JEE-MAIN

TOPIC

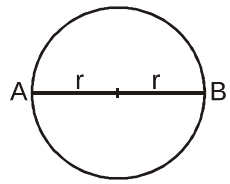
KINEMATICS

SOLUTIONS

KINEMATICS

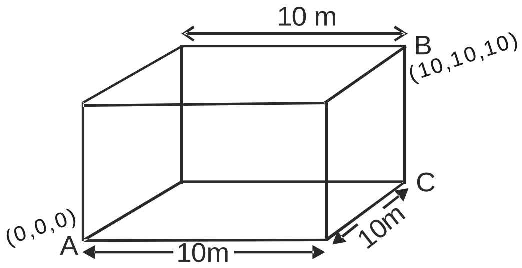
Exercise-I

1. **(B)**

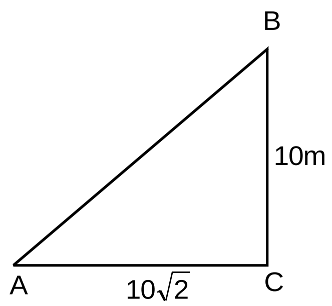


Displacement = 2r
distance = πr

2. **(B)**



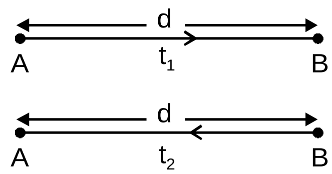
Fly start from A and reaches at B.



$\therefore \quad AB = \sqrt{(10\sqrt{2})^2 + 10^2} = 10\sqrt{3}m$

3. **(B)**

From A to B $t_1 = \frac{d}{20}$ hr $\Rightarrow$ From B to A $t_2 = \frac{d}{30}$ hr



$\therefore \quad$ Average Speed $= \frac{\text{Total Distance}}{\text{Total Time}}$

$= \frac{2d}{t_1 + t_2} = \frac{2d}{\frac{d}{20} + \frac{d}{30}} \Rightarrow v = 24 \text{ km/hr}$

4. **(B)**

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

$48 = \frac{2000}{\frac{1000}{40} + \frac{1000}{V}} = \frac{80V}{40 + V} \Rightarrow V = 60$

5. **(B)**

$V_x = 2at$

$V_y = 2bt$

$V = 2t\sqrt{a^2 + b^2}$

6. **(B)**

$t = 62.8$ sec

in each lap car travel a distance = $= 2\pi R$

$= 2 \times 3.14 \times 100 = 628$ m

In each lap displacement of the car = 0
Average speed

$= \frac{\text{Total Distance}}{\text{Total Time}} = \frac{628}{62.8} = 10 \text{ m/s}$

Average Velocity $\frac{\text{Total Displacement}}{\text{Total Time}} = 0$

7. (A)

$2s = gt^2 \Rightarrow s = \frac{1}{2}gt^2$

$v = \frac{ds}{dt} = gt$

8. (D)

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

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

$a = 0 \Rightarrow t = 2\,sec$

$V_{2\,sec} = 3(2)^2 - 12(2) + 3$ = + 12 - 24 + 3
= -9 m/s

9. (C)

let the acceleration of the body is a and $u = 0$

then $x_1 = \frac{1}{2}at^2 = \frac{1}{2}a(10)^2$

$x_2 = \frac{1}{2}a(20)^2 - x_1 \Rightarrow = \frac{1}{2}a\,(20)^2 - \frac{1}{2}a\,(10)^2$

$= \frac{1}{2}a(10)(30) \Rightarrow x_3 = \frac{1}{2}a(30)^2 - \frac{1}{2}a\,(20)^2$

$= \frac{1}{2}a(10)(50) \Rightarrow \therefore x_1 : x_2 : x_3 = 1 : 3 : 5$

10. (C)

$V_{inst} = \frac{dx}{dt}$ (slop of x-t graph)

At C $\tan\theta$ =+ve At E $\theta > 90^o(-\text{ve slop})$

At D $\theta = 0^o$ At F $\theta < 90^o(+\text{ve slope})$

$\therefore$ At E v_{inst} is negative

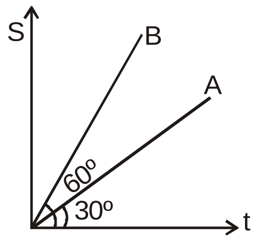
11. (C)

From graph it is clear that velocity is always positive during its motion
so displacement = distance
displacement = Area under V-t curve

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

$+1 \times 10 + 1 \times 10 \Rightarrow = 55$ m

12. (D)



$\frac{V_A}{V_B} = \frac{\tan 30^o}{\tan 60^o} \Rightarrow \therefore \frac{V_A}{V_B} = \frac{1/\sqrt{3}}{\sqrt{3}} = \frac{1}{3}$

13. (A)

Total Distance = Area
under the curve (Position + Negative)

$= \frac{1}{2} \times 4 \times 1 + 4 \times 2 + 1 \times 4 \times \frac{1}{2} + \frac{1}{2} \times 2 \times 1 + 2 \times 2 + \frac{1}{2} \times 1 \times 2$

= 2 + 8 + 2 + 1 + 4 + 1
= 18 meter

14. (A)

(acceleration) = Slope $= \frac{\Delta v}{\Delta t}$

$OA \rightarrow \frac{10}{10} = 1$

$AB \rightarrow 0 = 0$

$BC \rightarrow \frac{-10}{20} = -0.5$

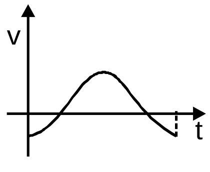
15. (B)

Distance = Total Area
= 105 m
Displacement = 90 - 15 = 75m
(-ve y asxis area) - (-ve y axis area)

16. (C)

Equation of given sin curve is

$x = -A\sin t$; $V = \frac{dx}{dt} = -A\cos t$



17. (D)

Let constant acceleration = a

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

$S_1 = \frac{1}{2}a \times 10^2 = 50a$

$S_2 = \frac{1}{2}a \times 20^2 - \frac{1}{2}a \times 10^2 = 150a$

$S_2 = 3S_1$

18. **(B)**
In inclined initial u = 0

S = $\frac{1}{2}$ at^2 and a = gsinθ

l **=** $\frac{1}{2}g\sin\theta x \times (4)^2$ ...(i)

$\frac{\ell}{4} = \frac{1}{2}g\sin\theta\, t^2$ ...(ii)

From (i) and (ii)
t = 2 sec

19. **(A)**
u = 10m/sec   a = - 2m/sec^2
Total time taken when final is zero.
a = 10m/sec^2
10m/sec
v = 0
0 = 10-2t
t = 5 sec

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

$S_{t=5}$ = 10 × 5 - $\frac{1}{2}$ × 2 × 25 = 25

$S_{t=4\ sec.}$ = 10 × 4 - $\frac{1}{2}$ × 2 × 16 = 24

$S_{t=5}$ - $S_{t=4}$ = 25 - 24 = 1 m

S = 10 + $\frac{-2}{2}$

1 m

20. **(B)**
Initial velocity u = 0, Let acceletion a = 0

$S_{t=2}$ = $\frac{1}{2}$ a × 4 = 2 a

$S_{t=3}$ = $\frac{1}{2}$ a × 9 = $\frac{9}{2}$a

$S_{t=3}$ - $S_{t=2}$ = $\frac{9}{2}$a - 2a = $\frac{5a}{2}$

$S_{t=3}$ - $S_{t=3}$ = 8a - $\frac{9a}{2}$ = $\frac{7a}{2}$

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

21. **(C)**

$\frac{h}{2} = \frac{1}{2}gt_1^2$ ....(1)

$h = \frac{1}{2}g(t_1 + t_2)$ ....(2)

From equation (1) and (2)

$2t_1^2 = (t_1 + t_2)^2$

$\sqrt{2}t_1 = t_1 + t_2$

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

$t_1 = \frac{t_2}{\sqrt{2}-1} \times \frac{\sqrt{2}+1}{\sqrt{2}+1}$

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

22. **(C)**
Acceleration for both is g

$a = \frac{1}{2}gt_a^2$

$b = \frac{1}{2}t_b^2$

$t_a : t_b = \sqrt{a} : \sqrt{b}$

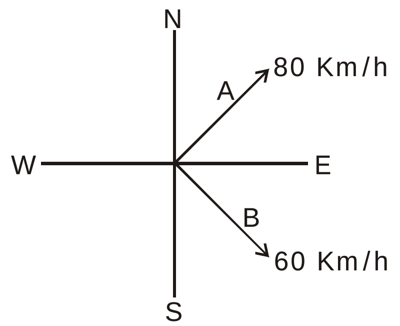
23. **(D)**
At H_{max} , v = 0
Acceleration constant & it is due to gravity
$|a|$ = g

24. **(B)**
Total Length of 2 trains = 50 + 50 = 100
Velocity V_1 = 10
V_2 = 15
V_1 + V_2 = 25

$\text{time} = \frac{100}{25} = 4\,\text{sec}$

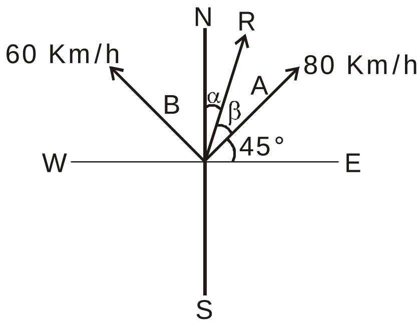
25. **(A)**

(i)



(ii) Hear V_A & V_B are '⊥' to each other.
$V_{AB} = V_A - V_B$

(iii)



$\tan\beta = \frac{60}{80} = \frac{3}{4}$

$\beta = 37°$

(iv) $37+\alpha=45^0$

$$\frac{\tan 37 + \tan\alpha}{1-\frac{3}{4}\tan\alpha} = 1$$

$$\frac{3}{4} + \tan\alpha = 1 - \frac{3}{4}\tan\alpha$$

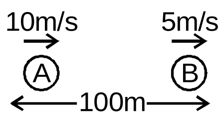
$$\frac{7}{4}\tan\alpha = \frac{1}{4}$$

$$V_B = 60 km/hr$$

$$\tan\alpha = \frac{1}{7}$$

$$V_{AB} = V_A - V_B$$

26. (C)



$$V_{AB} = 10 - 5 = 5 m/s$$

$$t = \frac{100}{5} = 20 sec$$

27. (D)

Horizontal Component of velocity
Because there is no acceleration in horizontal Direction

28. (D)

(i)
For θ and $90-\theta$
Range is ssame

$\theta = 15^0$
$90-\theta = 75^0$

(ii) $R = \frac{u\sin\theta . u\cos\theta}{g}$

$\therefore \sin(90-\theta) = \cos\theta$
$\therefore \cos(90-\theta) = \sin\theta$

29. (B)

$$E = \frac{1}{2}mv^2$$

At Highest Point
vel = $v\cos\theta$

$$KE = \frac{1}{2}mv^2\cos^2\theta = E\cos^2\theta = \frac{E}{2} \quad (\therefore \theta = 45°)$$

30. (D)

$R = u^2 \sin 2\theta / g$
$R_{max} = u^2/g$

$$22 = \frac{u^2}{g}$$

for $\theta = 15°$

$$R = \frac{u^2\sin 30}{g} \qquad = 22 \times \frac{1}{2} = 11m$$

31. (D)

$$y = x\tan\theta\left(1-\frac{x}{R}\right)$$

$$y = x\tan\theta - \tan\theta\frac{x^2}{R}$$

Compare from eq^n.
$\tan\theta = 16$

$$\frac{\tan\theta}{R} = \frac{5}{4}$$

$$R = \frac{64}{5} = 12.8 m$$

$\tan\theta = 16$

$$\frac{1}{2}\frac{g}{u^2\cos^2\theta} = \frac{5}{4.2}$$

$R = \frac{u^2 \sin 2\theta}{g} = \frac{2g}{5} \times \frac{2 \times 16}{g}$

$R = 12.8\,m$

32. (C)

Range of θ and $90-\theta$ is same

If $\theta = 30°$

So $90 - \theta = 60°$

33. (B)

at max height

$\therefore V_x = u_x = \frac{u}{2} = u\cos\theta$, $\theta = 60°$

So range $= \frac{u^2 \sin 2\theta}{g} = \frac{\sqrt{3}}{2}\frac{u^2}{g}$

34. (C)

For both particles $u_y = 0$ and $a_y = -g$

$h = \frac{1}{2}gt^2 \Rightarrow h \to \text{same} \Rightarrow t \to \text{same}$

35. (B)

Vel. of Bomb is same as the vel. of aeroplane.

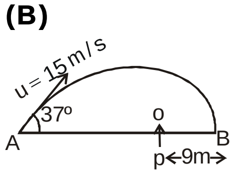
$u_x = 360$ km/h & $v_y = 0$.

$S_y = u_y t + \frac{1}{2} a_y t^2$,   Here u = 0

$1960 = \frac{1}{2} \times 9.8 t^2$

$t = 20\,sec$

36. (B)



In this process both time taken is same.

