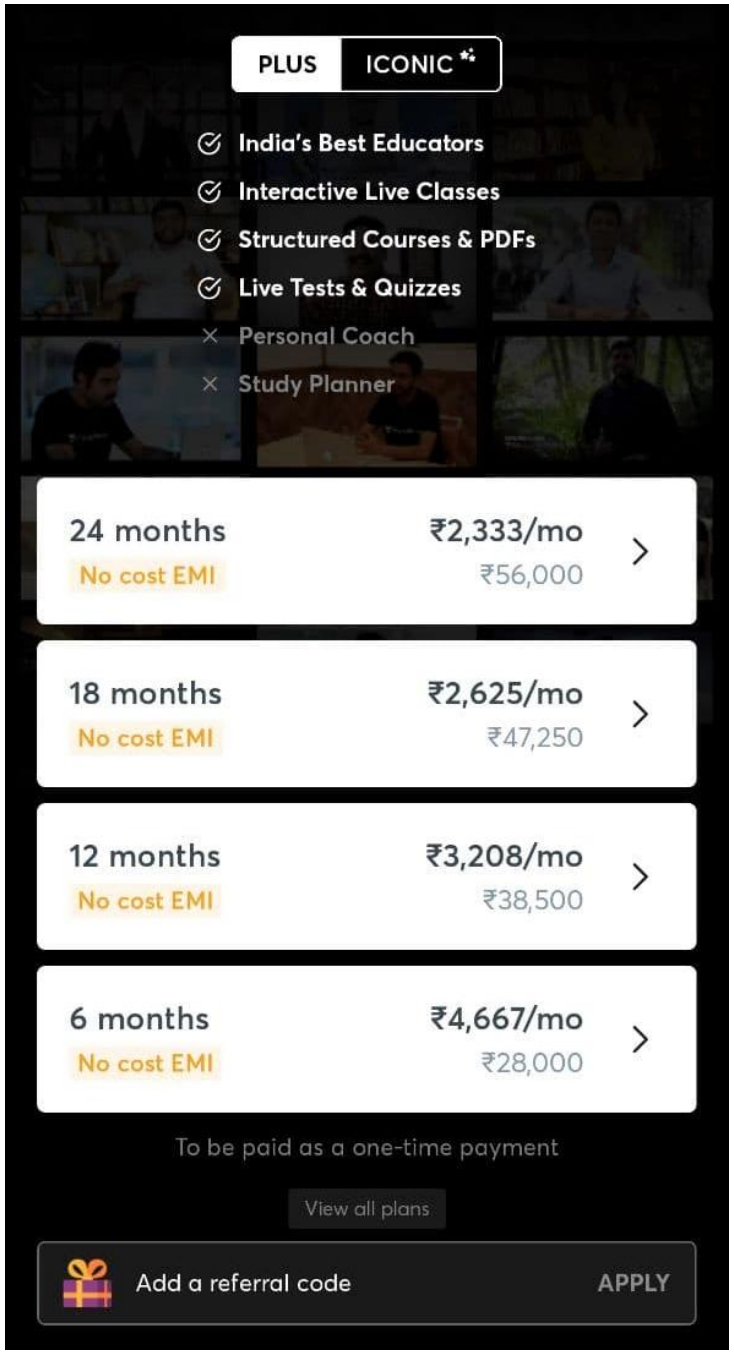
SIR PRATEEK JAIN

. Founder @Physicsaholics
. Top Physics Faculty on Unacademy (IIT JEE & NEET)
. 8+ years of teaching experience in top institutes like FIITJEE (Delhi, Indore) , CP (KOTA) etc.
. Produced multiple Top ranks.
. Research work with HC Verma sir at IIT Kanpur
. Interviewed by International media.



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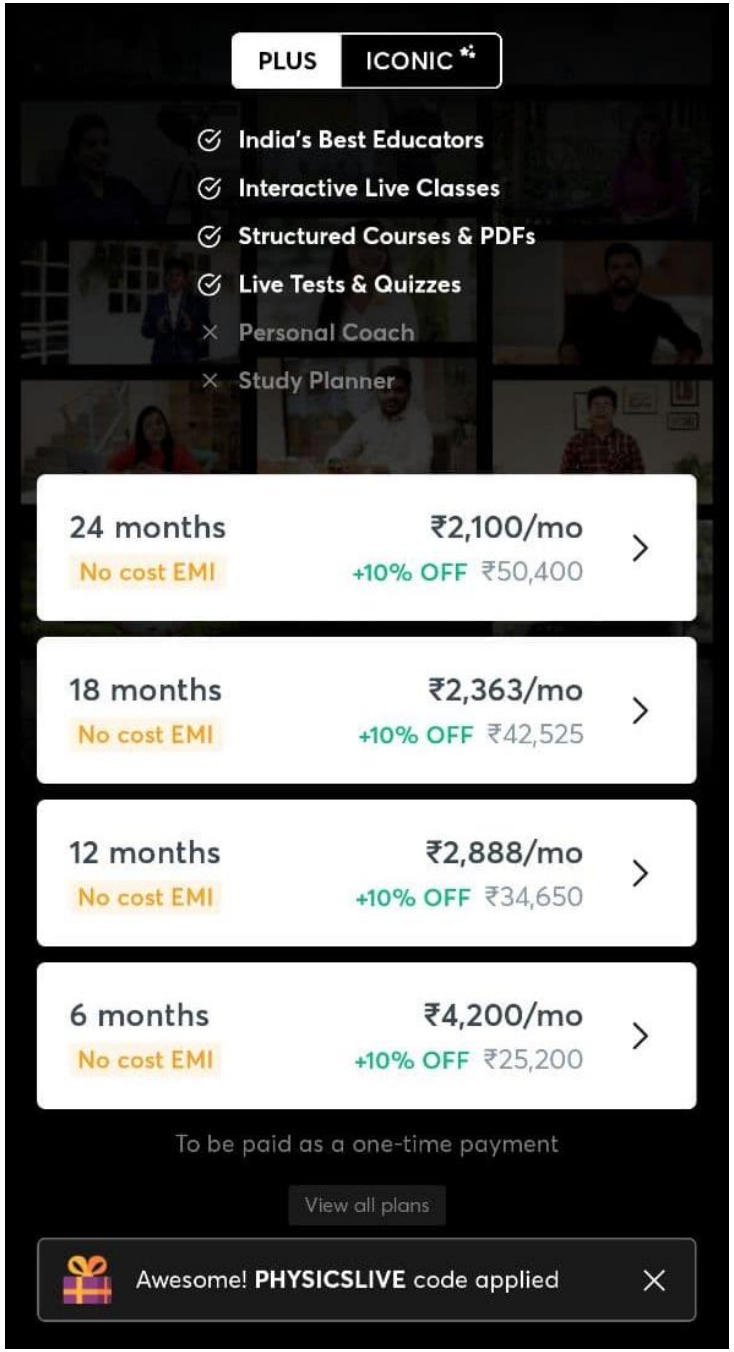

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Solution
Exercise: 1 (L-2)

Kinematics 2D

By Physicsaholics Team

1) $x = 4\sin 6t \;,\quad y = 4(1-\cos 6t)$

$\Rightarrow V_x = \frac{dx}{dt} \;,\quad V_y = \frac{dy}{dt} = 24\sin 6t$

$= 24\cos 6t$

$\Rightarrow V = \sqrt{V_x^2 + V_y^2}$

$= \sqrt{(24)^2\left[\cos^2 6t + \sin^2 6t\right]}$

$= 24\ m/sec$

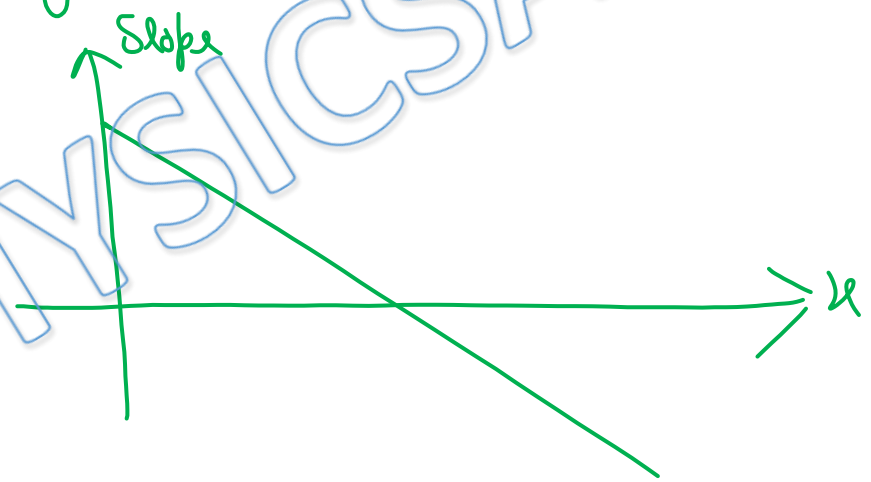
Ans (c)

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

$\Rightarrow \frac{dy}{dx} = \tan\theta - \left(\frac{g\sec^2\theta}{u^2}\right)x$

