Maximum height =  $h = \frac{u^2}{2g}$  [  $\because$  At maximum height  $v = 0$ . So  $0^2 = u^2 - 2gh$

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

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



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

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

$$\Rightarrow \frac{h}{3} = t\sqrt{2gh} + \frac{1}{2}(-g)t^2$$

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

Let  $t_1$  and  $t_2$  be two roots of above equation.

$$\begin{aligned} \text{Then, } \frac{t_2}{t_1} &= \frac{\sqrt{2gh} + \sqrt{2gh - 4 \times \frac{g}{2} \times \frac{h}{3}}}{\sqrt{2gh} - \sqrt{2gh - 4 \times \frac{g}{2} \times \frac{h}{3}}} \\ &= \frac{\sqrt{2gh} + \sqrt{\frac{4gh}{3}}}{\sqrt{2gh} - \sqrt{\frac{4gh}{3}}} = \frac{\sqrt{3} + \sqrt{2}}{\sqrt{3} - \sqrt{2}} \end{aligned}$$

44. (d)

$$\text{From equation of motion, } s = ut + \frac{1}{2}gt^2$$

$$\text{For first } \frac{h}{2}, \frac{h}{2} = \frac{1}{2}gt_1^2 \quad \dots(i)$$

For total height  $h$ ,

$$h = \frac{1}{2}g(t_1 + t_2)^2 \quad \dots(ii)$$

$$\text{Divide equation (ii) by (i) we have } \frac{1}{2} = \frac{t_1^2}{(t_1 + t_2)^2}$$

$$\frac{1}{\sqrt{2}} = \frac{t_1}{t_1 + t_2}; 1 + \frac{t_2}{t_1} = \sqrt{2}$$

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

45. (d)

Time taken by all to reach highest point,  $t = \frac{v}{g}$

Frequency of throw,  $n = \frac{1}{t} = \frac{g}{v}$

$$\Rightarrow v = \frac{g}{n} \quad \dots(i)$$

The maximum height the balls can reach,

$$H_{\max} = \frac{v^2}{2g} = \frac{\left(\frac{g}{n}\right)^2}{2g} = \frac{g}{2n^2} \text{ from equation (i)}$$

46. (a)

$$\text{From } h = ut + \frac{1}{2}gt^2 \Rightarrow t = \sqrt{\frac{2h}{g}}$$

$$\text{Time taken by mango, } t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 19.6}{9.8}} = 2\text{s}$$

$$\text{Distance } x = vt = \frac{5}{2} \times 2 = 5\text{m}$$

47. (a)

At  $t = 0$ ,  $u = 100\text{m/s}$  downwards

For 0 to 10 sec

$$v = u - gt = -100 - 10 \times 10 = -200\text{m/s}$$

So the curve will be straight line with  $-100$  as intercept for 10 to 20 sec,  $v=0$ , so option (A) is correct

48. (d)

Let us suppose both ball meet at  $t = t$  sec at high  $h$  below.

$$\text{For 'A', } h = \frac{1}{2}gt^2 \Rightarrow -80 = \frac{-1}{2} \times 10 \times t^2$$

$$\Rightarrow t^2 = 16 \Rightarrow t = 4\text{sec}$$

For ball 'B'

$$h = u(t-2) - \frac{1}{2}g(t-2)^2 \Rightarrow -80 = -2u - \frac{1}{2}g \times 2^2$$

$$\Rightarrow -80 = -2u - 20 \Rightarrow 2u = 60 \quad \therefore u = 30\text{m/s}$$

49. (c)

50. (d)

$$\text{Using } H = \frac{1}{2}gt^2 \Rightarrow 2H/g = t^2$$

$$\Rightarrow \frac{9.8 \times 2}{9.8} = t^2 \Rightarrow t = \sqrt{2} \text{ s}$$

For first drop,  $t=0$ . For second drop,  $t = \Delta t$ . For third drop,  $t = 2\Delta t$

Let  $h$  be the distance travelled by second drop when third drop begins to fall.