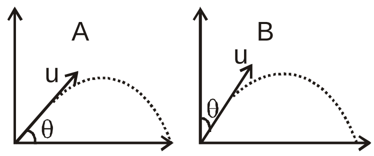
$T = \frac{2u\sin\theta}{g}$

$T = \frac{2u\sin 37°}{g}$

$= \frac{2 \times 15 \times 3}{10 \times 5} = 1.8\,Sec$

Minimum Velocity $= \frac{9}{1.8} = 5\,m/s$

37. (D)



Both may have same time of flight if $\theta = 45°$

Range of θ and $90 - \theta$ is same

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

So we can say that both must have same Range.

38. (B)

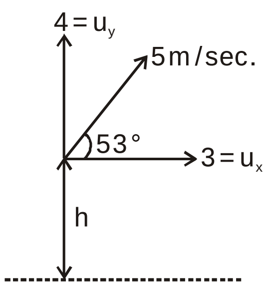
$\therefore H_{max} = \frac{u_y^2}{2g}$

$\Rightarrow u_y = \sqrt{2gH}$

$\therefore T = \frac{2u_y}{g} = \frac{2\sqrt{2gH}}{g} = 2\sqrt{2}\sqrt{\frac{H}{g}}$

39. (C)

$v_y^2 - u_y^2 = 2a_y S$



$v_y^2 - (4)^2 = -2 \times 10 \times 0.45$

$v_y^2 = 7 m^2/s^2$

$v_x = 5\cos 53° = 3$m/s   (always remains same)

$\therefore V_{net} = \sqrt{(V_x)^2 + (V_y)^2} = \sqrt{9+7}$

$= 4 m/s$

40. (B)

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

$h = \frac{1}{2}gt_1^2 \quad \Rightarrow t_1 = \frac{\sqrt{2h}}{g}$

$x = v_1t_1$

$x = v\sqrt{\frac{2h}{g}}$ ....(i)

$t_2 = \frac{\sqrt{4h}}{g}$, $2x = v_2 \times t_2$

$2x = v_2\sqrt{\frac{4h}{g}}$ ....(ii)

From (i) & (ii)

$V' = \sqrt{2}\,V$

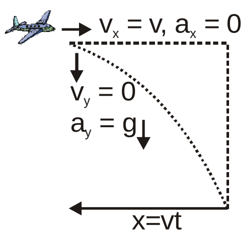
41. (C)

Time is depend only in vertical component V_y

but in both cases V_y=0 + a_yt = -g.

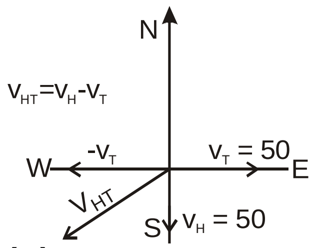
Both will reach the ground at the same time

42. (A)



Because horizontal velocity of plane and bomb is always same.

43. (D)



South - West

44. (D)

$\vec{v}_r = \vec{v}_1 - \vec{v}_2$

$|\vec{v}_r| = \sqrt{v_1^2 + v_2^2 - 2v_1v_2\cos\theta}$

$|\vec{v}_r|$ max when $\cos\theta = -1$ $\quad \theta = \pi$

$\Rightarrow v_r = v_1 + v_2$

45. (A)

$v_{br} = v_b - v_r$

given $v_r + v_{br} = v_b$

Let swimmer speed in still water = x

Let velocity of water = y

x + y = 16 , x - y = 8

x = 12 and y = 4

46. (C)

$V_m = 3\hat{i}$

$V_R = -10\hat{j}$

$V_{RM} = V_R - V_M$

$= -10\hat{j} - 3\hat{i} \Rightarrow |\vec{V}_{RM}| = \sqrt{109}$

Exercise-II

1. **(A)**

d/3, t_1 | d/3, t_2 | d/3, t_3
V_1=2m/s | V_2=3m/s | V_3=6m/s
← d →

Now $t_1 = \frac{d/3}{v_1} = \frac{d}{6}$

$t_2 = \frac{d/3}{3} = \frac{d}{9} \Rightarrow t_3 = \frac{d/3}{6} = \frac{d}{18}$

Average Velocity

$= = \frac{d}{\frac{d}{6}+\frac{d}{9}+\frac{d}{18}} = \frac{18}{6} = 3\ m/s$

2. **(D)**

3. **(B)**
Stone is dropped
so time taken by stone to reach the bottom of the wall t_1

$\therefore\ h = \frac{1}{2}gt_1^2$

$= t_1 = \sqrt{\frac{2h}{g}}\ -(i)$

time taken by sound to comes from bottom

to upper end $t_2 = \frac{h}{v}$ ...(ii)

$\therefore$ Total time $= t_1 + t_2 = \sqrt{\frac{2h}{g}} + \frac{h}{v}$

4. **(B)**

$x = 5\sin 10t \Rightarrow v_x = \frac{dx}{dt} = 50\cos 10t$

$y = 5\cos 10t \Rightarrow v_y = \frac{dy}{dt} = -50\sin 10t$

$V^2_{net} = V_x^{\ 2} + v_y^{\ 2}$

$v_{net} = \sqrt{(50)^2(\sin^2 10t + \cos^2 10t)}$ = 50 m/sec

5. **(D)**
v = lnx m/s (Given)

a = $\frac{vdv}{dx} = \frac{1}{x}\ln x$

$\Rightarrow F_{net} = 0$
$\Rightarrow a = 0 \Rightarrow$
x = 1 m

6. **(C)**

$\vec{F} = 2\sin 3\pi t\hat{i} + 3\cos 3\pi t\hat{j}$

a = $\frac{dv}{dt} = 2\sin 3\pi t\hat{i} + 3\cos 3\pi t\hat{j}$

$\int_0^v dv = 2\int_0^t \sin 3\pi t\ dt\,\hat{i} + 3\int_o^t \cos 3\pi t.dt\hat{j}$

$v = -\frac{2}{3\pi}\left[\cos 3\pi t\right]_o^t\hat{i} + \frac{3}{3\pi}\left[\sin 3\pi t\right]_o^t\hat{j}$

$\int_o^r dx = \int_o^t\left[\frac{-2}{3\pi}\left[\cos 3\pi t - 1\right]\hat{i} + \frac{1}{\pi}\sin 3\pi t\hat{j}\right].\ dt$

$\vec{r} = -\frac{2}{3\pi}\left[\int_0^t \cos 3\pi t - \int_0^t dt\right]\hat{i} + \frac{1}{\pi}\int_0^t \sin 3\pi t\,\hat{j}dt$

$= -\frac{2}{(3\pi)^2}\left[\sin 3\pi t\right]_o^t\hat{i} + \frac{2}{3\pi}t\hat{i} - \frac{1}{3\pi^2}\left[\cos 3\pi t\right]_o^t\hat{j}$

For t = 1 sec

$\vec{r} = \frac{2}{3\pi}\hat{i} + \frac{2}{3\pi^2}\hat{j}$

7. **(B)**

$F = Be^{-ct}$

$a = \frac{B}{m}e^{-ct} \qquad \Rightarrow \int_0^v dv = \int_o^t \frac{B}{m}e^{-ct}dt$

$v = -\frac{B}{mc}\left[e^{-ct} - 1\right] \Rightarrow$ At $t = \infty$

$v = \frac{B}{mc}$

8. **(B)**

$v = t^2 - t$ = t (t-1)

$\therefore\ a = \frac{dv}{dt} = 2t - 1$

Motion is consider as Retards
when V & a are in opposite Direction

Case - 1
If v > 0 then a < 0
But $t^2 - t > 0$, t > 1
and a > 0 for t > 1
so not Possible

Case - 2
v < 0, a > 0
$t^2 - t < 0$, $2t - 1 > 0$

$t \in (0,1)$, $t > \frac{1}{2}$

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

9. **(A)**

distance Travelled by (first ball)

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

$= 5\times2+\frac{1}{2}\times10\times2^2$

= 30 m

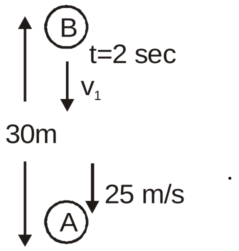
Relative Method

Velocity of first ball after 2 sec.

V = u + at

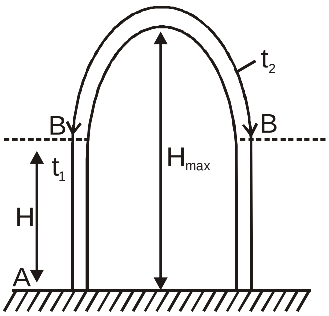
V = 5 + 10 × 2 = 25

$t = \frac{30}{v_1 - 25} = 2\,sec$



$30 = 2v_1 - 50 \Rightarrow v_1 = 40\,m/s$

10. **(D)**



$H = ut_1 - \frac{1}{2}gt_1^2$ ....(i)

v = u + at

$u = g\left(\frac{t_1+t_2}{2}\right)$ ....(ii)

From (i) and (ii)

$H = \frac{g}{2}(t_1^2 + t_1t_2) - \frac{1}{2}gt_1^2$

$H = \frac{1}{2}gt_1t_2$

11 **(C)**

$\therefore\ H_{max} = \frac{u^2}{2g} \Rightarrow u = \sqrt{2hg}$

Given = 5 m $\Rightarrow$

H_{max} = 5 m

$t = \frac{u}{g} = \frac{\sqrt{2gh}}{g} = \sqrt{\frac{2H}{g}}$

$= \sqrt{\frac{2\times5}{10}} = 1\,sec$

in 1 min = 60 Balls.

12. **(B)**

Length of groove is L

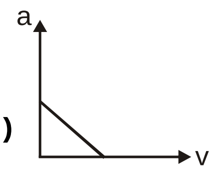
$(g_{eff})_{AB} = g$

$t_1 = \sqrt{\frac{2L}{g_{eff}}} = \sqrt{\frac{2L}{g}}$

$\Rightarrow t_2 = \sqrt{\frac{2L}{g\sin30^\circ}}$ $(g_{eff})_{CD}$ = g sin36

$\Rightarrow t_1 : t_2 = 1 : \sqrt{2}$

13. **(D)**



From graph

$a = -AV + B$

$\frac{dv}{dt} = -AV + B$

$\int \frac{dv}{B - AV} = \int dt$

$\Rightarrow \frac{-1}{A}\int\frac{dk}{k} = \int dt$ (B − AV) = K

$-\ln(B - AV) = At + c$

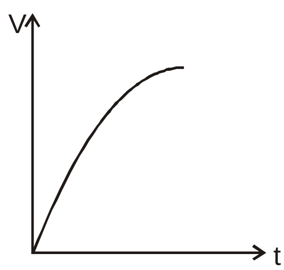
$c = -\ln B$ (When t = 0, V = 0)

$\therefore -\ln(B - AV) = At - \ln B$

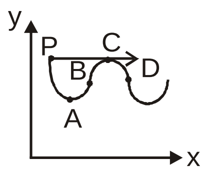
$t = \frac{1}{A}\ln\left(\frac{B}{B - AV}\right)$

$e^{At} = \frac{B}{B - AV} \Rightarrow B - AV = Be^{-At}$

$\Rightarrow V = \frac{B}{A}\left(1 - e^{-At}\right)$



14. **(C)**
Point C



Average Vel. vector is along the x-axis at point 'c' instanteous vel. vector is along the x-axis.

15. **(B)**
Area = = $0.4\times0.2+0.4\times0.2+0.4\times0.2$

$+\frac{1}{2}\times0.4\times0.2+0.6\times0.2$

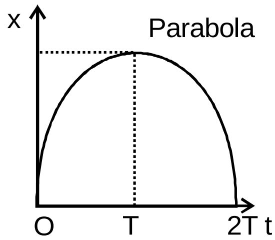
Area = 0.4 $\left[\int a.dx=\int vdv\right]$

$v_f^2 - v_i^2 = 2ax$

then $v_f^2-v_i^2=2$ Area

$v_f^2=0.8+(0.8)^2$; V_f = 1.2 m/s

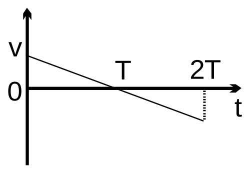
16. **(B)**



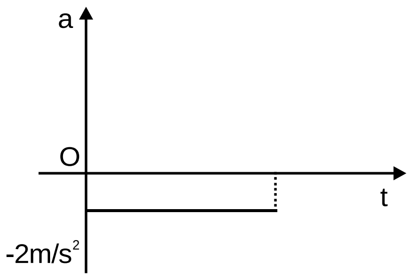
$x=-t(t-2T)$

$x=-t^2+2Tt$

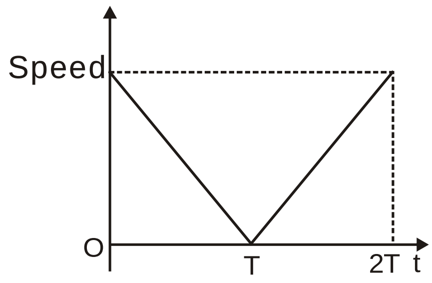
$\frac{dx}{dt}=-2t+2T$ and $\frac{d^2x}{dt^2}=-2$



17. **(D)**



18. **(C)**



19. **(B)**

V = u + at, $a=\frac{-20-10}{6-4}=\frac{-30}{2}$

$0=10-\frac{30}{2}t$ $t=\frac{2}{3}=0.66$ sec.