$\Rightarrow$ Slope $= \tan\theta - \left(\frac{g\sec^2\theta}{u^2}\right)x.$

$\Rightarrow$ St line graph with −ve slope & +ve intercept



ANS-(c)

3) $x = t^2 + 2t$, $y = 2t$

$\Rightarrow t = y/2$

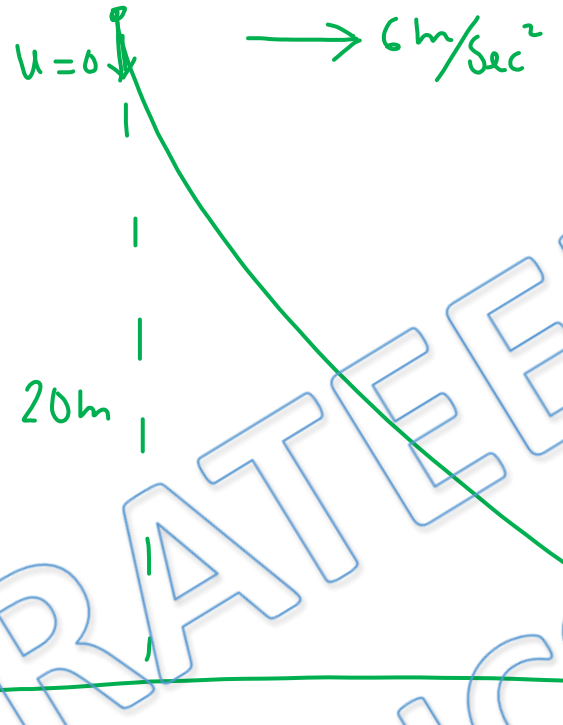
$\Rightarrow x = \left(\frac{y}{2}\right)^2 + y$

$\Rightarrow x = \frac{y^2}{4} + y$

$\Rightarrow$ Parabola

Ans - c

4)



from vertical motion

$$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 20}{g}}$$

$$= 2 \text{ sec}$$

horizontal displacement

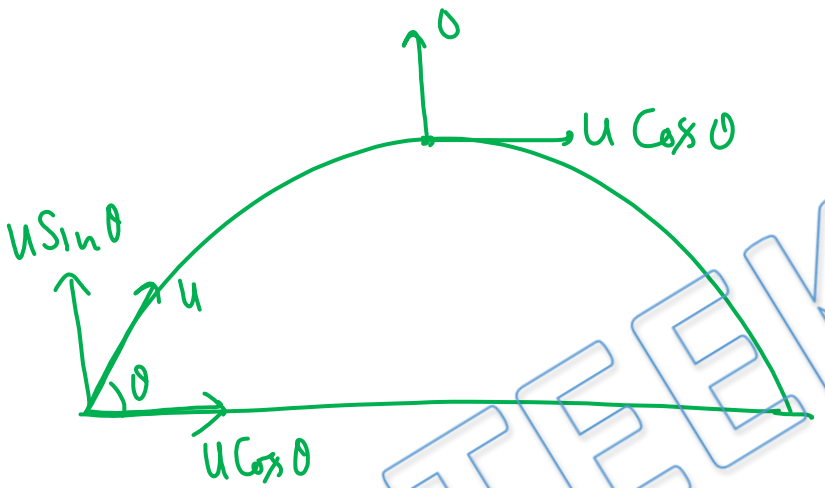
$$= \frac{1}{2} a_x t^2$$

$$= \frac{1}{2} \times 6 \times 4$$

$$= 12 \text{ m}$$

Ans (c)

5)



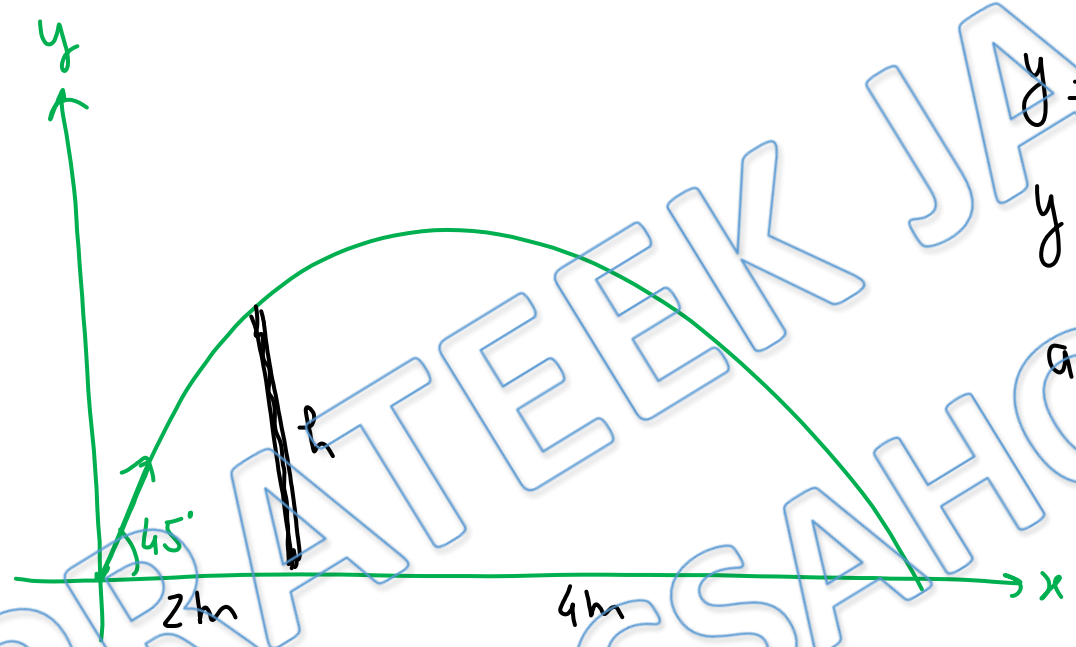
$$\overrightarrow{\Delta v} = (u\cos\theta\,\hat{i}) - (u\cos\theta\,\hat{i} + u\sin\theta\,\hat{j})$$

$$= -u\sin\theta\,\hat{j}$$

$$|\overrightarrow{\Delta v}| = u\sin\theta$$

Ans (c)

6)



Range $R = 6\,m$

Eq of trajectory

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

$$y = x\tan 45\left(1 - \frac{x}{6}\right)$$

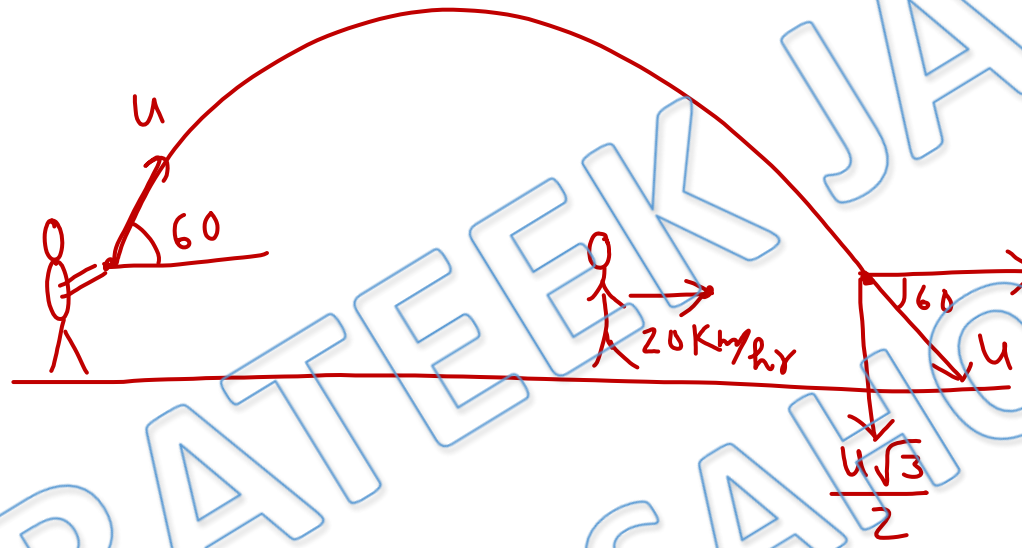
at $x = 2$, $y = h$

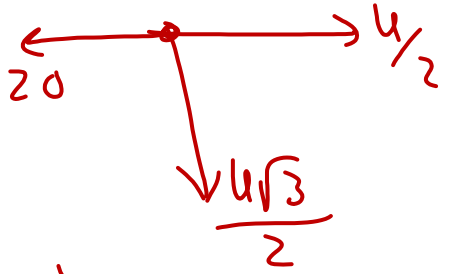
$$h = 2\left(1 - \frac{2}{6}\right)$$

$$= 4/3\ m$$

ANS-(C)

7)



Velocity of ball w.r.t boy = 

Since $V_{ball,boy}$ is vertical $\frac{u}{2} = 20 \Rightarrow u = 40\ km/hr$

ANS - (C)