$$\therefore h = \frac{1}{2} g (\sqrt{2} - \Delta t)^2 \Rightarrow 0 = \frac{1}{2} g (\sqrt{2} - \Delta t)^2 \Rightarrow \Delta t = \frac{1}{\sqrt{2}}$$

$$\therefore h = \frac{1}{2} g \left( \sqrt{2} - \frac{1}{\sqrt{2}} \right)^2 = \frac{1}{2} \times 9.8 \times \frac{1}{2} = \frac{9.8}{4} = 2.45 \text{ m}$$

Height of second drop from floor

$$H - h = 9.8 - 2.45 = 7.35 \text{ m}$$

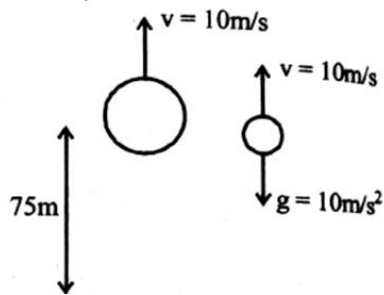
51. (c)

Given

Initial velocity of hot air balloon,  $u = 10 \text{ m/s}$

For stone

Using,



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

$$\Rightarrow 75 = -10t + \frac{1}{2} gt^2$$

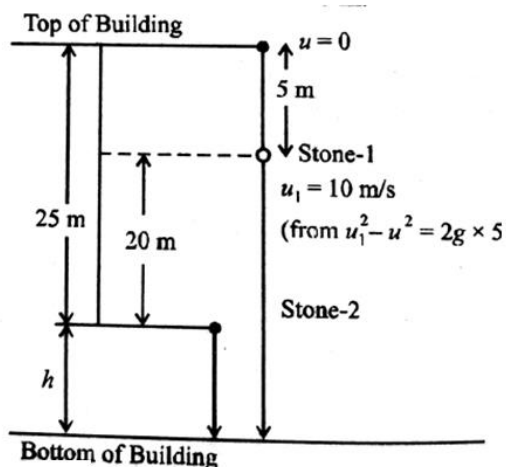
$$\Rightarrow 75 = -10t + 5t^2$$

$$\Rightarrow t^2 - 2t - 15 = 0 \Rightarrow t = 5 \text{ sec}$$

Height of balloon

$$H = vt + 75 \Rightarrow H = 10 \times 5 + 75 = 125 \text{ m}$$

52. (b)



For stone -1,  $20 + h = 10t + \frac{1}{2}gt^2$  .....(i)

And for stone -2,  $h = \frac{1}{2}gt^2$  .....(ii)

Putting value of h from eq.(ii) in eq. (i)

$$20 + \frac{1}{2}gt^2 = 10t + \frac{1}{2}gt^2 \therefore t = 2s$$

Therefore,  $h = \frac{1}{2}gt^2 = \frac{1}{2} \times 10 \times 2^2 = 20m$

$\therefore$  Height of the building =  $h + 25 = 20 + 25 = 45m$

53. (c)

For upward motion of helicopter,

$$v^2 = u^2 + 2gh \Rightarrow v^2 = 0 + 2gh \Rightarrow v = \sqrt{2gh}$$

Now, packet will start moving under gravity

Let 't' be the time taken by the food packet to reach the ground.

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

$$\Rightarrow -h = \sqrt{2gh}t - \frac{1}{2}gt^2 \Rightarrow \frac{1}{2}gt^2 - \sqrt{2gh}t - h = 0$$

$$\text{or, } t = \frac{\sqrt{2gh} \pm \sqrt{2gh + 4 \times \frac{g}{2} \times h}}{2 \times \frac{g}{2}} \Rightarrow t = \sqrt{\frac{2gh}{g}} (1 + \sqrt{2})$$

$$\Rightarrow t = \sqrt{\frac{2h}{g}} (1 + \sqrt{2}) \Rightarrow t = 3.4 \sqrt{\frac{h}{g}}$$

54. (a)

For uniformly accelerated or deceleration motion  $v^2 = u^2 \pm 2gh$  equation is quadratic hence v-h graph will be a parabola.