Particle comes to rest when v=0
on observing graphs V=0 at t=0, 4.66 sec, 8 sec
Incorrect t=5 sec

20. **(C)**
Rate of change of velocity is maximum
t = 4 to 6 sec

$a=\frac{-20-10}{6-4}=\frac{-30}{2}=-15$ m/sec^2

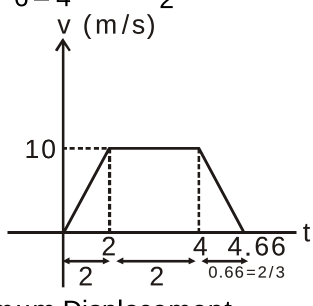
21. **(A)**
(Area of vt graph gives the displacement.
Here 0 to 2 sec.
Distance = Displacement

Area in 0 to 2 sec. = $\frac{1}{2}\ 2\times10=10$

Position = -15 + 10 = -5 m

22. **(A)**
t = 4 to 6 sec
t = 4 to 6 sec

$a=\frac{-20-10}{6-4}=\frac{-30}{2}=-15$ m/sec^2

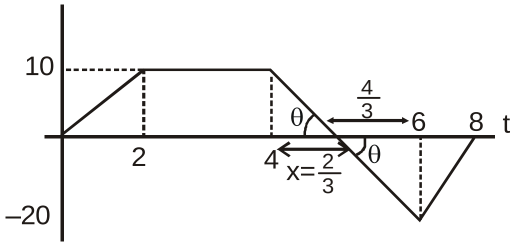


Maximum Displacement

$=\frac{1}{2}\times2\times10+2\times10+\frac{1}{2}\times\frac{2}{3}10$

$=33.3m$

23. **(A)**



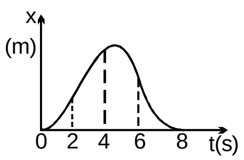
Total Distance = Upper area + Lower area

$= 33.3 + \frac{1}{2} \times \left(2 - \frac{2}{3}\right) \times 20 + \frac{1}{2} \times 2 \times 20$

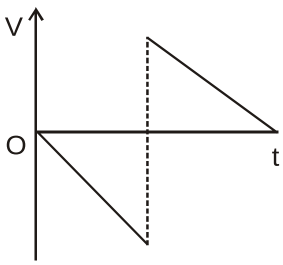
$= 33.3 + 33.3$

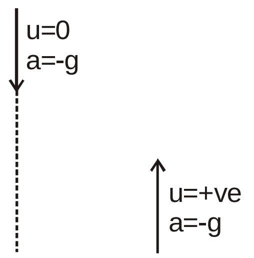
$= 66.6$ m

24. **(C)**
v - t Displacement is zero



25. **(A)**
(upward direction is +ve)





Vel. of the particle just before the collision with solid surface euqal to just after polision with solid surface.

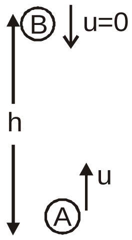
26. **(D)**
The slope of curve c_1 and c_2 is constant. so, their Relative velocity is Non-zero constant not a variable quantity

27. **(D)**
Slope of v-t curve gives aceleration

Here slope of P_1 > slope of P_2 $(a_{p_1} > a_{p_2})$

Relative velocity in their motion continousely increases.

28. **(C)**



$V_f^2 = u_1^2 - 2gh$
$O = u^2 - 2gh$

$u = \sqrt{2gh}$

$V_A = u + at$

$V_A = \sqrt{2gh} - gt$

$V_B = -gt$

$V_{AB} = V_A - V_B = \sqrt{2gh} - gt - (-gt)$

$= \sqrt{2gh}\left(\text{upto time } \frac{T}{2}\right)$

Particle B takes the time to reaches the ground is $t = \sqrt{\frac{2h}{g}}$

where T = Time period ⇒ $V_B = 0$

at $t = \sqrt{\frac{2h}{g}}$, vel. of particle A is $V_A = 0$

then particle come in downward dir^n.(downward dir^n is -ve).

After ∴ $V_{AB} = V_A - V_B$ = -ve.

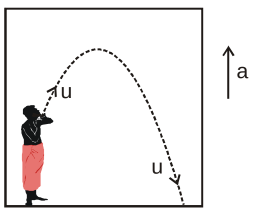
29. **(B)**

$V_E = \frac{H}{60}$ m/s and $V_M = \frac{H}{180}$ m/s

$t = \frac{H}{V_E + V_M} = \frac{H}{\frac{H}{60} + \frac{H}{180}} = \frac{180}{4}$

∴ $t = 45$ sec

30. **(B)**



Initial vel. = u
& Final vel. = -u
a = acceleration of lift
u = velocity relative to lift According to problem
– u = u – (g + a) × t

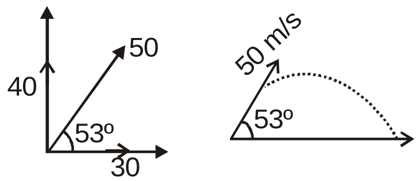
$t = \frac{2u}{g+a}$

$\Rightarrow at + gt = 2u$

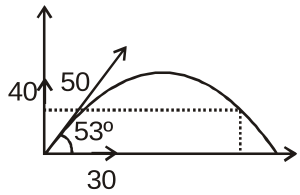
$\therefore = \frac{2u - gt}{t}$

31. **(D)**

32. **(A)**



33. **(D)**



$H = 40t - \frac{1}{2} \times 10 \times t^2$

$5t^2 - 40t + H = 0$

Now, $t_1 + t_2 = \frac{40}{5} = 8\,\text{sec}$

34. **(A)**
By Equation of trajectory

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

$\theta = 53°$

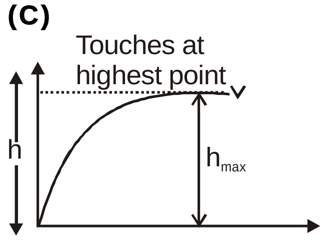
$\Rightarrow y = \frac{4x}{3} - \frac{10x^2}{1800} \qquad \Rightarrow 180y = 240x - x^2$

35. **(B)**

$\vec{V} = a\hat{i} + (b - ct)\hat{j} = u_x\hat{i} + (u_y - gt)\hat{j}$

$R = \frac{2u_xu_y}{g} = \frac{2ab}{c}$

36. **(C)**



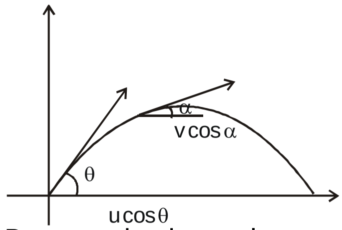
$h = \frac{U_y^2}{2g}$

$U_y = \sqrt{2gh}$

$R = U_xT = \frac{U.\sqrt{2gh}}{g}$

$R = U\sqrt{\frac{2h}{g}}$

37. **(C)**



Because horizontal component of the vel. is never change in projectile motion.
Horizontal Component

$u\cos\theta = v\cos\alpha$

$\therefore v = u\cos\theta\sec\alpha$

38. **(B)**
u_y = 50 sin 53° = 40 m/s

$s_y = u_yt - \frac{1}{2}a_yt^2 \quad u_x = 50\cos 53° = 30\,m/s$

Here S_y = 75, u_y = 40, a_y = 10

$75 = 40.t - \frac{1}{2} \times 10 \times t^2$

$\Rightarrow t^2 - 8t + 15 = 0$

$\Rightarrow t^2 - 5t - 3t + 15 = 0$, t_1 = 3sec, t_2 = 5sec

$x = u_xt$

$x_2 = 30 \times 5 = 150m$

$x_1 = 30 \times 3 = 90m$

$\therefore x_2 - x_1 = 150 - 90 = 60m$

39. **(A)**
In t = 2 sec , $x = u_xt$ $(\therefore u_x = 30)$

$x = 30 \times 2 = 60m$

$y = 40 \times 2 - \frac{1}{2} \times 10 \times (2)^2$

$= 80 - 20 = 60m$

Distance = $\sqrt{x^2 + y^2}$

Distance $= 60\sqrt{2}m$

40. **(C)**
H=20 m, u_y = 0

$+S_y = u_y t + \frac{1}{2} g t^2 \qquad \therefore \quad t = \sqrt{\frac{2s_y}{g}}$

$T = \sqrt{\frac{2 \times 20}{10}} = 2\sec$

Range $= u_x t + \frac{1}{2} a_x t^2$

Here $u_x = 0$, $a_x = 6 m/s^2$ (due to wind)

$= 0 + \frac{1}{2} \times 6 \times (2)^2 = 12m$

41. (C)

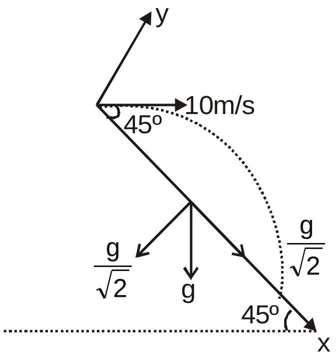
$a_y = -{g}/{\sqrt{2}} \; m/s^2$

$a_x = {g}/{\sqrt{2}} \; m/s^2$

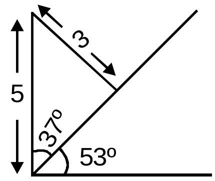
$T = \frac{2u\sin\theta}{g_{eff}}$

$T = \frac{2 \times (10/\sqrt{2})}{g/\sqrt{2}}$

= 2 sec



42. (A)



$h = \frac{u^2}{2g} = \frac{100}{20} = 5$

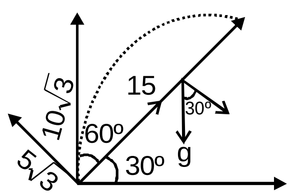
As particle has thrown from ground.
from inclined plane

43. (C)

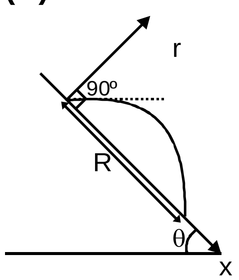
$T = \frac{2u_y}{g\cos\theta}$

$T = \frac{2 \times 5\sqrt{3}}{10 \times \cos 30^o}$

$T = 2\sec$



44. (C)



$a_y = -g\cos\theta$

$a_x = g\sin\theta$

$u_y = v$

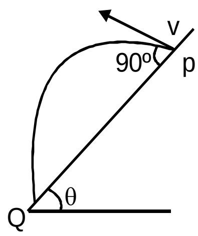
$u_x = 0$

Range $= \frac{1}{2} a_x T^2 \qquad T = \frac{2.v}{g\cos\theta}$

$= \frac{1}{2} g\sin\theta \left(\frac{2v}{g\cos\theta}\right)^2$

$R = 2\frac{v^2}{g}\tan\theta\sec\theta$

45. (D)



$R = u_x t + \frac{1}{2} a_x t^2$

$[\therefore u_x = 0.\ u_y = v]$

$\Rightarrow \therefore\ T = \frac{2u_y}{g\cos\theta} = \frac{2v}{g\cos\theta}$

$R = \frac{1}{2} g\sin\theta\ T^2$

$R = \frac{1}{2} g\sin\theta \left(\frac{2V}{g\cos\theta}\right)^2$

$R = Tv\tan\theta$

46. (B)

$a_{AB} = 0$

$\therefore$ Straight line

47. (C)

Given $V_1\cos\theta_1 = v_2\cos\theta_2 \Rightarrow v_{xA} = V_{xB}$

$\vec{v}_A = V_{XA}\hat{i} + V_{yA}\hat{j}\ ;\ \vec{V}_B = V_{XB}\hat{i} + V_{yB}\hat{j}$

$\therefore\ \vec{v}_{AB} = V_{yA}\hat{j} - V_{yB}\hat{j}$

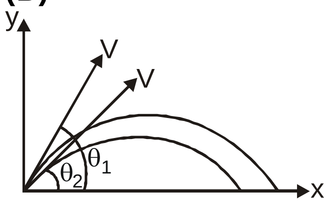
48. (D)

$T = \frac{2u_y}{g} \qquad \therefore$ Same

$H = \frac{u_y^2}{2g}$

$\vec{V}_{AB} = V_{xA}\hat{i} - V_{xB}\hat{i}$

49. (B)



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

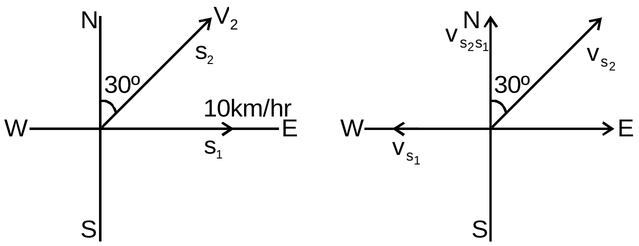
when θ and $90-\theta$ range is same

$$v_{21}=v_{2x}\hat{i}-v_{2y}\hat{j}-v_{1x}\hat{i}-v_{1y}\hat{j}$$

$$\tan\theta=\left(\frac{v_{2y}-v_{1y}}{v_{2x}-v_{1x}}\right)\begin{matrix}v_{2y}<v_{1y}\\ v_{2x}>v_{1x}\end{matrix}$$

$\tan\theta$ = –ve

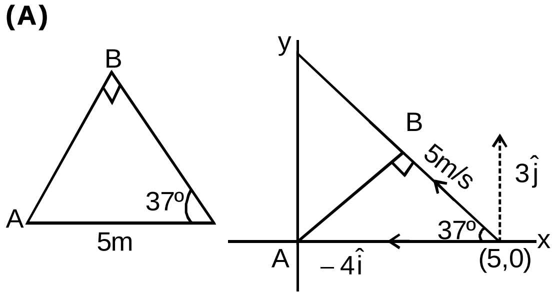
50. (C)



East component of both ship must be same.
from fig :
: $Vs_2 \sin 30^o = v_{s1}$

$$Vs_2=\frac{10}{1/2}=20\text{ km/hr}$$

51. (A)



Draw a perpendicular from A on the line of a velocity of the particle B. $\sin 37^o=\frac{AB}{5}$,AB = 3m

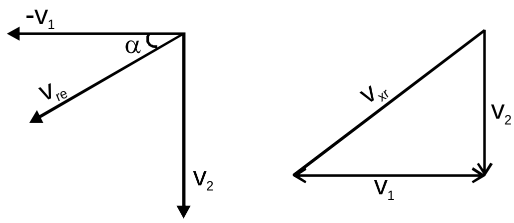
52. (A)

Each porticle move perpendicular with the neighbour particle so no component of v along the line of motion of neighbour

velocity so vel. of approach = v $\Rightarrow t=\frac{a}{v}$

53. (A)

Drops of rain move parallel to the walls if v_{rp} makes angle with the horizontal.