8)

$$\vec{u} = 10\hat{i} + 20\hat{j} + 20\hat{k}$$

$$\vec{a} = -g\hat{j} + 2.5\hat{i}$$

$$= 25\hat{i} - 10\hat{j}$$

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

$$= (10\hat{i} + 20\hat{j} + 20\hat{k}) + 2(25\hat{i} - 10\hat{j})$$

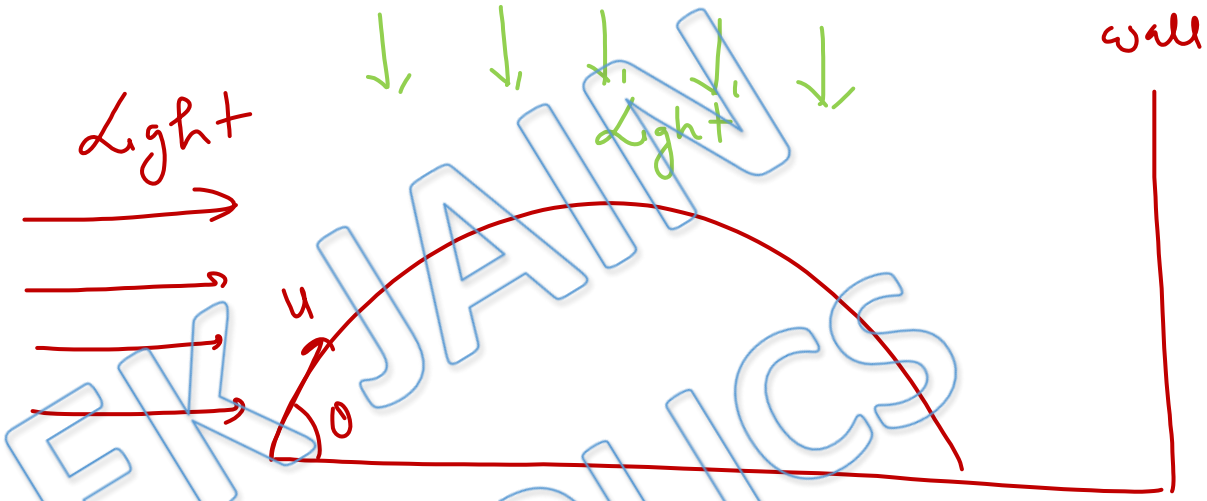
$$= 15\hat{i} + 0\hat{j} + 20\hat{k}$$

$$v = \sqrt{15^2 + 20^2} = 25 \text{ m/sec}$$

Ans-(A)

9) Shadow on ground represents horizontal motion of projectile

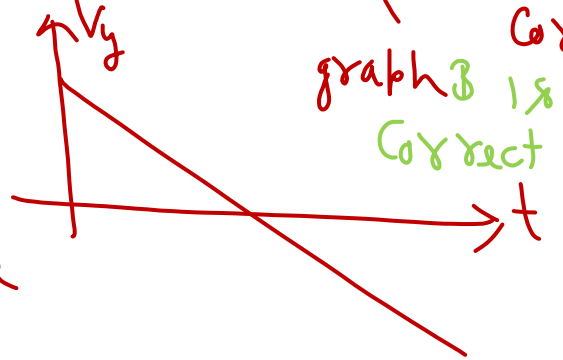
V_x = Constant



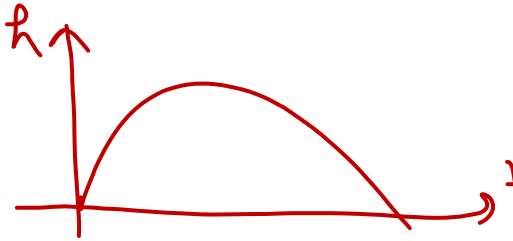
motion of Shadow on wall represents vertical motion of ball

acceleration of Shadow on wall = $g\downarrow$ = Constant (graph A is Correct)

Velocity of Shadow on wall = $u\sin\theta - gt$



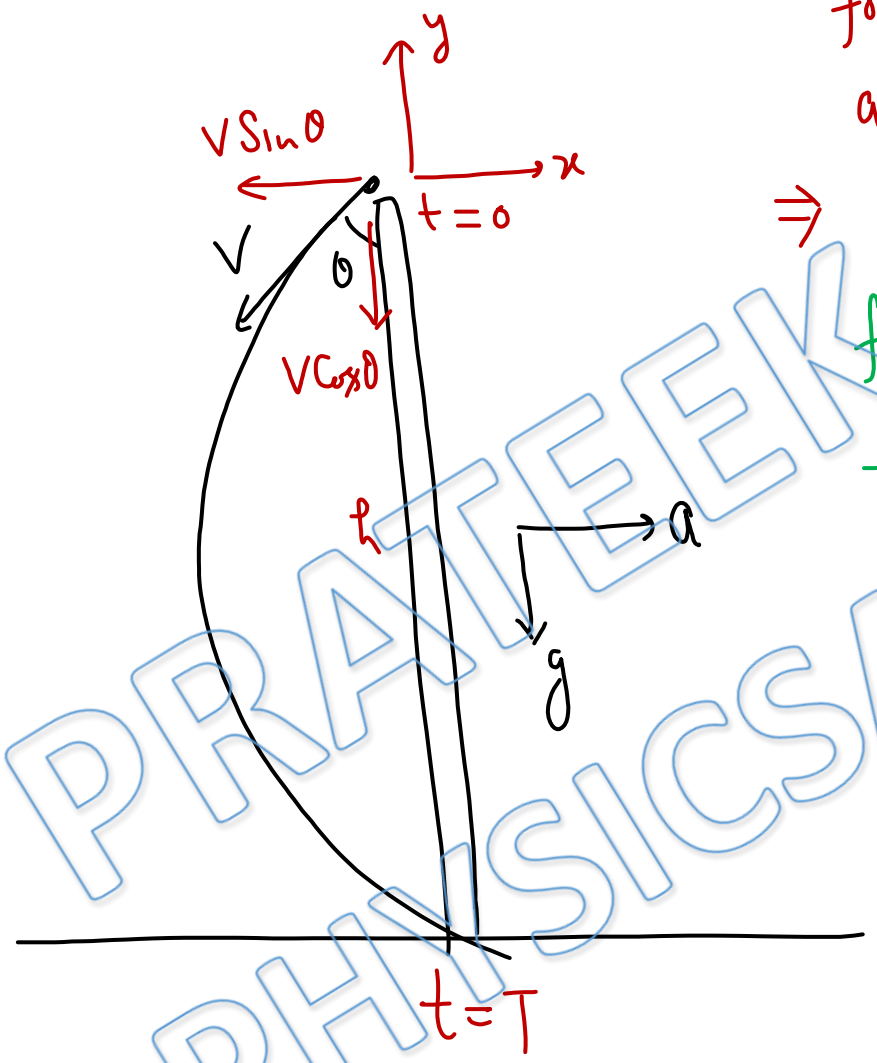
Height of Shadow on wall = $u\sin\theta\, t - \frac{1}{2}gt^2$



graph (d) is Correct

ANS (c)

10)



for motion along x axis

$$\text{at } t=T,\ \Delta x = 0 = V\sin\theta\, T - \frac{1}{2}aT^2$$

$$\Rightarrow T = \frac{2V\sin\theta}{a}$$

for motion along y axis

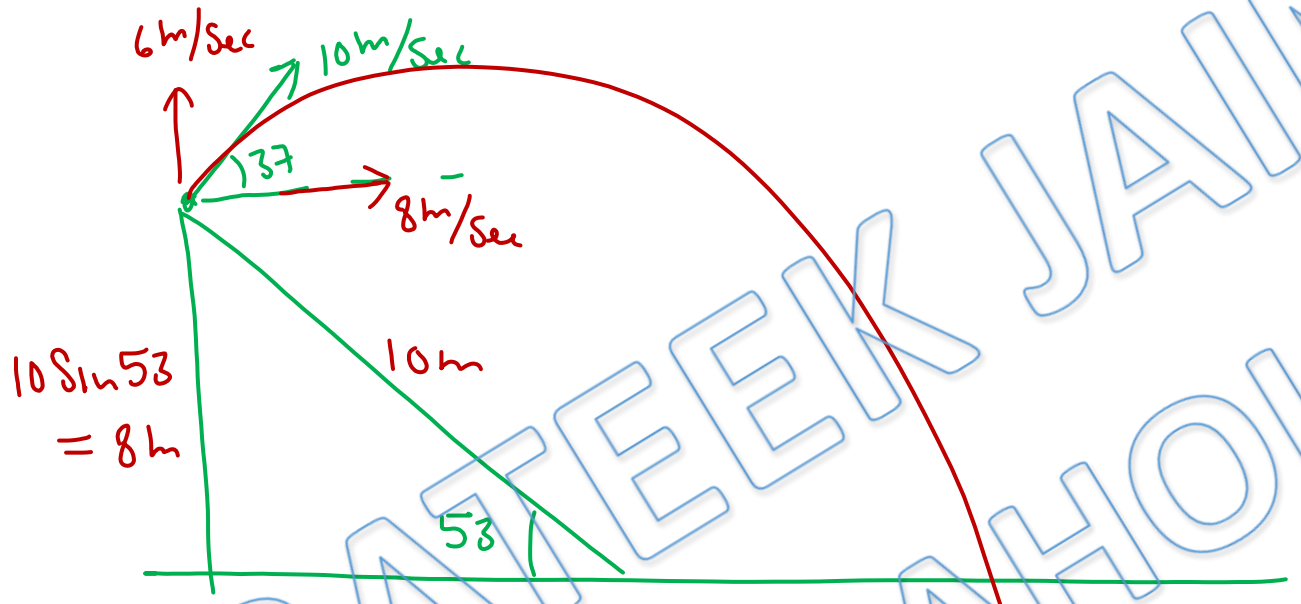
$$h = V\cos\theta\, T + \frac{1}{2}gT^2$$

$$h = \left[V\cos\theta + \frac{g}{2}\times\frac{2V\sin\theta}{a}\right]\frac{2V\sin\theta}{a}$$

$$= \left[\cos\theta + \frac{g}{a}\sin\theta\right]\frac{2V^2\sin\theta}{a}$$

ANS (D)