Initial velocity downwards so negative after collision, it reverses its direction with smaller value hence velocity is upwards

Further,  $v'^2 = 2g \times \left(\frac{d}{2}\right) = gd$  ;

$$\therefore \left(\frac{v}{v'}\right) = \sqrt{2} \text{ or } v = v'\sqrt{2} \Rightarrow v' = \frac{v}{\sqrt{2}}$$

As the direction is reversed and speed is decreased so graph(a) correctly depicts these conditions.

55. (3)

$$V_{av} = \frac{S_{total}}{T_{total}} = \frac{200 + 200 + \frac{2\pi \times 200}{4}}{238}$$

$$= \frac{400 + 100\pi}{238} = \frac{714}{238} = 3 \text{ m/s}$$

56. (18)

$$v_{avg} = \frac{l_{total}}{t_{total}} = \frac{l/3 + l/3 + l/3}{\frac{l}{3v_1} + \frac{l}{3v_2} + \frac{l}{3v_3}}$$

$$= \frac{l}{\frac{l}{3} \left( \frac{1}{v_1} + \frac{1}{v_2} + \frac{1}{v_3} \right)} = \frac{1}{\frac{1}{3} \left( \frac{1}{11} + \frac{1}{22} + \frac{1}{33} \right)}$$

$$= \frac{33}{1 + \frac{1}{2} + \frac{1}{3}} = \frac{198}{6 + 3 + 2} = \frac{198}{11} = 18 \text{ m/s}$$

57. (580)

For particle 'A'                      For particle 'B'

$$X_A = -3t^2 + 8t + 10 \quad Y_B = 5 - 8t^3$$

$$\vec{v}_A = (8 - 6t)\hat{i} \quad \vec{v}_B = -24t^2\hat{j}$$

$$\vec{a}_A = -6\hat{i} \quad \vec{a}_B = -48t\hat{j}$$

At  $t = 1 \text{ sec}$

$$\vec{v}_A = (8 - 6t)\hat{i} = 2\hat{i} \quad \text{and} \quad \vec{v}_B = -24\hat{j}$$

$$\therefore \vec{v}_{B/A} = -\vec{v}_A + \vec{v}_B = -2\hat{i} - 24\hat{j}$$

$$\therefore \text{speed of B w.r.t. A, } \sqrt{v} = \sqrt{2^2 + 24^2}$$

$$= \sqrt{4 + 576} = \sqrt{580}$$

$$\therefore v = 580 \text{ (m/s)}$$

58. (15 or 75)

$$\text{We know that range (R)} = \frac{u^2 \sin 2\theta}{g}$$

$$\text{So, } R_{\max} = \frac{u^2 \sin 2(45^\circ)}{g} = \frac{u^2}{g} \Rightarrow \frac{R}{2} = \frac{u^2}{2g} = \frac{u^2 \sin 2\theta}{g}$$

$$\Rightarrow \sin 2\theta = \frac{1}{2} \Rightarrow 2\theta = 30^\circ, 150^\circ \Rightarrow \theta = 15^\circ, 75^\circ$$

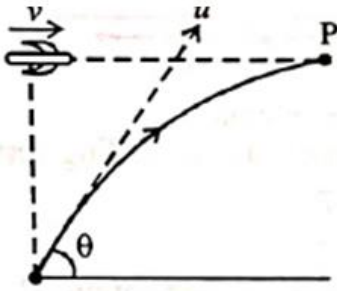
59. (1)

Here, time of flight is same

So, vertical component of velocity is same

Therefore  $H_{\max}$  is same.

60. (60)



If fighter, jet and bullet have same horizontal component of velocity, then it will strike after some time as shown above because horizontal displacement of both of them in given time interval will always be same.