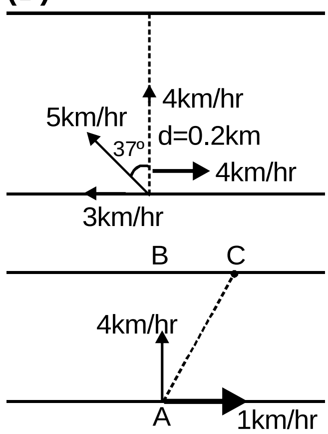
$$\vec{V}_{RC}=\vec{V}_R-\vec{V}_C$$

$$=\vec{V}_R\hat{j}-\vec{V}_C\hat{i}$$

$$\tan\alpha=\frac{v_2}{v_1}=\frac{6}{2}$$

$\alpha = \tan^{-1}(3)$

54. (B)



given : V_{br} = 5 km/hr
v_r=4 km/hr d = 0.2 km

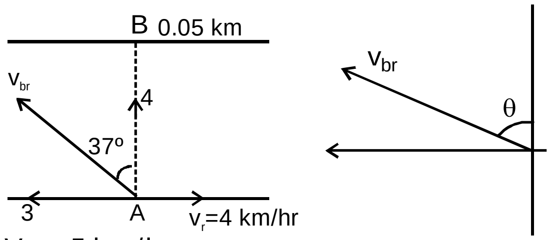
$$t=\frac{0.2}{4}$$

= 0.05 hr = 3 min
BC = 1 Km/hr × 0.05 hr.

$$t_2=\frac{0.05}{3}\times 60$$

= 1 min
$t_1 + t_2$ = 4 min

55. (B)



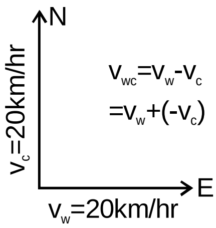
V_{br} = 5 km/hr

$$\sin\theta=\frac{v_r}{5}$$

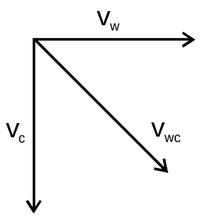
$t = \dfrac{d}{v_{br}\cos\theta} \Rightarrow \cos\theta = \dfrac{4}{5} \Rightarrow \theta = 37^o$

$\sin 37^o = \dfrac{v_r}{5} \Rightarrow v_r = 3\text{km/hr}$

56. (C)



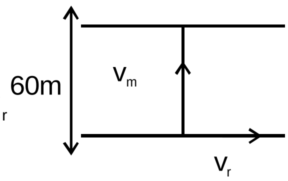
∴



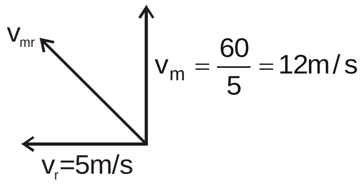
57. (B)

v_r=5m/s

$v_{mr}=v_m-v_r$



∴



$v_{mr} = \sqrt{(12)^2 + (5)^2} = 13\text{m/s}$

58. (B)

59. (A, B, C, D)

$X = \alpha T^2 - \beta t^3$

(A) $0 = \alpha t^2 - \beta t^3 \Rightarrow t = \dfrac{\alpha}{\beta}$

(B) $v = \dfrac{dx}{dt} = 2\alpha t - 3\beta t^2 \Rightarrow v = 0 \Rightarrow t = \dfrac{2\alpha}{3\beta}$

(C) $a = \dfrac{d^2x}{dt^2} = 2\alpha - 6\beta t$

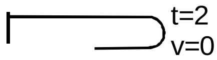
when $t=0 \Rightarrow a = 2\alpha$; $v=0$

(D) Acceleration at $t = \dfrac{\alpha}{3\beta}$; $a = 0$

∴ net force = 0

60. (A, C)

$v = 10 - 5t$



When v = 0 at t = 2 sec.

Max displacement = $10t - \dfrac{5t^2}{2}$

put $t=2 \Rightarrow$ 20-10=10m

Distance traveled in first 3 seconds

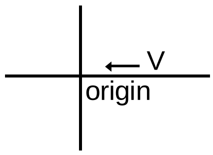
$= 10 + \left(0 + \dfrac{1}{2} \times 5 \times (1)^2\right) \Rightarrow$ = 12.5 m

61. (B, C, D)

(B) $\Rightarrow a = \dfrac{dv}{dt}$

(C) $\vec{v}$ / $\overleftarrow{a}$ Object is slowing down.

(D)



the particle is moving towards origin.

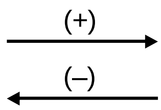
62. (B, D)

$F_{net} = f - kv \Rightarrow a = \dfrac{f}{m} - \dfrac{kv}{m}$

As $v\uparrow, a\downarrow$

and when a=0, velocity remains constant

63. (C, D)



$\vec{v}$, $\vec{a}$ • (v)↑ $\overleftarrow{v}$, $\overleftarrow{a}$ • (v)↑

$\vec{v}$, $\overleftarrow{a}$ • (v)↓ $\overleftarrow{v}$, $\vec{a}$ • (v)↓

64. (A, C)

$|\vec{V}|\uparrow,\ \vec{V}\uparrow$

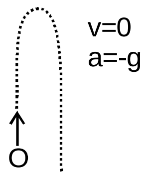
$\vec{a} = \dfrac{d\vec{V}}{dt}$

In circular motion speed may be constant but velocity will not be constant and particle have some acceleration.

65. (A, C)

(A) At the top of the motion v = 0 but a = –g.

(A, B) $a = \frac{dv}{dt}$

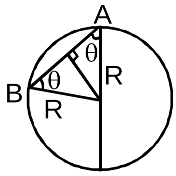


(C) If particle is moving with costant velocity

(D) No

66. (A, D)

AB=l=2Rcosθ



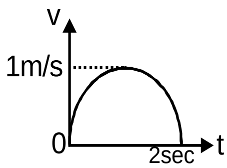
$a = g \cos\theta$

$v^2 = 2 \times g \cos\theta \times 2R\cos\theta$

$v \alpha \cos\theta$ and $2R\cos\theta = \frac{1}{2} g \cos\theta\, t^2$

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

67. (C)



Area = $\frac{\pi(1)^2}{2} = \frac{\pi}{2}$m

Av velocity = $\frac{\pi}{2 \times 2} = \frac{\pi}{4}$m/s

68. (A, B, C, D)

(a) At T (velocity changes its direction)

(b) slope constant

(c) Upper area = Lower area

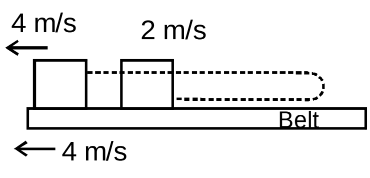
(d) Initial speed = final speed.

69. (B, C, D)

V = u + at

$\therefore -4 = 2 + a \times 4$

$a = -\frac{3}{2}\, m/s^2$



(B) Now $s = 2 \times 4 - \frac{1}{2} \times \frac{3}{2} \times (4)^2$

$= 8 - 12 = -4$m (w.r.t. ground)

w.r.t. Belt

(C) Relative velocity u_i = 6m/s and v=0

$s = 6 \times 4 - \frac{1}{2} \times \frac{3}{2} \times (4)^2$

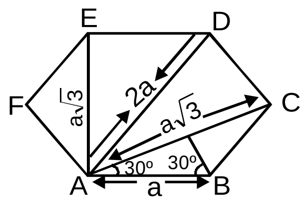
= 24-12=12 m

(D) Displacement w.rt. ground is zero

$0 = 2 \times t - \frac{1}{2} \times \frac{3}{2} \times t^2$

$t = \frac{8}{3}$ sec

70. (A, C, D)



(A) A to F

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

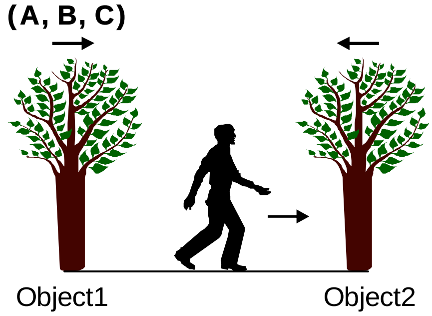
$= \frac{a}{5a/v} = \frac{v}{5}$

(B) A to D = $\frac{2a}{3a/v} = \frac{2}{3}v$

(C) A to C = $\frac{a\sqrt{3}}{2a/v} = \frac{v\sqrt{3}}{2}$

(D) A to B $= \frac{a}{a/v} = v$

71. (A, B, C)



72. C,D

From theory.

73. C,D

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

$\sqrt{3} = \frac{20\sin^2\theta}{10} \Rightarrow \sin 2\theta = \frac{\sqrt{3}}{2}$

$\therefore \theta = 30^o$

(A) $H_{max} = \frac{u^2 \sin 2\theta}{2g} = \frac{\left(\sqrt{20}\right)^2 \times \frac{1}{4}}{2\times 10} = 0.25m$

(B) Minimum Velocity $u\cos\theta$

$= \sqrt{20} \times \cos 30^o$

$= \sqrt{20} \times \frac{\sqrt{3}}{2} = \sqrt{15} m/s$

(C) $T = \frac{2u\sin\theta}{g}$

$= \frac{2 \times \sqrt{20} \times \frac{1}{2}}{10}$

$\Rightarrow \sqrt{\frac{1}{5}}$ sec

(D) mgh = 1 × 10 × $\frac{1}{4}$ = 2.5 Joule

74. (A, B, C, D)

$h = \frac{u^2}{2g} \Rightarrow u = \sqrt{2gh}$

(a) $R_{max} = \frac{u^2}{g} = 2h$

(b) $R = nH_{max}$

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

4 = n tanθ

$\theta = \tan^{-1}\left(\frac{4}{n}\right)$

(c) $gT^2 = g \times \frac{4u^2 \sin^2\theta}{g^2} = \frac{2 \times u^2 \sin 20}{g} \times \tan\theta$

$gT^2 = 2R\tan\theta$

(d) $T = \frac{2u_y}{g}, H_{max} = \frac{u_y{}^2}{2g}$

$\therefore$ Ratio 1:1

75. (A, B)

Put the value of T, R, H, in the given equation and solve each option.

76. (A, B, C, D)

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

Given $y = ax - bx^2$

on comparing $\tan\theta = a \quad b = \frac{g}{2u^2\cos^2\theta}$

$\therefore 1 + \tan^2\theta = \sec^2\theta = 1 + a^2$

$b = \frac{g}{2u^2}\left(1+a^2\right) \Rightarrow u = \left(\frac{g}{2b}\left(1+a^2\right)\right)^{1/2}$

$\therefore u_x = u\cos\theta = u.\frac{1}{\sqrt{1+a^2}}$

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

77. (A, C, D)

$T = \sqrt{\frac{2H}{g}} \Rightarrow 0.4 = \sqrt{\frac{2H}{g}}$

$\Rightarrow H = 0.8m$

R= 0.4 × 4 = 1.6m

and $U_y = \sqrt{2gH} = \sqrt{2\times 10\times 0.8} = 4m/s$

$\theta = 45^o$

78. (B)

As $\theta\uparrow$, H and T both increases

But R ↑ from 0º to 45º & at θ = 45° Max then decreases

Ans (B) R↑ then ↓ [θ from from 30º to 60º]

while H↑ and T↑.