11)



for motion along y axis $y = ut + \frac{1}{2}at^2$

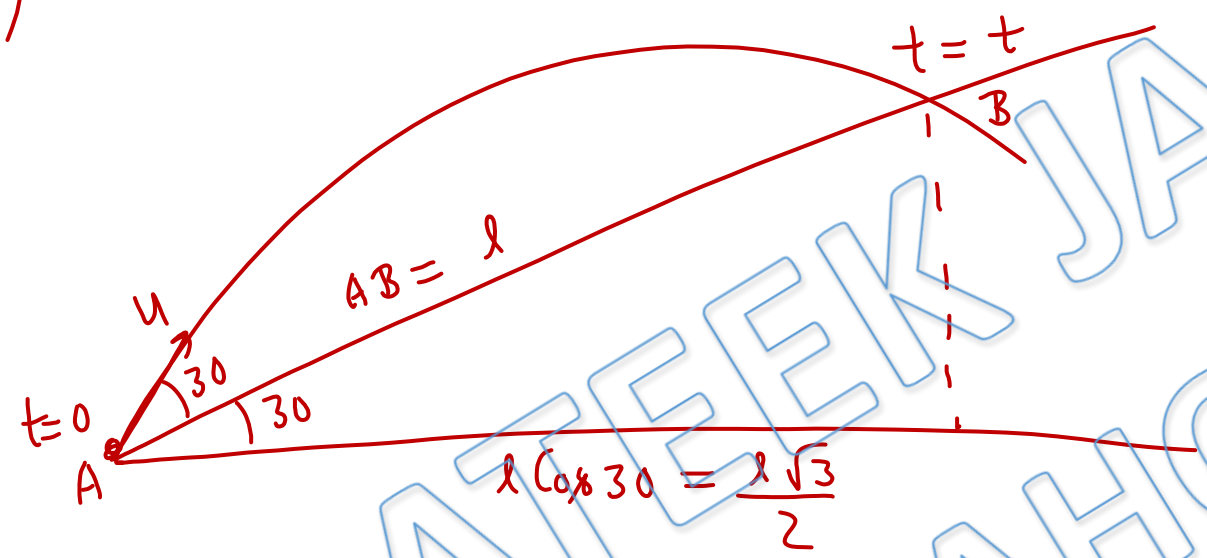
$\Rightarrow 8 = -6t + \frac{1}{2} \times 10 \times t^2$

$\Rightarrow 5t^2 - 6t - 8 = 0$

$\Rightarrow t = 2\,Sec$

ANs-(c)

12)



horizontal velocity of projectile = $u\cos 60 = u/2$

for horizontal motion

$$\Delta x = u_x t$$

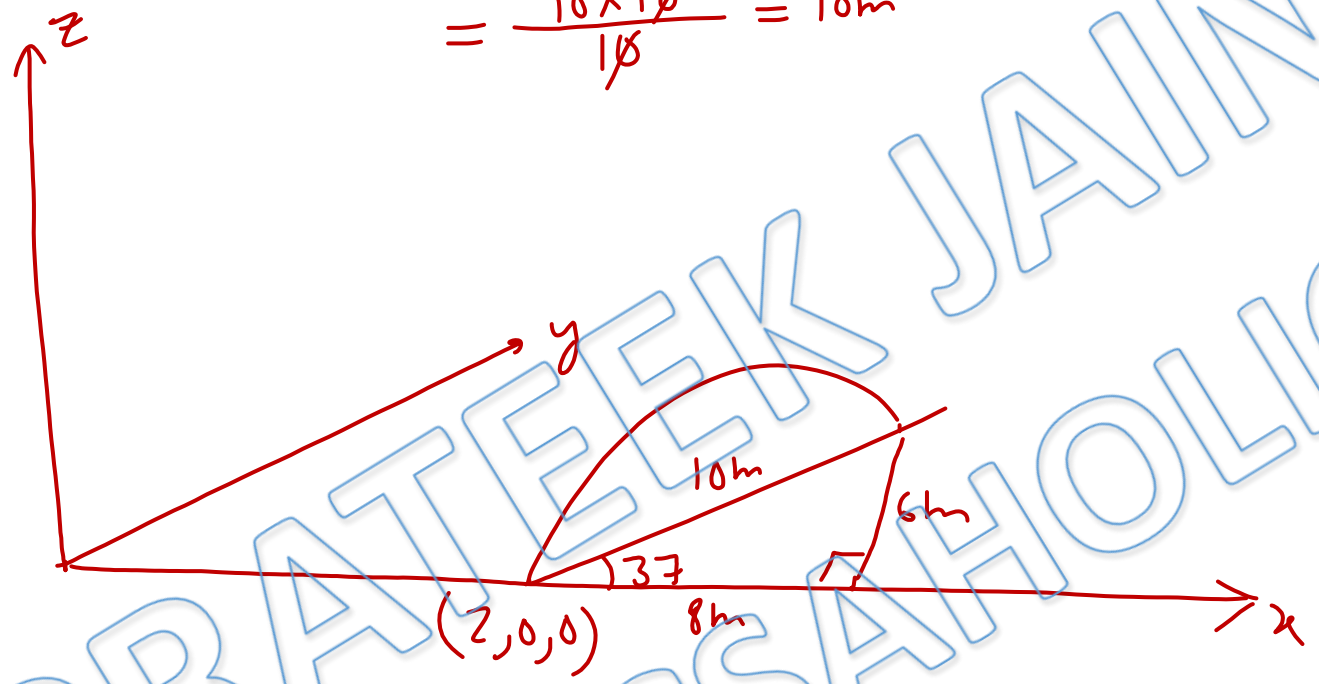
$$\frac{l\sqrt{3}}{2} = \frac{u}{2} t \Rightarrow l = \frac{ut}{\sqrt{3}}$$

ANS (A)

13)

Range of projectile

$= \frac{10 \times 10}{10} = 10m$



Striking point of projectile = (10, 6, 0)

Ans (A)

14) when both are in air

relative acceleration = 0 $\Rightarrow$ relative velocity is Constant

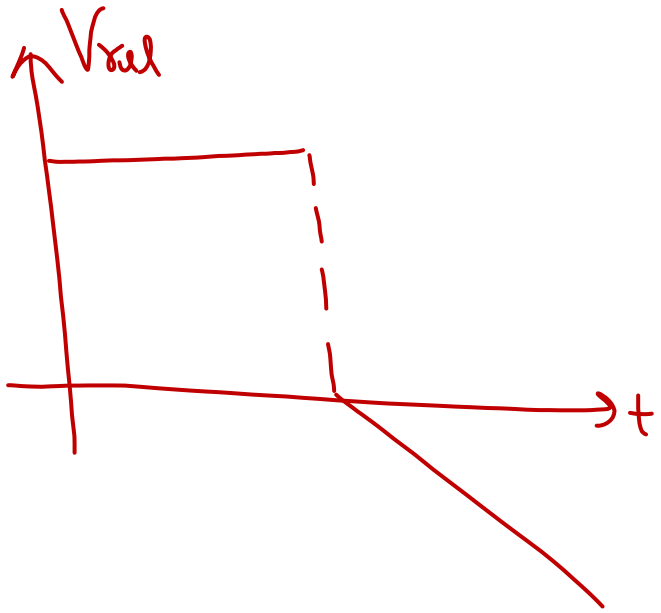
$\overrightarrow{u_{A,B}}$ = u_A in vertically upward direction (+ve)

when A will be at height h, B will be on ground

after that

relative acceleration = $g \downarrow = -g$

$\Rightarrow$ graph will be straight line with -ve slope



Ans (c)

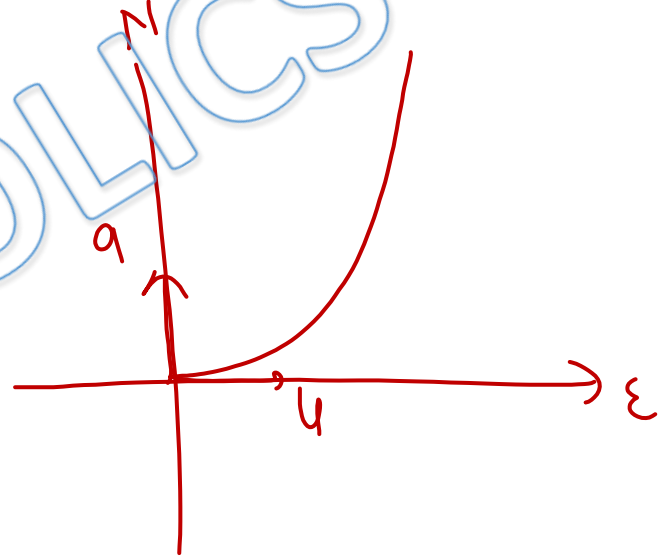
15)