$$\text{i.e. } v = u \cos \theta \Rightarrow 200 = 400 \cos \theta$$

$$\Rightarrow \cos \theta = \frac{1}{2} \Rightarrow \theta = 60^\circ$$

61. (20)

$$\text{Let } \vec{v}_1 = a\hat{i} + a\hat{j} \left[ \because \theta = 45^\circ \Rightarrow u_x = u_y \right]$$

$$\text{Then, } \vec{V}_f = a\hat{i} + (a - 2 \times 10)\hat{j}$$

$$= a\hat{i} + (a - 20)\hat{j}$$

$$\text{As, } |\vec{V}_f| = 20$$

$$\Rightarrow a^2 + (a - 20)^2 = 400$$

$$\Rightarrow a^2 + a^2 + 400 - 40a = 400 \Rightarrow 2a^2 - 40a = 0$$

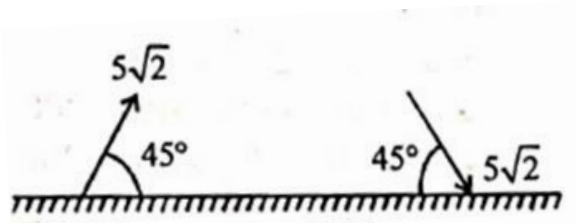
$$\Rightarrow a^2 = 20a = 0 \Rightarrow a(a - 20) = 0$$

$$\Rightarrow a = 20. \text{ So, } V_i = \sqrt{20^2 + 20^2} = 20\sqrt{2}$$

$$\therefore h_{\max} = \frac{V_i^2 \sin^2 45^\circ}{2g} = \frac{800 \times \frac{1}{2}}{2 \times 10} = 20\text{m}$$

62. (5)

Change in momentum,



$$\Delta \vec{P} = \vec{P}_B - \vec{P}_A$$

$$\Delta \vec{P} = mV \cos \theta \hat{i} - mV \sin \theta \hat{j}$$

$$= m(5\sqrt{2} \cos 45^\circ \hat{i} - 5\sqrt{2} \sin 45^\circ \hat{j})$$

$$= -m \left( 5\sqrt{2} \times \frac{1}{\sqrt{2}} \hat{i} + 5\sqrt{2} \times \frac{1}{\sqrt{2}} \hat{j} \right) = -2m \times 5\sqrt{2} \times \frac{1}{\sqrt{2}}$$

$$|\Delta \vec{P}| = 2 \times (5 \times 10^{-3}) \times (5) = 5 \times 10^{-2} \text{ kg ms}^{-1}$$

$$\therefore x = 5$$

63. (3)

If speed becomes 'n' times by keeping 'a' constant, then stopping distance becomes  $n^2$  times

Here,  $V \rightarrow V/3$

$$\text{So, } S \rightarrow \frac{S}{9} \text{ i.e. } \frac{27}{9} \text{ m i.e. } 3\text{m}$$

64. (100)

$$\frac{dv}{ds} = 5; \text{ As } a = \frac{dV}{dt} = \frac{dV}{ds} \times \frac{ds}{dt} = v \frac{dV}{ds}$$

$$\text{So, } a = v \frac{dv}{ds} = 20 \times 5 = 100 \text{ m/sec}^2$$

65. (1)

$$\text{As } v^2 = u^2 + 2ax$$

At point 'A'

$$40 = u^2 + 2a \cdot 10 \quad \dots(i)$$

At point 'B'

$$60 = u^2 + 2a \cdot 20 \quad \dots(ii)$$

Subtracting (ii) from (i), we get

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

66. (12)

Acceleration equals to  $a = v \frac{dv}{dx}$

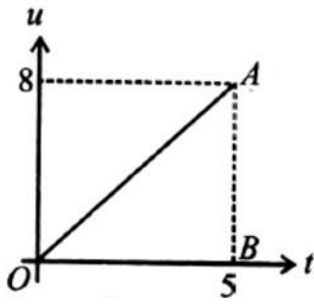
$$a = \frac{v dv}{dx} \text{ \& } v = \sqrt{5000 + 24x}$$

$$\Rightarrow \frac{dv}{dx} = \frac{1}{2\sqrt{5000 + 24x}} \times 24 = \frac{12}{\sqrt{5000 + 24x}}$$

$$\Rightarrow a = v \frac{dv}{dx} = \sqrt{5000 + 24x} \times \frac{12}{\sqrt{5000 + 24x}} = 12 \text{ m/s}^2$$

67. (20)





Distance travelled = Area of speed-time graph

$$= \frac{1}{2} \times 5 \times 8 = 20\text{m}$$

68. (3)