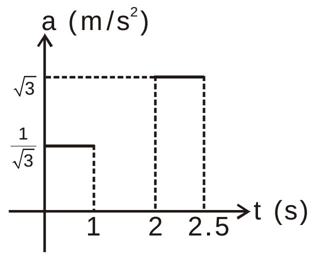
Exercise-III Level - I

1. **(A)**
x = t^2 - 4
y = t - 4
t = y + 4
x = $(y+4)^2$ - 4
= (y+4-2) (y+6)
x = y^2+8y+12
(B)
crosses x axis ⇒ y = 0
t = 4 sec
crossess y axis ⇒ x = 0
t = $\pm 2\,\text{sec}$

2. **(A)**
velocity = $\frac{dr}{dt} = (2t+1)\hat{i} + 3\hat{j} + (6t^2 - 8t)\hat{k}$
= $5\hat{i} + 3\hat{j} + 8\hat{k}$
B acceleration = $\frac{dv}{dt}$
$= 2\hat{i} + (12t-8)\hat{k}$ = $= 2\hat{i} + 16\hat{k}$
C
Speed = $|\vec{V}| = \sqrt{25+9+64} = \sqrt{98} = 7\sqrt{2}$
D $|\vec{a}| = \sqrt{4+256} = \sqrt{260} = 2\sqrt{65}$

3. $a(t) = \frac{d^2r}{dt^2} = -6t\hat{j} - \cos t\hat{k}$
$\vec{r} = 6t\hat{i} - t^3\hat{j} + \cos t\hat{k}$
$\frac{d\vec{r}}{dt} = 6\hat{i} - 3t^2\hat{j} - \sin t\hat{k}$
$F(t) = ma(t) = -18t\hat{j} - 3\cos t\hat{k}$
$a\left(\frac{\pi}{2}\right) = 3\pi\hat{j} - 0 \Rightarrow 3\pi$
$v(t) = 6\hat{i} - 3t^2\hat{j} - \sin t\hat{k}$
$v(\pi) = 6\hat{i} - 3\pi^2\hat{j}$
speed = $\sqrt{36+9\pi^4}$ = $3\sqrt{4+\pi^4}$

4. **(A)**
tan 30 = $\frac{V}{1}$
$V = \frac{1}{\sqrt{3}}\text{ m/s.}$
(B)
tan 60 = $\frac{\Delta V}{\Delta t} = \frac{\Delta V}{\frac{1}{2}}$
⇒ $\Delta V = \frac{\sqrt{3}}{2}$
average acc = $\frac{\Delta V}{\Delta t}$ = $\sqrt{3/2}$
(C)
$0 \to 1 \Rightarrow a = \frac{1}{\sqrt{3}}$
$1 \to 2 \Rightarrow a = 0$
$2 \to 2.5 \Rightarrow \sqrt{3}$



5. y = 0 , t = 5
V_y = -8t
at t = 5
v_y = -40
v_x = -30
$\vec{a} = \frac{dv_x\hat{i}}{dt} + \frac{d^2y\,\hat{j}}{dt^2}$
$\vec{v} = -30\hat{i} - 40\hat{j}$
$\vec{a} = -16\hat{i} - 8\hat{j}$

6. V = max
When a = 0
$\frac{dv}{dt} = a - 2bt = 0$
$t = \frac{a}{2b}$
$v = \frac{a^2}{2b} - \frac{a^2}{4b} = \frac{a^2}{4b}$

7. $a = 3t^2 - 4t + 1$

$v = t^3 - 2t^2 + t + C$

$C = 0$

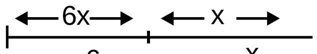
$$x = \frac{t^4}{4} - \frac{2t^3}{3} + \frac{t^2}{2} + C$$

$C = 0$

at t = 2 sec.

$$x = 4 - \frac{2}{3}(8) + 2 = \frac{2}{3}$$

8.

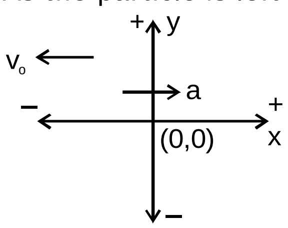


$t_1 = \frac{6x}{40}$, $t_2 = \frac{x}{60}$

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

$$= \frac{7x}{\frac{6x}{40} + \frac{x}{60}} = 42 \text{ km/hr}$$

9. As the particle is left

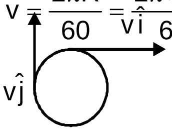


initial at position (-5,0)

Slowingdown condition occurs only if acceleration and velocity are opposite sign.

10. Change in velocity = $v_{\hat{j}} - v_{\hat{i}}$

$$v = \frac{2\pi R}{60} = \frac{2\pi \times 10}{60} = \frac{\pi}{3} \text{cm/min}$$



$$|\Delta v| = \sqrt{2}v = \sqrt{2} \times \frac{\pi}{3} = \frac{\sqrt{2}\pi}{3} \text{ cm / min}$$

11. $v_i = 54 \text{km/hr} = 15 \text{ m/s}$

$v_f = 0 \therefore 0 = 15 - 0.3t \Rightarrow t = 50$ sec

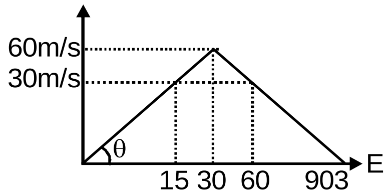
Distance travelled by the locomotive

$$s = ut - \frac{1}{2}at^2$$

$$s = 15(50) - \frac{1}{2}(0.3)(50)^2 = 375 \text{ m}$$

Position of the locomotive = 400-375 = 25m

12.



$v = u + at$

$$v = 0 + 2 \times \frac{60}{2} = 60 \text{ m/s}$$

$$t = \frac{1}{2} \text{ min} = 30 \text{ sec.}$$

$$\tan\theta = \frac{v_{max}}{30} \Rightarrow V_{max} = 30 \times 2 = 60 \text{ m/s}$$

(A) Total Distance

$$= \frac{1}{2} \times 30 \times 60 + \frac{1}{2} \times 60 \times 60$$

= 2700m = 2.7 km

(B) Max Speed

$$2 = \tan\theta = \frac{v_{max}}{30}$$

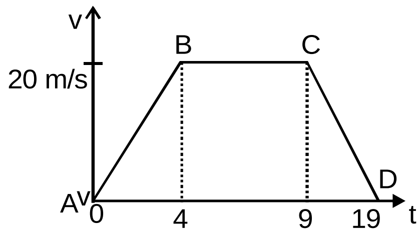
$$v_{max} = 60 \text{m/s}$$

(C) Positions of the train

$$\text{I}^{st} \text{ Positon} = \frac{1}{2} \times 15 \times 30 = 225\text{m}$$

$$\text{II}^{nd} \text{ Position} = 2700 - \frac{1}{2} \times 30 \times 30 = 2250\text{m}$$

13.



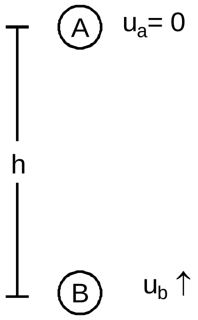
for AB $20 = 0 + 5t \Rightarrow t = 4$ sec

for CD $0 = 20 - 2t \Rightarrow t = 10$ sec

$$\text{Area covered} = \frac{1}{2} \times 20 \times 4 + 5 \times 20 + \frac{1}{2} \times 10 \times 20$$

= 240 m

14. Max height of B



$$\frac{u^2}{2g} = 4h \Rightarrow u_B = \sqrt{8gh}$$

Relative velocity $V_{AB} = 0 - \sqrt{8gh} = -\sqrt{8gh}$

$$t = \frac{h}{\sqrt{8gh}} = \sqrt{\frac{h}{8g}}$$

15. Given a = 0.2 m/s

$a_{eff} = g + a$

$$S = \frac{1}{2} \times 10 \times \left[\left(\frac{7}{2}\right)^2 - \left(\frac{3}{2}\right)^2\right] = 50 \text{ m}$$

16. Area of V–T curve give displacement.

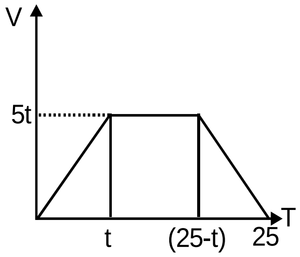
Distance travelled by the particle

= 50 + 50

= 100 m

Av. velocity = zero

17.



V = u + at

V = 0 + 5t

$$\tan\theta = \frac{v_{max}}{t} = 5$$

$v_{max} = 5t$

Displacement

$$= \frac{1}{2} \times t \times 5t + (25 - 2t) \times 5t + \frac{1}{2} \times t \times 5t$$

$= 125t - 5t^2$

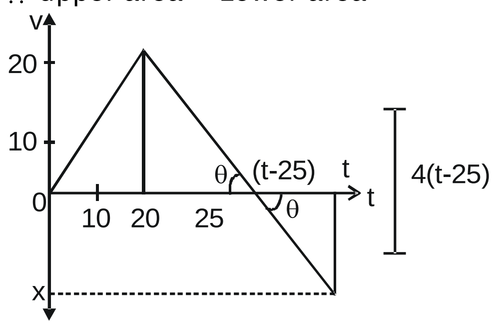
Average velocity $20 = \dfrac{125t - 5t^2}{25}$

$125\,t - 5t^2 = 500$

t = 20, 5 ; $t \neq 20$

18. Particle return to starting point it means displacement = 0

∴ upper area = Lower area



$$\tan\theta = \frac{20}{5} \Rightarrow \tan\theta = \frac{x}{(t-25)} \Rightarrow x = 4(t-25)$$

Now, $\dfrac{1}{2} \times 20 \times 20 + \dfrac{1}{2} \times 5 \times 20 = \dfrac{1}{2}(t-25) \times 4(t-25)$

On solving t = 36.2 sec

19. At t= 2 sec $\therefore \theta = 45^\circ$

$\therefore v_y = v_x$

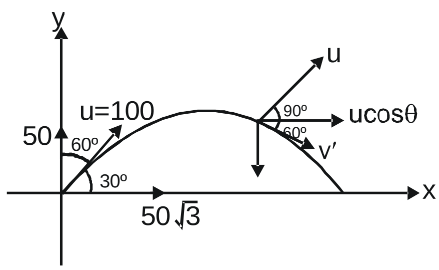
for t = 4 sec, $u_y = 0 \Rightarrow T = \dfrac{u_y}{g} \Rightarrow u_y = 40$ m/s

At t= 2 sec $v_y = 40 - 20 = 20$

$\therefore v_y = v_x = 20$

$$v = \sqrt{(20)^2 + (40)^2} = 20\sqrt{5}$$

20.



$u_x = 50\sqrt{3}$ m/s

$u_y = 50$ m/s

$V_x = u_x = 50\sqrt{3}$

$V_y = u_y - gt = 50 - 10t$

$$\tan(-60) = \frac{50 - 10t}{50\sqrt{3}}$$

t = 20 sec

21. $y = \sqrt{3}x - \dfrac{gx^2}{2}$

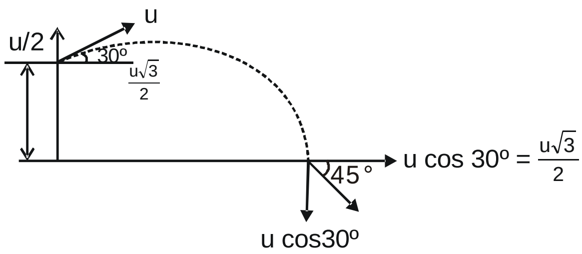
$$y = x\tan\theta - \frac{gx^2}{2u^2\cos^2\theta}$$

on comparing $\tan\theta = \sqrt{3}$ $\theta = 60°$

and $u^2\cos^2\theta = 1$

$u = 2$ m/s

22.



$$-\frac{u\sqrt{3}}{2} = \frac{u}{2} - 10 \times 5$$

$$u = \frac{100}{\sqrt{3}+1} = 50(\sqrt{3}-1)\,m/sec$$

$$S = \frac{50}{2}\left(\sqrt{3}-1\right) \times 5 - \frac{1}{2} \times 10 \times 215$$

$$S = 125\sqrt{3} - 125 - 125$$

$$S = 125\left(-\sqrt{3}+2\right)$$

23. $s = 100 \times 3 + \frac{1}{2} \times 30 \times 3^2$

$V = 100 + 30 \times 3 = 190$ m/s

= 435 m

$\Rightarrow \quad H_{max} = \frac{(190)^2}{2 \times 10} \times \sin^2 53^o = 1155.2$

(A) Total = 348 + H_{max}

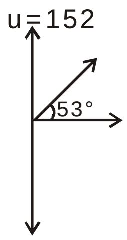
= 348 + 1155.2

= 1503.2 m = maximum altitude

(B) u = 190 sin 53°;