Since $\vec{u}$ = Constant

& $\vec{F}$ i.e $\vec{a}$ is also Constant

& $\vec{u} \not\parallel \vec{a}$

$\Rightarrow$ Path will be parabolic



ANS-(C)

16) In first Case

$$R = \frac{2u_x u_y}{g}$$ where $u_x = V\cos 60 = V/2$

$u_y = V\sin 60° = \frac{V\sqrt{3}}{2}$

$\vec{V}_{b,g} = \vec{V}_{b,p} + \vec{V}_{p,g}$ =

$u_x = V + V\cos 60 = 3V/2$

$u_y = V\sin 60 = \frac{V\sqrt{3}}{2}$

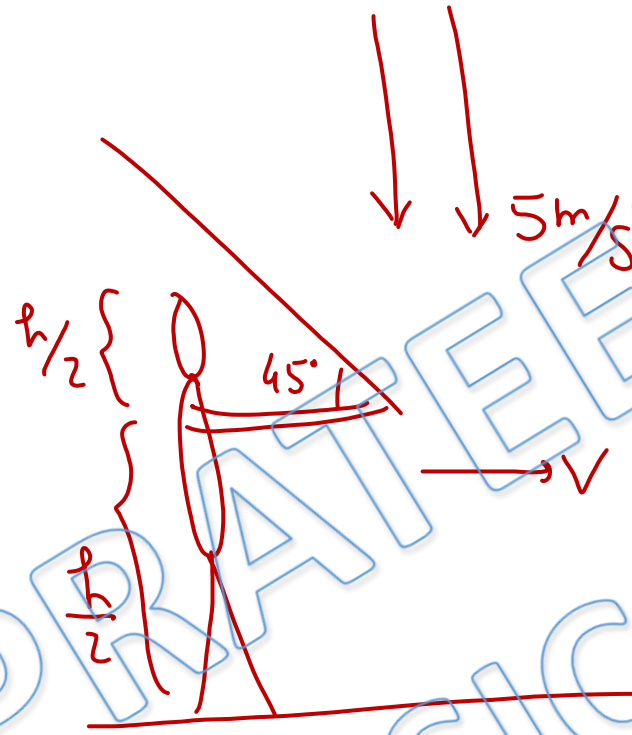
In Second Case

$$R' = \frac{2u_x u_y}{g}$$ where

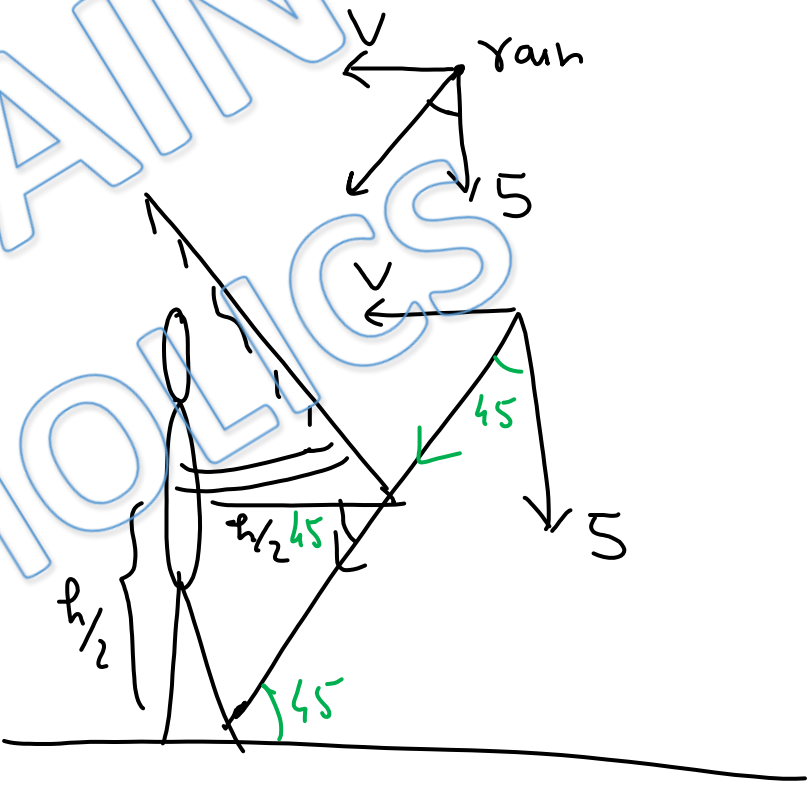
$\Rightarrow R' = 3R$

ANS-(D)

17)



w.r.t man

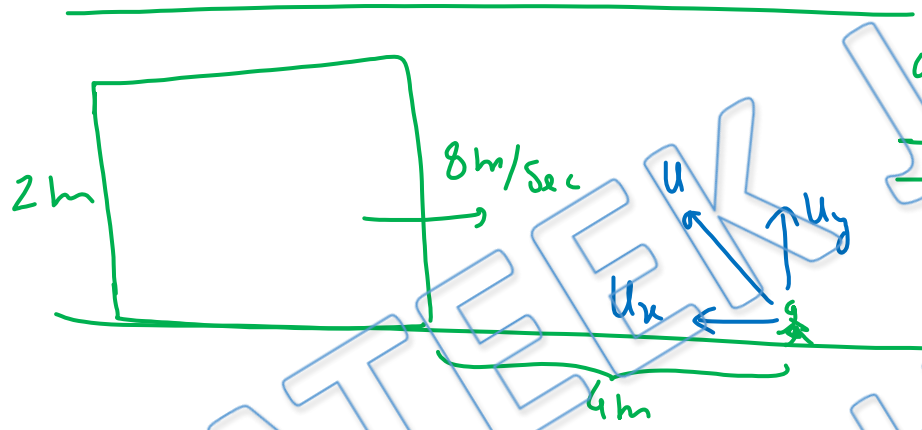


$\tan 45 = V/5$

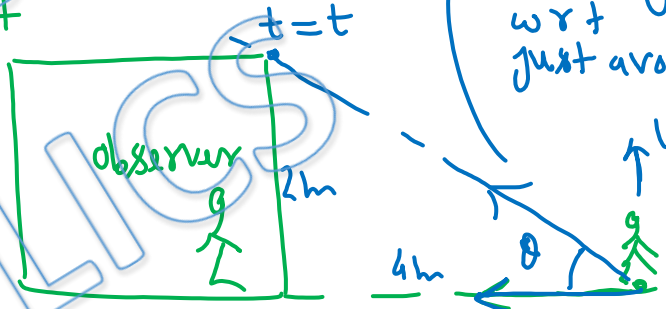
$\Rightarrow V = 5\,m/sec$

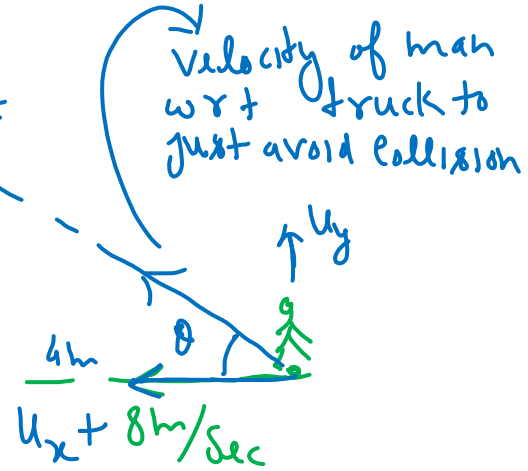
ANS (A)

18)



w.r.t truck





$$u^2 = u_x^2 + u_y^2 = u_y^2 + (2u_y - 8)^2$$

for minimum u, $\frac{d(u^2)}{du_y} = 0$

$$\Rightarrow 2u_y + 2(2u_y - 8) \times 2 = 0$$

$$\Rightarrow 5u_y = 16$$

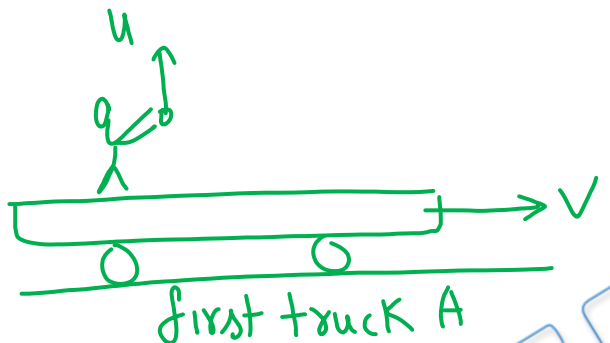
$$u_y = 16/5 \Rightarrow u^2 = \left(\frac{16}{5}\right)^2 + \left(\frac{32}{5} - 8\right)^2 \Rightarrow u = \frac{8}{5}\sqrt{5} = 16\sqrt{5}\ \text{m/sec}$$