Distance X varies with time t as  $x^2 = at^2 + 2bt + c$

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

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

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

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

$$\Rightarrow a \propto x^{-3} \text{ Hence, } n=3$$

69. (392)

$$t_a = \frac{u}{g} = \frac{19.6}{9.8} = 2\text{s} \left[ \begin{array}{l} \because V = u - gt \\ 0 = u - gt \\ \Rightarrow t = u/g \end{array} \right]$$

$$t_d = (6-2)\text{s} = \sqrt{\frac{2h_{\max}}{g}}$$

$$h_{\max} = \frac{16 \times 9.8}{2} = \frac{392}{5}$$

70. (5)

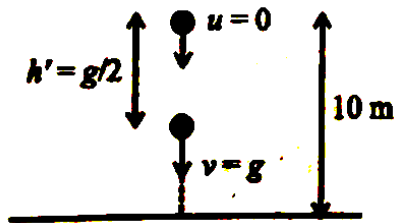
$$v^2 = u^2 + 2gh'$$

$$g^2 = 0^2 + 2gh'$$

$$h' = \frac{g}{2}$$

So, req. height

$$= 10 - h' = 10 - \frac{g}{2}$$



$$= 10 - \frac{10}{2} = 5\text{m}$$

71. (6)

Let the two ball meet at  $t = t$  sec

Then, first ball get 't' sec and second ball get  $(t - 2)$  sec and they will meet at same height

So,  $h_1 = h_2$

$$\Rightarrow 50t - \frac{1}{2}gt^2 = 50(t - 2) - \frac{1}{2}g(t - 2)^2$$

$$\Rightarrow 0 = -100 + \frac{1}{2}g[t^2 - (t - 2)^2] \Rightarrow 20 = 4t - 4$$

$$\Rightarrow 24 = 4t \Rightarrow t = 6\text{sec}$$

72. (3)

Taking upward direction as positive, we get

$$h = u \times 6 - \frac{1}{2}g \cdot 6^2 \rightarrow \text{Case I}$$

$$h = -u \times 1.5 - \frac{1}{2}g \times 1.5^2 \rightarrow \text{Case II}$$

$$h = -\frac{1}{2}gt^2 \rightarrow \text{Case III}$$

$$\text{So, } 6u - \frac{1}{2}g \cdot 6^2 = -1.5u - \frac{1}{2}g \times 1.5^2 \text{ [ from I and II]}$$

$$7.5u = \frac{1}{2}g(6^2 - 1.5^2); u = \frac{g(33.75)}{2 \times 7.5} \Rightarrow u = \frac{45}{2} \text{ m/s}$$

$$\text{Again, } -\frac{1}{2}gt^2 = 6u - \frac{1}{2}g \cdot 6^2 \text{ [from I and III]}$$

$$t^2 = \frac{-2}{g} \left( 6u - \frac{1}{2}g \times 36 \right)$$

$$t^2 = \frac{-2}{10} \left( 6 \times \frac{45}{2} - \frac{1}{2} \times 10 \times 36 \right)$$

$$\Rightarrow t^2 = -\frac{2}{10}(135 - 180) \Rightarrow t^2 = \frac{+2 \times 45}{10} \Rightarrow t^2 = 9 \Rightarrow t = 3\text{s}$$

73. (8)

Let the ball takes time to reach the ground

$$\text{Using, } S = ut + \frac{1}{2}gt^2 \Rightarrow S = 0 \times t + \frac{1}{2}gt^2$$

$$\Rightarrow 200 = gt^2 \quad [\because 2S = 100\text{m}]$$

$$\Rightarrow t = \sqrt{\frac{200}{g}} \quad \dots\dots(i)$$

In last  $\frac{1}{2}$  s body travels a distance of 19 m, so in  $\left(t - \frac{1}{2}\right)$  distance travelled = 81

$$\text{Now, } \frac{1}{2}g\left(t - \frac{1}{2}\right)^2 = 81 \Rightarrow g\left(t - \frac{1}{2}\right)^2 = 81 \times 2$$

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

Using (i)

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

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