$-a_y = 10$: $s_y = -348$

after t = 3 sec. $\quad u_y = 152$ m/s



$$-348 = 152t - \frac{1}{2} \times 10 \times t^2$$

$5t^2 - 152t - 348 = 0$, $\quad t = 32.54$ sec

Total = 35.54 sec

R = 435cos 53° + 190 cos 53 × 32.54

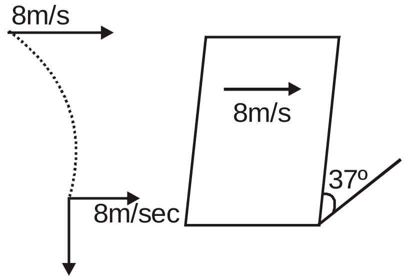
$$= 435 \times \frac{3}{5} + 190 \times \frac{2}{5} \times 32.54 = 3970.56m$$

24. $\sqrt{\frac{2h}{g}} = 5\,sec \;(h = y) \Rightarrow y = 125$ m

Now, $\tan 37^o = \frac{125}{x} \Rightarrow \frac{3}{4} = \frac{125}{x} \Rightarrow x = 500/3$

$\therefore\; x = u \times 5 \Rightarrow u = \frac{100}{3}\,m/s$

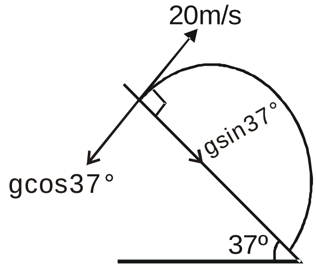
25.



g sin (37°) = 6 , $\quad V_y = 6 \times 1 = 6$

$V = \sqrt{6^2 + 8^2} = 10\,m/s$

26.



$$T = \frac{2u}{g\cos 37^o} = \frac{2 \times 20}{10 \times 4/5}$$

$R = \frac{1}{2}a_x T^2$, $\quad R = \frac{1}{2} \times 10 \sin 37^o \times T^2$

$$= \frac{1}{2} \times 10 \times \frac{3}{5} \times (5)^2 = 75m$$

27. $R = \frac{u^2 \sin 2\theta}{g}$; $H = \frac{u^2 \sin^2\theta}{2g}$

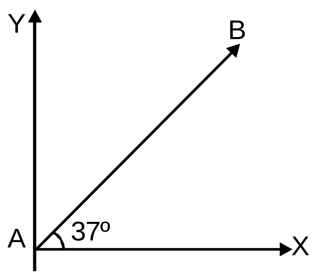
$T = \frac{2u\sin\theta}{g}$; $a_x = g/2$

Due to acceleration in x-direction range will increase.

Now, $R' = u\cos\frac{(2u\sin\theta)}{g} + \frac{1}{2} \times \frac{g}{2} \times \left(\frac{2u\sin\theta}{g}\right)^2$

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

28.



$V_b = 10\hat{i} + 12\hat{j} \quad \Rightarrow \quad V_w = u\hat{i}$

$\vec{v}_{bw} = \vec{v}_b - \vec{v}_w$, $\quad \vec{v}_b = \vec{v}_{bw} + \vec{v}_w$

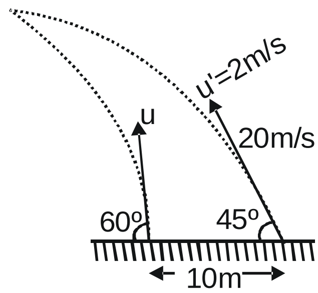
$= 10\hat{i} + 12\hat{j} + u\hat{i}$

$= (10+u)\hat{i} + 12\hat{j}$

$\tan 37^o = \frac{12}{10+u} \Rightarrow \frac{3}{4} = \frac{12}{10+u}$

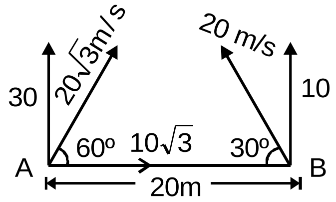
$10 + u = 16$, $\quad u = 6\,m/s$

29. Vertical component of both particle be same for collision of particle.



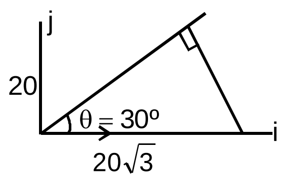
$$\frac{u\sqrt{3}}{2}=\frac{20}{\sqrt{2}} \Rightarrow u=\frac{40}{\sqrt{6}} \Rightarrow u=20\sqrt{\frac{2}{3}}$$

30. w.r.t. B



$v_{ABX} = 10\sqrt{3}-\left(-10\sqrt{3}\right)=20\sqrt{3}\,m/s$

$v_{ABy} = 30 - 10 = 20$ m/s



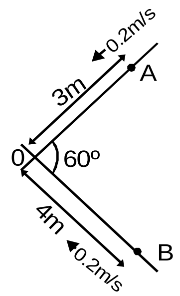
$$\vec{V}_{AB}=20\sqrt{3}\hat{i}+20\hat{j}$$

$$\tan\theta=\frac{20}{20\sqrt{3}}$$

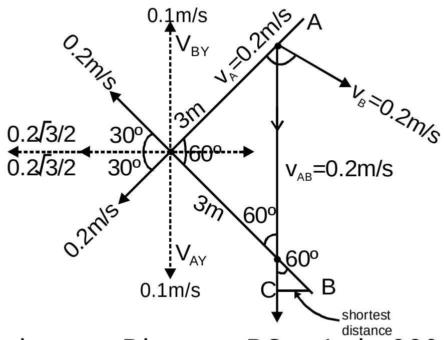
$$\tan\theta=\frac{1}{\sqrt{3}} \Rightarrow \theta=30^o$$

$x=20\sin 30^o \Rightarrow x=10m$

31.



Now, we solve the problem w.r.t. B then



shortest Distance BC = 1 sin 60°

$$=\frac{\sqrt{3}}{2}m=50\sqrt{3}cm$$

32. $v_{rw}=-20\hat{j}$

$V_m=5\hat{i}$

$V_w=15\hat{i}$

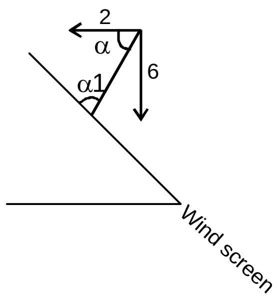
$\vec{v}_{rw}=\vec{v}_r-\vec{v}_w$

$\vec{v}_r=\vec{v}_{rw}+\vec{v}_w=-20\hat{j}+15\hat{i}$

$\vec{v}_{rm}=\vec{v}_r-\vec{v}_m=-20\hat{j}+15\hat{i}-5\hat{i}=10\hat{i}-20\hat{j}$

$$\tan\theta=\frac{10}{20}\Rightarrow\theta=\tan^{-1}\left(\frac{1}{2}\right)$$

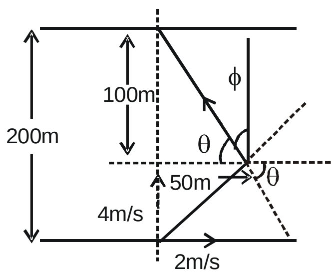
33.



$\vec{v}_{rc}=\vec{v}_r-\vec{v}_c$

$$\tan\alpha=\frac{6}{2}\Rightarrow\alpha=\tan^{-1}(3)$$

34. $t=\frac{200}{4}=50\,sec$



$V_y = 4\sin\theta$

$V_x = 4\cos\theta - 2$

$\tan\theta = 2$

$$2=\frac{4\sin\theta}{4\cos\theta-2}$$

$4\cos\theta - 2 = 2\sin\theta$

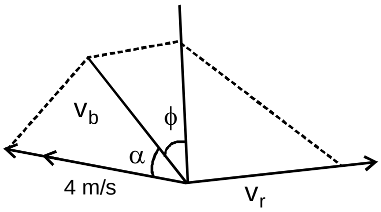
$2\cos\theta - 1 = \sin\theta$

$4\cos^2\theta + 1 - 4\cos\theta = 1-\cos^2\theta$

$5\cos^2\theta = 4\cos\theta \quad \Rightarrow \quad \theta = 37°$

$$\tan\phi=\frac{1}{2}$$

$4\sin\alpha = 2\sin(90+\phi)$



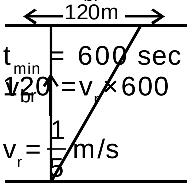
$4\sin\alpha = 2\cos\phi$

$$\sin\alpha = \frac{2\cos\phi}{4}=\frac{2}{4}\times\frac{2}{\sqrt{5}}=\frac{1}{\sqrt{5}}$$

$$t = \frac{100}{4\cos(\alpha+\varphi)}=\frac{100}{4(\cos\alpha\cos\varphi-\sin\alpha\sin\varphi)}$$

$$t = \frac{100}{4\times\frac{3}{5}}=\frac{125}{3}$$

35. $t_{min}=\frac{d}{v_{br}}=10\times 60 \text{ sec}$

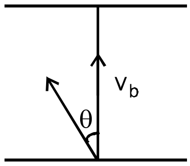


$t_{min} = 600 \text{ sec}$

$120 = v_r \times 600$

$v_r = \frac{1}{5}\text{ m/s}$

$$\sin\theta=\frac{v_r}{v_{br}}=\frac{1}{v_{br}\times 5}$$



$$12.5\times 60 = \frac{d}{v_{br}\cos\theta}$$

$$\left[\because \frac{d}{v_{br}}=10\times 60\right]$$

$$12.5\times 60=\frac{10\times 60}{\cos\theta}$$

$$\cos\theta=\frac{4}{5}\Rightarrow\theta=37^{o}$$

$$\text{Now, } \frac{3}{5}=\frac{1}{v_{br}\times 5}$$

$v_{br}=\frac{1}{3}\text{ m/s} \qquad 12.5\times 60=\frac{10\times 60}{\cos\theta}$

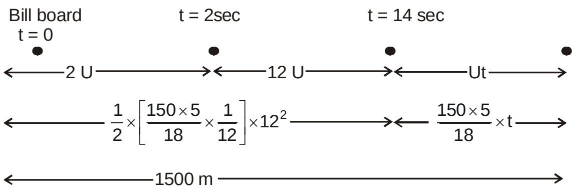
$$\cos\theta=\frac{4}{5}\Rightarrow\theta=37^{o}$$

$$\text{Now, } \frac{3}{5}=\frac{1}{v_{br}\times 5}$$

$$v_{br}=\frac{1}{3}\text{ m/s}$$

Exercise-III Level-II

1



14 U + Ut = 1500m ...(1)

$$\frac{1}{2}\times\frac{150\times5}{18}\times\frac{1}{12}\times12^2+\frac{150\times5}{18}\times t=1500\text{ m}$$

$$\Rightarrow\quad t=30\,\text{sec}$$

U(30 + 14) = 1500 m $\Rightarrow\quad U=122.7\text{ km/hr}$

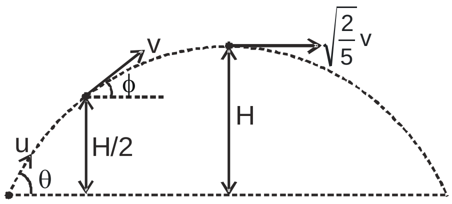
2 Bullets will spread in a area of radius equal to the range of bullets. Therefore for area to be maximum.

Range should be maximum. i.e. $\frac{v^2}{g}\Rightarrow A=\frac{\pi v^4}{g^2}$

3 $v^2-u^2=2\vec{a}.\vec{S}_y$

$$\frac{2}{5}v^2-u^2=-2gH\quad\Rightarrow\quad v^2-u^2=-\frac{2gH}{2}$$

$$\frac{3}{5}v^2=g\times\frac{(U\sin\theta)^2}{2g}\quad\Rightarrow\quad U\sin\theta=\sqrt{\frac{6}{5}}\,v$$



$$U\cos\theta=\sqrt{\frac{2}{5}}\,v$$

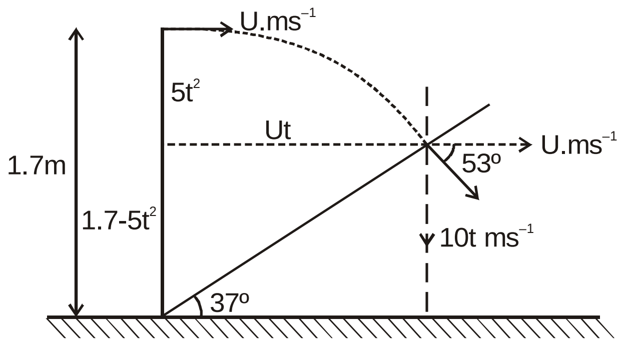
$$\tan\theta=\sqrt{3}\Rightarrow\theta=60^o$$

$$v\cos\phi=\sqrt{\frac{2}{5}}\,v\quad\Rightarrow\quad\phi=\cos^{-1}\sqrt{\frac{2}{5}}$$

4 $\tan53^o=\frac{10t}{U}$

$$\Rightarrow\quad\frac{4}{3}=\frac{10t}{U}\qquad....(1)$$

$$\tan53^o=\frac{Ut}{1.7-5t^2}\qquad.....(2)$$



from (1) & (2) : $t=\frac{2}{5}\text{sec}$

from (1) : $U=\frac{3}{4}\times10\times\frac{2}{5}$

$U = 3\text{ ms}^{-1}$

5 Let us choose the x and y directions along OB and OA respectively. Then,

$u_x = u = 10\sqrt{3}$ m/s, $u_y = 0$

$a_x = -g\sin60° = -5\sqrt{3}$ m/s^2

and $a_y = -g\cos60° = -5$ m/s^2

(a) At point Q, x-component of velocity is zero. Hence, substituting in

$v_x = u_x + a_xt$

$0 = 10\sqrt{3}-5\sqrt{3}t\quad\Rightarrow\quad t=\frac{10\sqrt{3}}{5\sqrt{3}}=2s$ **Ans.**

(b) At point Q, $v = v_y = u_y + a_yt$

$\therefore\quad v = 0 - (5)(2) = -10$ m/s **Ans.**

Here, negative sign implies that velocity of particle at Q is along negative y direction.