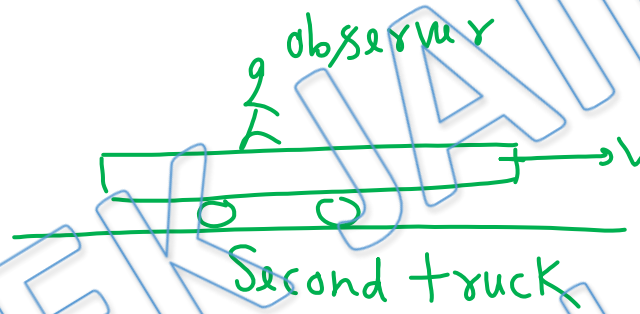
$$\tan\theta = \frac{u_y}{u_x + 8} = \frac{2}{4} = \frac{1}{2}$$

$$\Rightarrow u_x + 8 = 2u_y \text{ ---- (1)}$$

ANS (A)

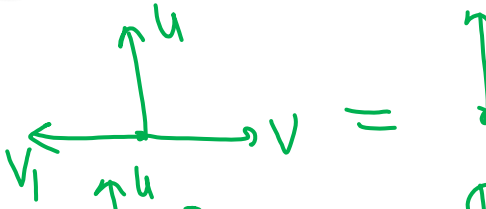
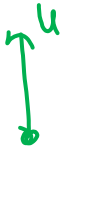
19)

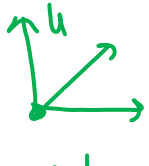


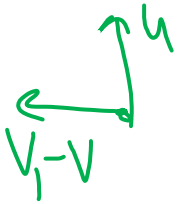


$\vec{u}_{ball,g} = \vec{u}_{ball,A} + \vec{u}_{A,g}$ =  ⇒ Path is parabola

w.r.t Second truck →

If $V_1 = V$ ⇒ Initial velocity of ball =  =  ⇒ straight line path

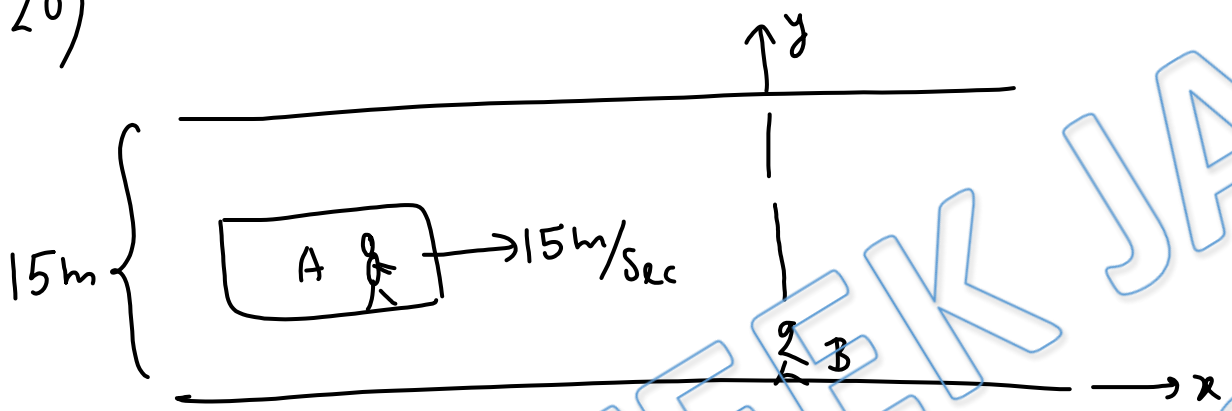
If $V_1 < V$ ⇒ " " " =  ⇒ Parabolic Path

If $V_1 > V$ ⇒ " " " =  ⇒ Parabolic path

ANS (C)

$V_A = 54\ Km/hr = 15\ m/Sec$

20)



$$\overrightarrow{V_{B,A}} = \frac{15}{3}\hat{j} = 5\hat{j}$$

$$\overrightarrow{V_{A,g}} = 15\hat{i}$$

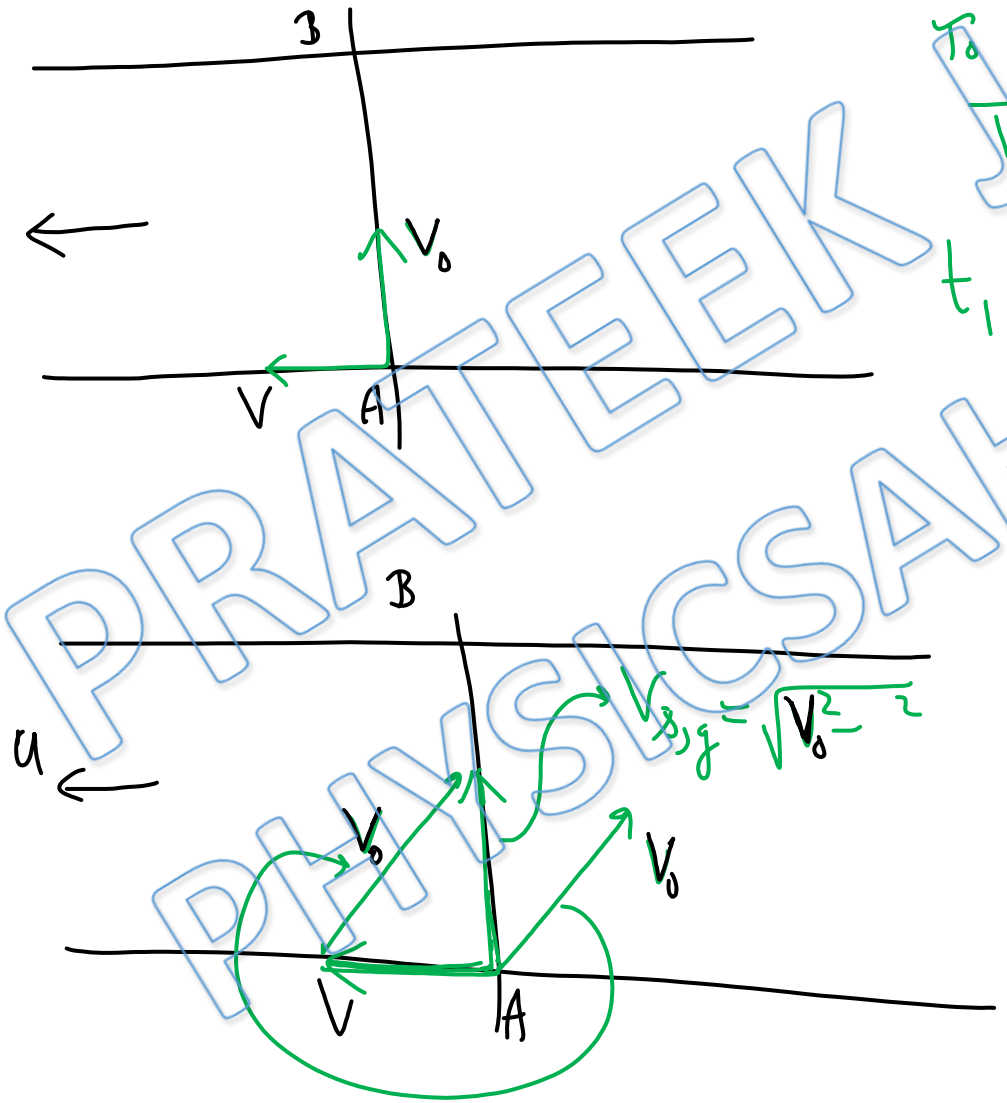
$$\overrightarrow{V_{B,g}} = \overrightarrow{V_{B,A}} + \overrightarrow{V_{A,g}} = 5\hat{j} + 15\hat{i} =$$

$$\left|\overrightarrow{V_{B,g}}\right| = \sqrt{5^2 + 15^2} = 5\sqrt{10}\ m/Sec$$

ANS (B)

$\vec{V_0}$ → velocity of swimmer in still water, d → width of river

21)