(c) Distance PO = |displacement of particle along y-direction| = $|s_y|$

Here, $s_y = u_yt+\frac{1}{2}a_yt^2 = 0-\frac{1}{2}(5)(2)^2$

= – 10 m

$\therefore$ PO = 10 m

Therefore, h = POsin30° = $(10)\left(\frac{1}{2}\right)$

or h = 5m **Ans.**

(d) Distance OQ = displaement of particle along x-direction = s_x

Here, $s_x = u_xt+\frac{1}{2}a_xt^2$

$= (10\sqrt{3})(2)-\frac{1}{2}(5\sqrt{3})(2)^2$

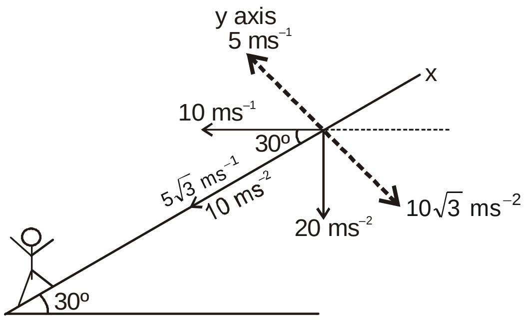
$= 10\sqrt{3}$ m or OQ = $10\sqrt{3}$ m

PQ = $\sqrt{(PO)^2+(OQ)^2} = \sqrt{(10)^2+(10\sqrt{3})^2}$

$= \sqrt{100+300}=\sqrt{400}$

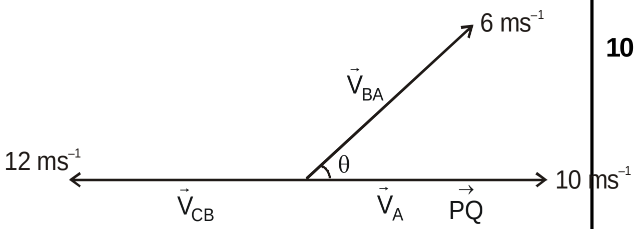
PQ = 20 m

6



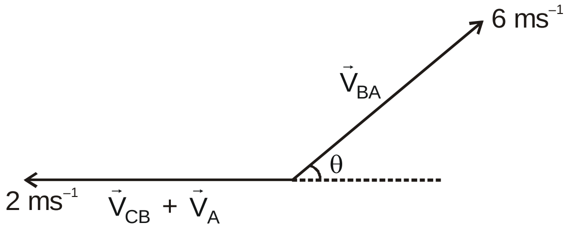
$$O = 5T - \frac{1}{2} \times 10\sqrt{3}\ T^2 \quad \Rightarrow \quad T = \frac{1}{\sqrt{3}}$$

7



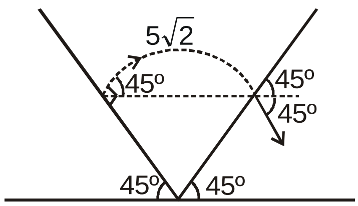
$\therefore \qquad \vec{V}_C = \vec{V}_{CB} + \vec{V}_B$

$= \vec{V}_{CB} + \vec{V}_{BA} + \vec{V}_A$



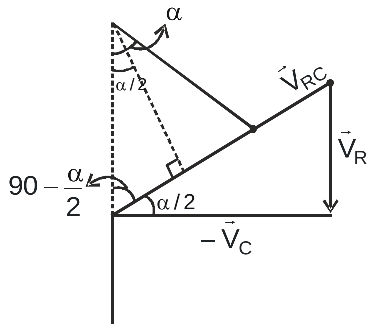
$$|\vec{V}_C| = \sqrt{4 + 36 + 2 \times 2 \times 6\cos(\pi - \theta)} = 5\text{ms}^{-1}$$

8



$$T = \frac{2 \times 5\sqrt{2}\sin 45^\circ}{g} = 1\text{sec}$$

9



$$\tan \alpha/2 = \frac{|\vec{V}_R|}{|-\vec{V}_C|} = \frac{2}{6} \quad \Rightarrow \quad \alpha = 2\tan^{-1}(1/3)$$

10 $\frac{1}{2}gt^2 = 4$

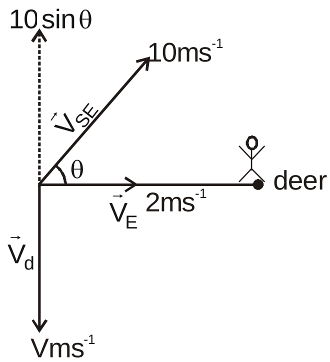
$\Rightarrow \quad t = \frac{2}{\sqrt{5}}$ sec

[Time taken by spear to reach dear]
Motion in horizontal plane

$\vec{a}_{horizontal} = \vec{0}$

$10 \sin \theta = V_d$

$$(10\cos\theta + 2)\frac{2}{\sqrt{5}} = 4\sqrt{5}$$



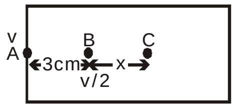
$\Rightarrow \quad \theta = 37^\circ$

$\therefore \quad V_d = 6\text{ms}^{-1}$

Exercise-IV Level - I

1. (A)

Let initial velocity of body at point A is v, AB is 3 cm.



From $v^2 = u^2 - 2as \Rightarrow \left(\frac{v}{2}\right)^2 = v^2 - 2a \times 3$

or $a = \frac{v^2}{8}$

Let on penetrating 3 cm in a wooden block, the body moves x distance from B to C.

So, for B to C

$u = \frac{v}{2}, \quad v = 0$

$s = x, \quad a = \frac{v^2}{8}$ (deceleration)

$(0)^2 = \left(\frac{v}{2}\right)^2 - 2.\frac{v^2}{8}.x$

or x = 1 cm

NOTE :

Here, it is assumed that retardation is uniform.

2. (B)

From conservation of energy, potential energy at height h

= KE at ground

Therefore, at height h, PE of ball A

PE = $m_A gh$

KE at ground = $\frac{1}{2} m_A v_A^2$

So, $m_A gh = \frac{1}{2} m_A v_A^2$

or $v_A = \sqrt{2gh}$

Similarly, $v_B = \sqrt{2gh}$

Therefore, $v_A = v_B$

NOTE : In question it is not mentioned that magnitude of thrown velocity of both balls are some which is assumed in solution.

3. (C)

At the highest point of its flight, vertical component of velocity is zero and only horizontal component is left which is

$u_x = u \cos\theta$

Given $\theta = 45^0$

$\therefore u_x = u \cos 45^0 = \frac{u}{\sqrt{2}}$

Hence, at the highest point kinetic energy,

$E' = \frac{1}{2} m u_x^2$

$= \frac{1}{2} m \left(\frac{u}{\sqrt{2}}\right)^2 = \frac{1}{2} m \left(\frac{u^2}{2}\right)$

$= \frac{E}{2} \qquad \left(\because \frac{1}{2} mu^2 = E\right)$

4. (D)

In this question the cars are identical means coefficient of friction between the tyre and the ground is same for both the cars, as a result retardation is same for both the cars equal to μg. Let first car travel distance s_1, before stopping while second car travel distance s_2, then from

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

$\Rightarrow 0 = u^2 - 2\mu g \times s_1 \qquad \Rightarrow s_1 = \frac{u^2}{2\mu g}$

and $0 = (4u^2) - 2\mu g \times s_2$

$\Rightarrow \qquad s_2 = \frac{16u^2}{2\mu g} = 16 s_1 \quad \Rightarrow \frac{s_1}{s_2} = \frac{1}{16}$

5. (B)

$x = \alpha t^3$, $y = \beta t^3$

$v_x = \frac{dx}{dt} = 3\alpha t^2$

$v_y = \frac{dy}{dt} = 3\beta t^2$

Resultant velocity,

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

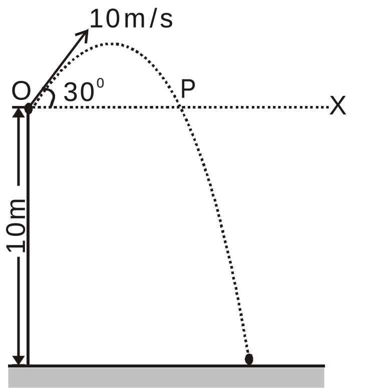
$v = \sqrt{9\alpha^2 t^4 + 9\beta^2 t^4}$

$= 3t^2\sqrt{\alpha^2 + \beta^2}$

6. (D)

$OP = R = \frac{u^2 \sin 2\theta}{g} = \frac{10^2 \times \sin(2 \times 30^0)}{10}$

$= \frac{10\sqrt{3}}{2} = 5\sqrt{3} = 8.66\,m$



7. (C)

$v^2 = u^2 + 2as$

$\Rightarrow 0 = \left(50 \times \frac{5}{18}\right)^2 + 2a \times 6$

$a = -16 m/s^2$

Again $v^2 - u^2 + 2as$

$\Rightarrow 0 = \left(100 \times \frac{5}{18}\right)^2 - 16 \times 2 \times s$

$s = \frac{(100 \times 5)^2}{18 \times 18 \times 32}$

$s = 24.1 \approx 24$ m

8. (A)

Man will catch the ball, if the horizontal component of velocity becomes equal to the constant speed of man ie.

$v_o \cos\theta = \frac{v_o}{2}$

or $\cos\theta = \frac{1}{2}$

$\cos\theta = \cos 60^0$

or $\theta = 60^0$

9. (C)

When a force of constant magnitude acts on velocity of particle perpendicularly, then there is no change in the kinetic energy of particle. Hence, kinetic energy remains constant.

10. (D)

$v^2 = u^2 + 2as$

$0 = \left(60 \times \frac{5}{18}\right)^2 - 2a \times s_1$

$\Rightarrow s_1 = \left(\frac{60 \times 5/18}{2a}\right)^2$

$0 = \left(120 \times \frac{5}{18}\right)^2 - 2a \times s_2$

$\Rightarrow s_2 = \frac{(120 \times 5/18)^2}{2a}$

$\therefore \frac{s_1}{s_2} = \frac{1}{4}$

$\Rightarrow s_2 = 4s_1 = 4 \times 20 = 80m$

11. (C)

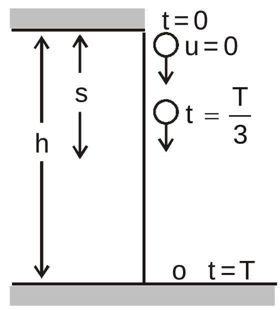
Second law of motion gives

$s = ut + \frac{1}{2}gT^2$

or $h = 0 + \frac{1}{2}gT^2$

$(\therefore u = 0)$

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



At $t = \frac{T}{3}$ s,

$s = 0 + \frac{1}{2}g\left(\frac{T}{3}\right)^2$

or $s = \frac{1}{2}g.\frac{T^2}{9}$

$\Rightarrow s = \frac{g}{18} \times \frac{2h}{g} \qquad \left(\therefore T = \sqrt{\frac{2h}{g}}\right)$

or $\qquad s = \frac{h}{9}$

Hence, the position of ball from the ground

$= h - \frac{h}{9} = \frac{8h}{9}\,m$

12. (C)

Parachute bails out at height H from ground.

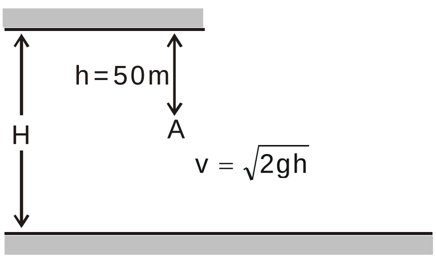
Velocity at A

$v = \sqrt{2gh}$

$= \sqrt{2 \times 9.8 \times 50} = \sqrt{980}\,ms^{-1}$

Velocity at ground, v_1 = 3ms^{-1} (given)

Acceleration = - 2ms^{-2} (given)



$\therefore H - h = \frac{v^2 - v_1^2}{2 \times 2}$

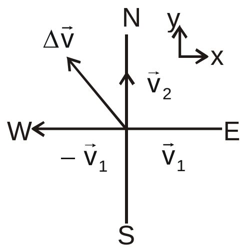
$= \frac{980 - 9}{4} = \frac{971}{4} = 242.75$

$\Rightarrow H = 242.75 + h$

$= 242.75 + 50 = 293\,m$

13. (D)

$\vec{v}_1 = +5\hat{i}$



$\vec{v}_2 = +5\hat{i}$

$\Delta\vec{v} = \vec{v}_2 - \vec{v}_1 = 5\hat{j} - 5\hat{i}$

$|\Delta\vec{v}| = 5\sqrt{2}$

$\therefore \quad \alpha = \frac{|\Delta\vec{v}|}{t} = \frac{5\sqrt{2}}{10} = \frac{1}{\sqrt{2}}\,ms^{-2}$

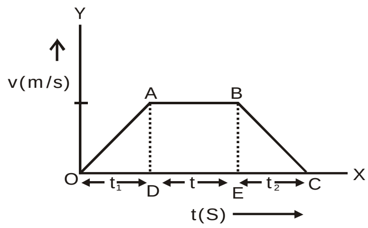
For direction,

$\tan\alpha = -\frac{5}{5} = -1$

Average acceleration is $\frac{1}{\sqrt{2}}\,ms^{-2}$ towards north-west.