To cross in shortest time $\vec{V}$ should be along AB

$$t_1 = t_{min} = \frac{d}{V_0}$$

$$t_2 = \frac{d}{\sqrt{V_0^2 - V^2}}$$

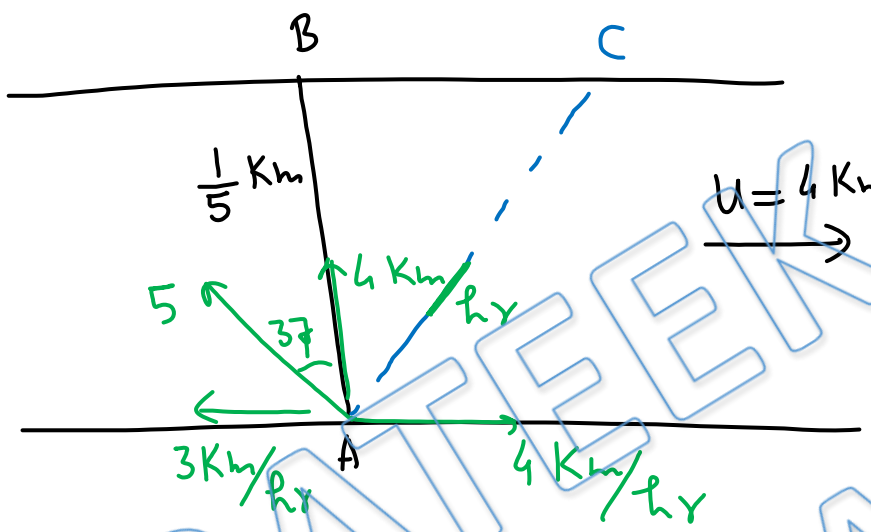
$$\frac{t_1}{t_2} = \frac{\sqrt{V_0^2 - V^2}}{V_0} = \frac{1}{2} \Rightarrow 1 - \frac{V^2}{V_0^2} = \frac{1}{4}$$

$$\Rightarrow \frac{V_0}{V} = \frac{2}{\sqrt{3}}$$

Ans(c)

22)

$V_{s,f} = 5$ Km/hr



time of swimming

$$T = \frac{1/5}{4} = \frac{1}{20} \text{ hr} = 3 \text{ minute}$$

$$BC = (4-3) \times \frac{1}{20} = \frac{1}{20} \text{ Km}$$

$$\text{walking time} = \frac{1/20}{3} = \frac{1}{60} \text{ hr}$$

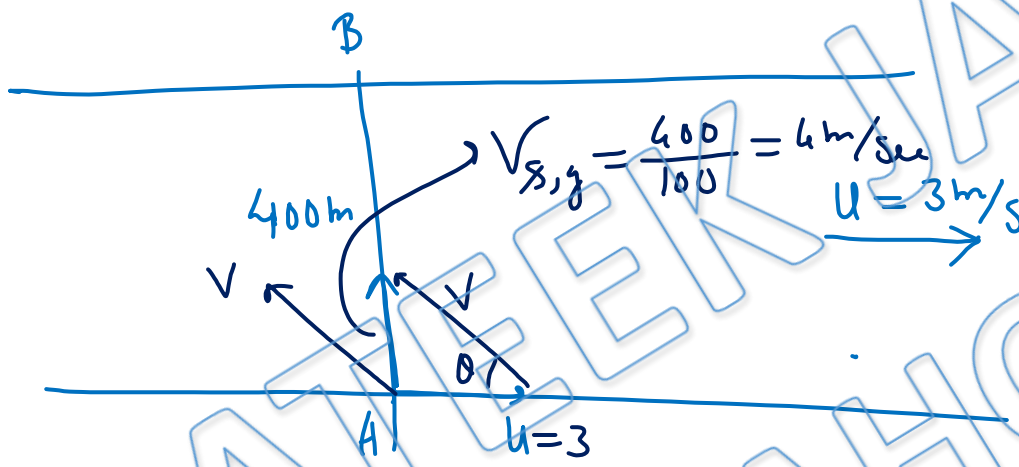
$$= 1 \text{ minute}$$

Total time = 4 minute

ANS (B)

23)

$V \rightarrow$ velocity of swimmer w.r.t flow



$\tan\theta = 4/3 \Rightarrow \theta = 53$

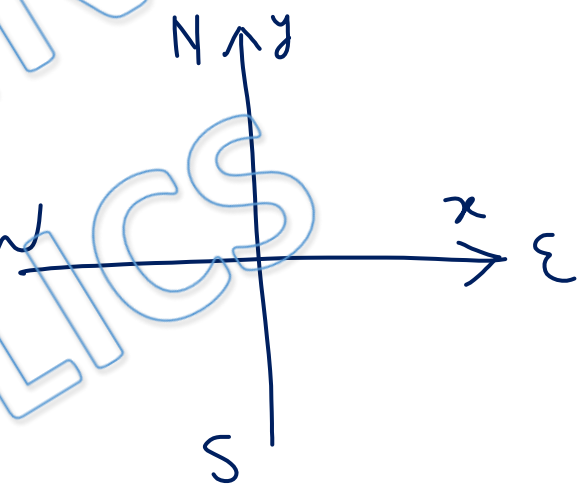
angle of $\vec{V}$ with flow velocity $= 127^\circ$

ANS (B)

24) $\overrightarrow{V_{b,f}} = 4\hat{i}$

$\overrightarrow{V_{f,g}} = 2\hat{j}$

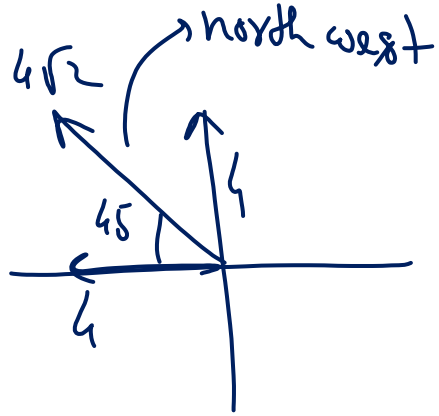
$\overrightarrow{V_{w,g}} = 6\hat{j}$



Direction of flag $\parallel \overrightarrow{V_{w,boat}}$

$$\overrightarrow{V_{w,b}} = \overrightarrow{V_{w,g}} - \overrightarrow{V_{b,g}} = \overrightarrow{V_{w,g}} - \left(\overrightarrow{V_{b,g}} + \overrightarrow{V_{f,g}}\right)$$

$$= 6\hat{j} - (4\hat{i} + 2\hat{j}) = 4\hat{j} - 4\hat{i}$$



ANS (A)

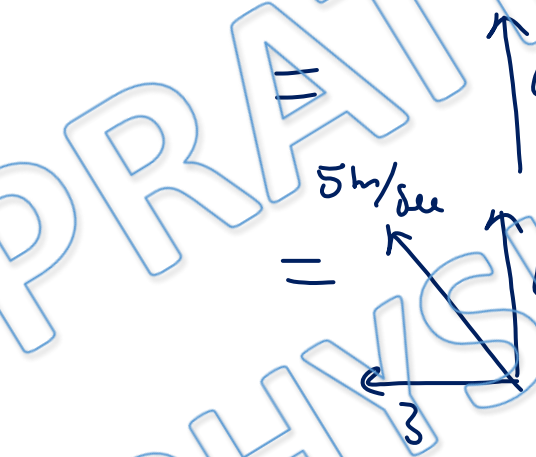
25)

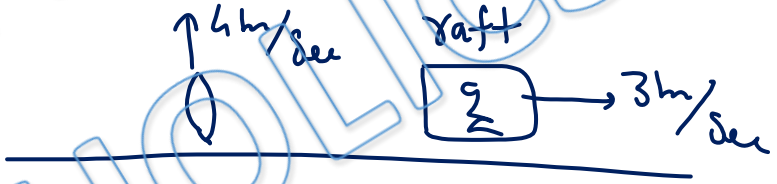
$$V_{b,g} = \frac{800}{200} = 4\,m/sec$$

$$\vec{V}_{b,raft} = \vec{V}_b - \vec{V}_{raft}$$

$$= \vec{4} - \vec{3}$$

$$= \vec{5}$$





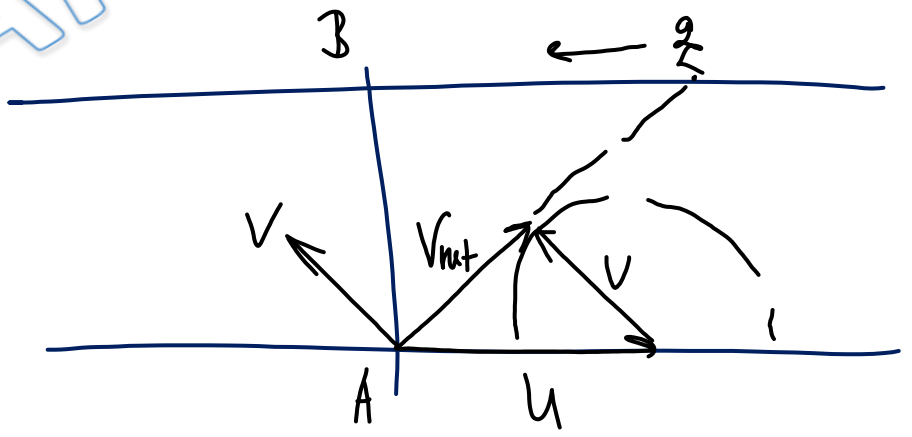
$$\delta = vt$$

$$= 5 \times 200 = 1000\,m$$

ANS (B)

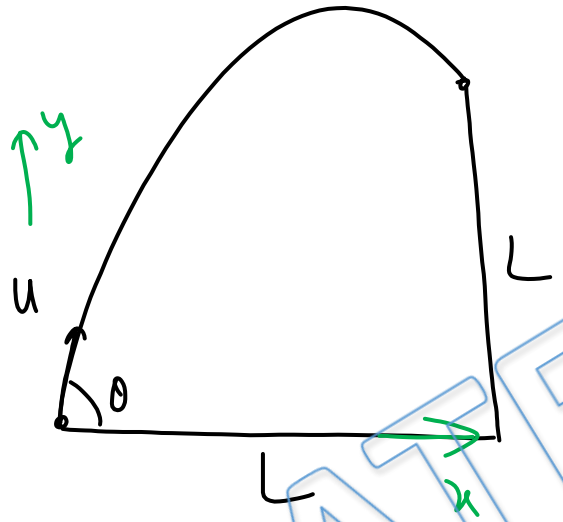
26) Since $V < u \Rightarrow$ man can not swim (w.r.t ground) to just opposite point

To minimize distance he should try to minimize drift & walk Dift distance to reach just opposite point



Ans (c)

27)



Equation of trajectory

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

at $x = L, y = L$

$$L = L\tan\theta - \frac{gL^2}{2u^2\cos^2\theta}$$

$$\frac{gL}{2u^2\cos^2\theta} = \tan\theta - 1$$

$$u = \left[\frac{gL}{2\cos^2\theta(\tan\theta - 1)}\right]^{1/2} = \frac{1}{\cos\theta}\left[\frac{gL}{2(\tan\theta - 1)}\right]$$

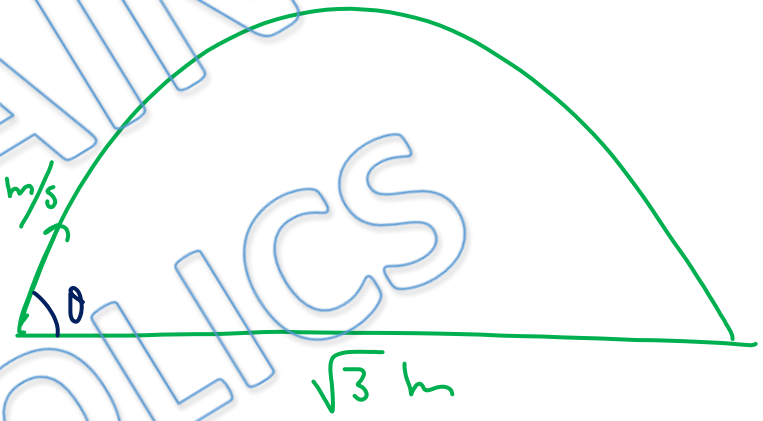
ANS (B)

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

$\sqrt{3} = \frac{20 \sin 2\theta}{g}$

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

$\Rightarrow 2\theta = 60, 120^\circ \Rightarrow \theta = 30, 60 \Rightarrow$



min velocity during motion

$u\cos\theta = \sqrt{20}\cos 30, \sqrt{20}\cos 60$

$= \sqrt{15}, \sqrt{5}$

for maximum Height

$H_{max} = \frac{u^2 \sin^2\theta}{2g} = \frac{20 \times 3/4}{2 \times 10} = 3/4$ m or $H_{max} = \frac{20 \times 1/4}{2 \times 10} = 1/4$ m

$T = \frac{2u\sin 30}{g}, \frac{2u\sin 60}{g} = \frac{2\sqrt{20} \times 1/2}{10}, \frac{2\sqrt{20} \times \sqrt{3}/2}{10}$

$= \sqrt{\frac{20}{100}}, \sqrt{\frac{60}{100}} = \frac{1}{\sqrt{5}}, \sqrt{\frac{3}{5}}$

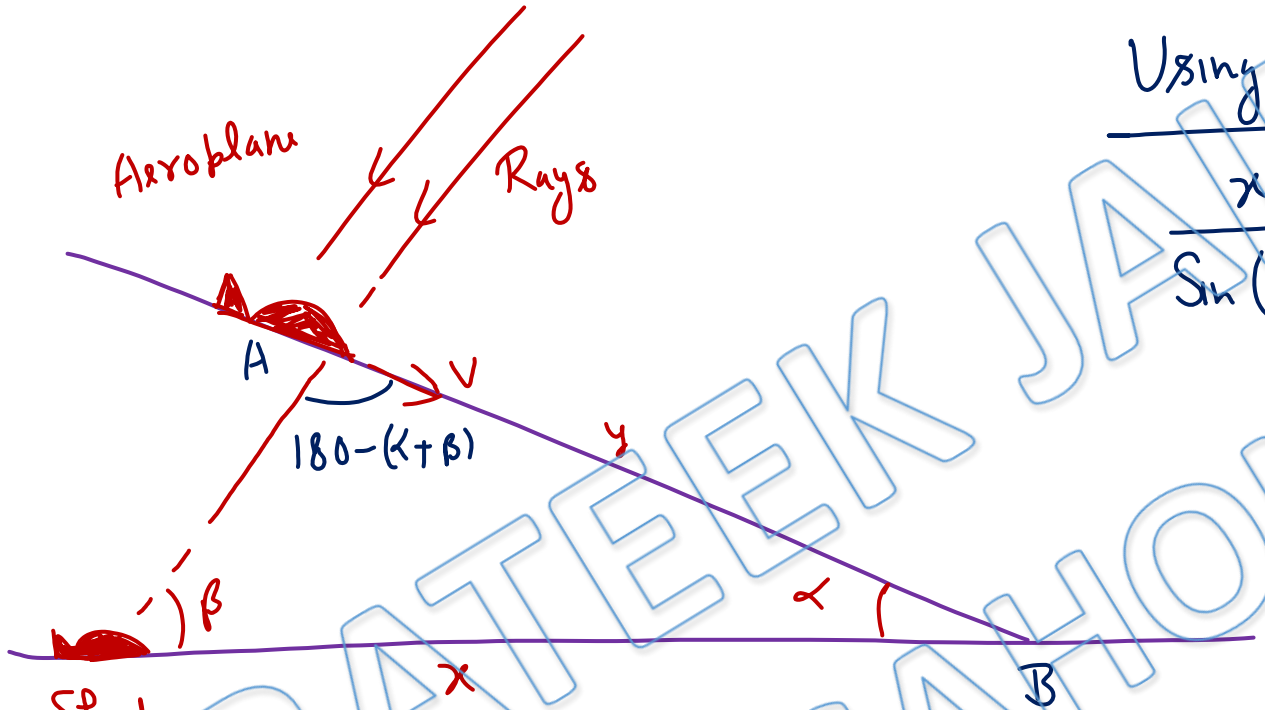
Minimum Kinetic Energy $= \frac{1}{2} m v_{min}^2$

$= \frac{1}{2} \times 1 \times 15$, $\frac{1}{2} \times 1 \times 5$

$= \frac{15}{2}$ J , $\frac{5}{2}$ J

ONLY D IS INCORRECT

29)



Using Sine Rule in $\triangle ABC$

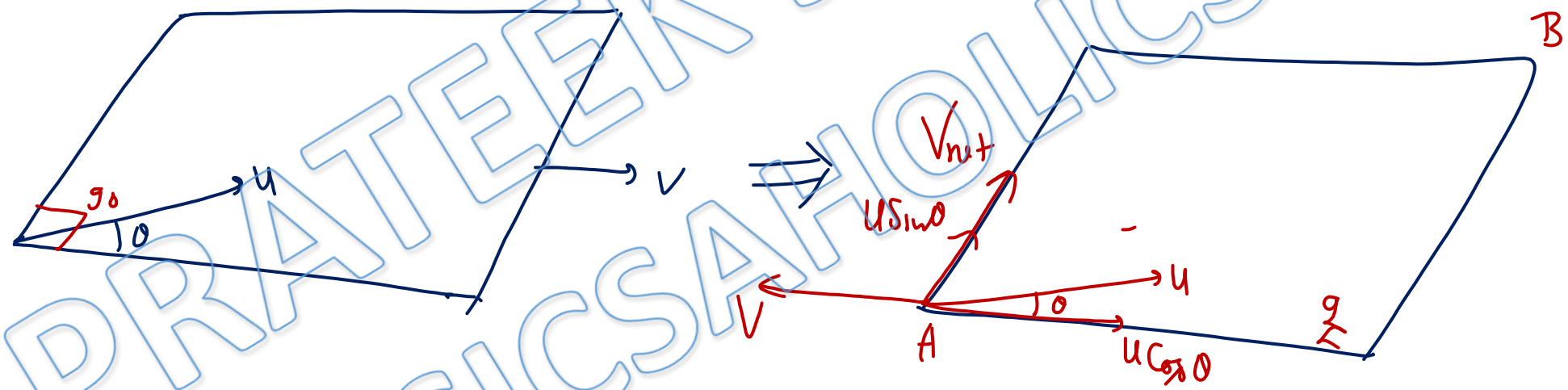
$$\frac{x}{\sin(180-(\alpha+\beta))} = \frac{y}{\sin\beta}$$

$$\frac{dx}{dt} = \frac{\sin(\alpha+\beta)}{\sin\beta}\,\frac{dy}{dt}$$

$$\Rightarrow V_{Shadow} = \frac{V\sin(\alpha+\beta)}{\sin\beta}$$

Ans (B)

30)



$$V = u\cos\theta$$

$$\Rightarrow \theta = \cos^{-1}\left(\frac{V}{u}\right)$$

ANS (B)

Chalo Niklo