14. (A)

The velocity time graph for the given situation can be drawn as below. Magnitudes of slope of OA = f



and slope of BC $= \frac{f}{2}$

$v = ft_1 = \frac{f}{2}t_2$

$\therefore \quad t_2 = 2t_1$

In graph area of ΔOAD gives distance

$s = \frac{1}{2}ft_1^2 \qquad \ldots\text{(i)}$

Area of rectangle ABED gives distance travelled in time t.

$s_2 = (ft_1)t$

Distance travelled in time t_2,

$s_3 = \frac{1}{2}\frac{f}{2}(2t_1)^2$

Thus, $\quad s_1 + s_2 + s_3 = 15s$

$\Rightarrow \quad s + (ft_1) + ft_1^2 = 15s$

or

$s + (ft_1)t + 2s = 15s \qquad \left(s = \frac{1}{2}ft_1^2\right)$

or $\quad (ft_1)t = 12s \qquad \ldots\text{(ii)}$

From Eqs. (i) and (ii), we have

$\frac{12s}{s} = \frac{(ft_1)t}{\frac{1}{2}(ft_1)t_1}$

or $t_1 = \frac{t}{6}$

From Eq. (i), we get

$$s = \frac{1}{2} f (t_1)^2$$

$$\Rightarrow \quad s = \frac{1}{2} f\left(\frac{t}{6}\right)^2 = \frac{1}{72} ft^2$$

Hence, none of the given options is correct.

15. (C)
Given, $t = ax^2 + bx$
Differentiating w.r.t t

$$\frac{dt}{dt} = 2ax\frac{dx}{dt} + b\frac{dx}{dt}$$

$$v = \frac{dx}{dt} = \frac{1}{(2ax+b)}$$

Again diferentiating w.r.t. t

$$\frac{d^2x}{dt^2} = \frac{-2a}{(2ax+b)^2} \cdot \frac{dx}{dt}$$

$$\therefore \quad f = \frac{d^2x}{dt^2}$$

$$= \frac{-1}{(2ax+b)^2} \cdot \frac{2a}{(2ax+b)} \quad \text{or} \quad f = \frac{-2a}{(2ax+b)^3}$$

$$\Rightarrow \quad f = -2av^3$$

16. (D)
A Projectile can have same range if angle of projection are complementary ie, θ and (90^0-θ) Thus, in both cases

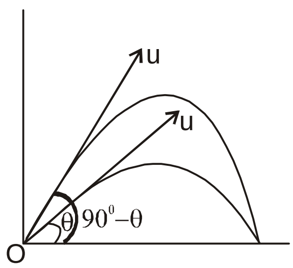
$$t_1 = \frac{2u \sin\theta}{g} \quad \ldots(i)$$

$$t_2 = \frac{2u \sin(90^0 - \theta)}{g} = \frac{2u \cos\theta}{g} \quad \ldots(ii)$$

From Eqs. (i) and (ii)

$$t_1 t_2 = \frac{4u^2 \sin\theta \cos\theta}{g^2}$$

$$t_1 t_2 = \frac{2u^2 \sin 2\theta}{g^2}$$



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

$$\therefore \quad t_1 t_2 = \frac{2R}{g}$$

$$\left(\therefore \quad R = \frac{u^2 \sin 2\theta}{g}\right)$$

or $t_1 t_2 \propto R$

17. (A)

$$v = \alpha\sqrt{x}$$

or $$\frac{dx}{dt} = \alpha\sqrt{x}$$

or $$\frac{dx}{\sqrt{x}} = \alpha dt$$

Perform integration

$$\int_0^x \frac{dx}{\sqrt{x}} = \int_0^t \alpha\, dt$$

[$\therefore$at t = 0,x=0 and let at any time t, particle is at x]

$$\Rightarrow \quad \left.\frac{x^{1/2}}{1/2}\right|_0^x \alpha t$$

or $$x^{1/2} = \frac{\alpha}{2} t$$

or $$x = \frac{\alpha^2}{4} \times t^2$$

or $$x \propto t^2$$

18. (C)
Kinetic energy at highest point,

$$(KE)_H = \frac{1}{2} mv^2 \cos^2\theta$$

$$= K \cos^2\theta$$

$$= K(\cos 60^0)^2 = \frac{K}{4}$$

19. (B)
$v = v_0 + gt + ft^2$

or $$\frac{dx}{dt} = v_o + gt + ft^2$$

$\Rightarrow \quad dx = (v_o + gt + ft^2)dt$

So, $\int_0^x dx = \int_0^1 (v_o + gt + ft^2)dt$

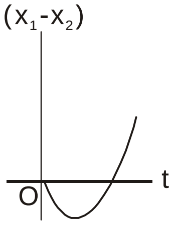
$\Rightarrow \quad x = v_o + \frac{g}{2} + \frac{f}{3}$

20. (B)

Here, $x_2 = vt$ and $x_1 = \frac{at^2}{2}$

$x_1 - x_2 = -\left(vt - \frac{at^2}{2}\right)$

So, the graph would be like

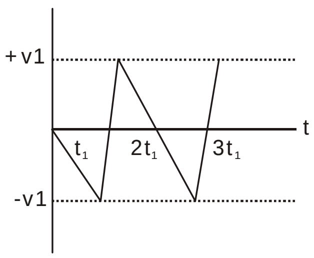


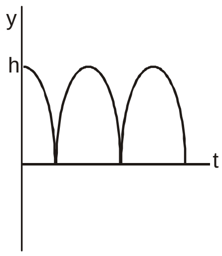
21. (C)

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

v= - gt and after the collision, v = gt (straight line)

Collision is perfectly elastic then ball reaches to same height again and again with same velocity





22. (B)

$\vec{u} = 3\hat{i} + 4\hat{j}\,;\vec{a} = 0.4\hat{i} + 0.3\hat{j}$

$\vec{u} = \vec{u} + \vec{a}t$

$= 3\hat{i} + 4\hat{j} + (0.4\hat{i} + 0.3\hat{j})10$

$= 3\hat{i} + \hat{j} + 4\hat{i} + 3\hat{j} = 7\hat{i} + 7\hat{j}$

Speed is $\sqrt{7^2 + 7^2} = 7\sqrt{2}$ unit

23. (C)

$\vec{L} = m(\vec{r} \times \vec{v})$

$\vec{L} = m[v_o \cos\theta t\,\hat{i} + (v_o \sin\theta t - \frac{1}{2}gt^2)\hat{j}]$

$\times [v_o \cos\theta\,\hat{i} + (v_o \sin\theta - gt)\hat{j}]$

$= mv_o \cos\theta t\left[-\frac{1}{2}gt\right]\hat{k} = -\frac{1}{2}mgv_o t^2 \cos\theta\,\hat{k}$

24. (D)

$\vec{v} = ky\,\hat{i} + kx\hat{j}$

$\frac{dx}{dt} = ky, \frac{dy}{dt} = kx$

$\frac{dy}{dx} = \frac{dy}{dt} \times \frac{dt}{dx} = \frac{kx}{ky}$

ydy = xdx

$y^2 = x^2 + c$

25. (C)

Maximum range of water coming out of the fountain,

$R_m = \frac{v^2}{g}$

$\therefore$ Total area around fountain,

$A = \pi R_m^2 = \pi \frac{v^4}{g^2}$

26. (A)

$\frac{dv}{dt} = -2.5\sqrt{v}$

$\Rightarrow \quad \frac{dv}{\sqrt{v}} = -2.5\,dt \Rightarrow \int_{6.25}^{0} v^{-1/2}dv = -2.5\int_0^t dt$

$\Rightarrow \; -2.5[t]_0^t = [2v^{1/2}]_{6.25}^{0}$

$\Rightarrow t = 2\,s$

27. (D)

Maximum speed with which the boy can throw stone is

$u = \sqrt{2gh} = \sqrt{2 \times 10 \times 10} = 10\sqrt{2}\,m/s.$

Range, is maximum when projectile is thrown at an angle of 45^0 thus,

$$R_{max} = \frac{u^2}{g} = \frac{(10\sqrt{2})^2}{10} = 20\,m$$

28. C

As the force is exponentially decreasing, so it's acceleration, i.e., rate of increase of velocity will decrease with time. Thus, the graph of velocity will be an increasing curve with decreasing slope with time.

$$a = \frac{F}{m} = \frac{F_o}{m}e^{-bt} = \frac{dv}{dt}$$

$$\Rightarrow \quad \int_0^v dv = \int_0^t \frac{F_o}{m}e^{-bt}dt$$

$$\Rightarrow \quad v = \frac{F_o}{m}\left(\frac{1}{-b}\right)e^{-bt}\Big|_0^t$$

$$= \frac{F_o}{mb}e^{-bt}\Big|_0^t$$

$$= \frac{F_o}{mb}(e^o - e^{-bt})$$

$$= \frac{F_o}{mb}(1 - e^{-bt})$$

with $v_{max} = \frac{F_o}{mb}$

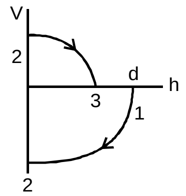
Exercise-IV Level - II

1. **(B)**

2. **(A)**

$\therefore v^2 = u^2 \pm 2gh$

$\therefore$ v – h graph gives parabola



initially v is $\downarrow$ and after collision v $\uparrow$

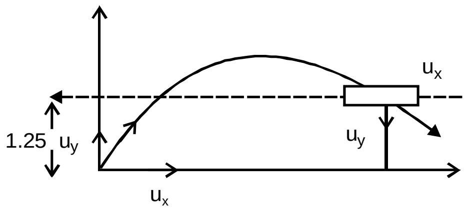
At t=0, h = d

$1 \rightarrow 2$ v $\uparrow$ (Downwards)

At 2 v change direction

At 2-3 v $\downarrow$ (upwards)

3.



$v_y = u_y + a_y t$

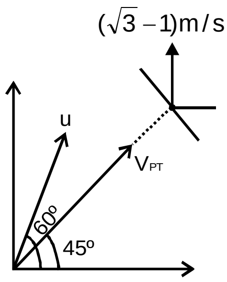
$-u_x = u_y - gt$ -(1)

$u_x.t = 3 + \frac{1}{2} \times 1.5t^2$ - (2)

$1.25 = u_y t - \frac{1}{2} gt^2$ -(3)

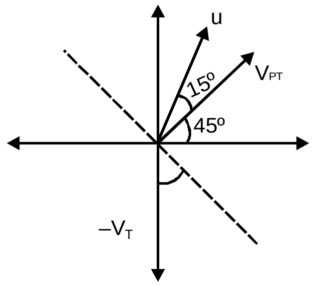
on solving u = 7.29 m/sec; t= 1 sec

4.



$\phi = 45 \times \frac{4}{3} = 60^o$

$\vec{v}_{PT} = \vec{v}_P - \vec{v}_T$; $v_T \cos 45^o = u \sin 15^o$



$\frac{v_T}{\sqrt{2}} = \frac{u.(\sqrt{3}-1)}{2\sqrt{2}}$; u = 2 m/s

5. **(B)**

Area = $v_f - v_i$ $a = \frac{dv}{dt}$

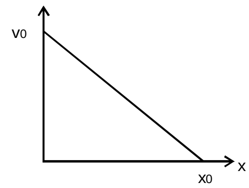
$\frac{1}{2} \times 11 \times 10 = v_f - 0$ $dv = \int a dt$

v_f = 55 m/s

6. **(C)**

7. **(B)**

$v\frac{dv}{dx}$ is negative; $\frac{dv}{dx}$ is constant



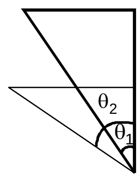
but , v is decreasing with x

$\therefore \left| v\frac{dv}{dx} \right|$ is decreasing

$\therefore$ B is correct.

8. B

$\theta_2 > \theta_1$



9. $t = \frac{2u\sin\theta}{g} \therefore t = \frac{2 \times 10 \times \sqrt{3}/2}{10} = \sqrt{3}$ sec

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

$\therefore 1.15 = 5 \times \sqrt{3} - \frac{1}{2} \times a \times 3$

or $1.15 = 5\sqrt{3} - \frac{3a}{2}$

or a = 5 m/s²