YAKEEN NEET 2.0

2026

(One Shot)

Motion in a plane

Physics | Summary Lecture

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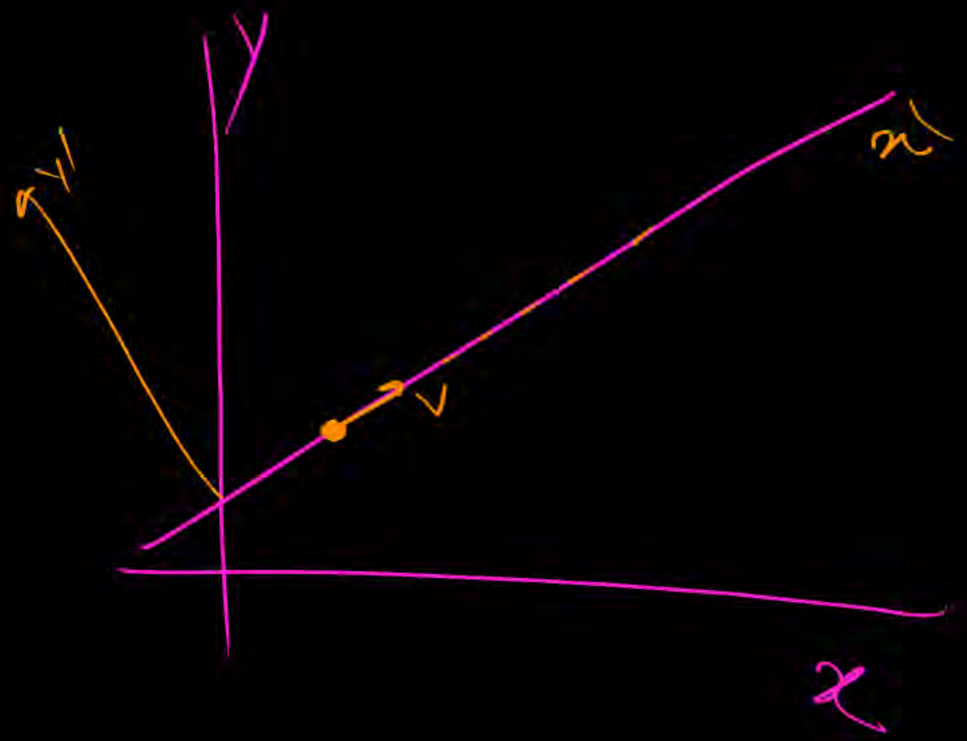
Summary Lecture

Motion in plane

Todays Goal

1. Equation of Trajectory ✓
2. Genral 2-D motion ✓
3. Equation of motion in 2-D. ✓
4. Projectile motion
5. Horizontal Projectile motion ✓
6. Projectile on Inclined*
7. Relative velocity in 1-D ✓
8. Relative velocity in 2-D ✓
9. River-man Prob^{m}
10. Condition of Collsion.
11. Rain Man Prob^{m}



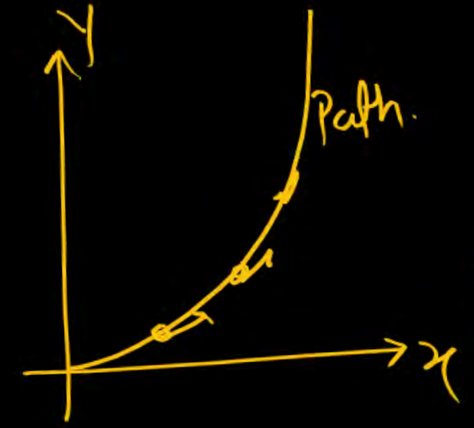
Projectile

2-D motion ✓

Equation of Trajectory → Relation between x- and y - Co-ordinate of motion

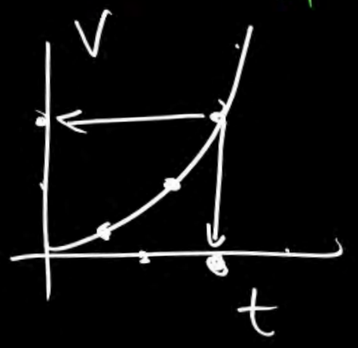
MR* Box → Graph b/w x and y represent Path, but v/t, x/t a/t graph does not represent Path of motion.

MR* Box
$x(t)$, $y(t)$, $v(t)$
$a(t)$, Kuch bhi given ho, time ko hata ke x & y ka relation Nikalo.
⇒ x/y ka relⁿ eqn of Trajectory hoga.



MR* Box
equation → Path
$y^1 = mx^1 + c$ → Straight line
$y = x^2$ → Parabola
$x^2 + y^2 = R^2$ → circular
$x^2/a^2 + y^2/b^2 = 1$ → elliptical path

(+)



① $x = 8\sin(t)$ -(i)
$y = 4\sin(t)$ -(ii)

(i)/(ii)

$\frac{x}{y} = \frac{8\sin(t)}{4\sin(t)}$

$\frac{x}{y} = 2$

$y = \frac{x}{2}$ straight line

② $x = 3t$
$y = 9t$

$\frac{x}{y} = \frac{3t}{9t}$ 3

$y = 3x$

1-D

③ $y = 3t^2$ -(i)
$x = 2t$ -(ii)

Puting value of 't' from eqn (ii) to (i)

$t = x/2$

Parabola

$y = 3\left(\frac{x}{2}\right)^2 = \frac{3x^2}{4}$

④ $x = 3\sin(t)$ -(i)
$y = 3\cos(t)$ -(ii)

(i)^2 + (ii)^2

$x^2 + y^2 = 9[\sin^2 t + \cos^2 t]$, $\sin^2 t + \cos^2 t = 1$

$x^2 + y^2 = 9$

circle

⑤ $x = 4\sin(t)$
$y = 5\cos(t)$

$\frac{x}{4} = \sin(t)$ -(i)

$\frac{y}{5} = \cos(t)$ -(ii)

$\frac{x^2}{16} + \frac{y^2}{25} = 1$

⑥ $\vec{r} = 2t\hat{i} + 4t^2\hat{j}$

$\vec{r} = x\hat{i} + y\hat{j}$

$x = 2t$ *

$y = 4t^2$ *

Parabol

⑦ $\vec{v} = 2\hat{i} + x\hat{j}$

$\vec{v} = v_x\hat{i} + v_y\hat{j}$

$v_x = 2$ $v_y = x$

$\frac{dx}{dt} = 2$ -(i) $\frac{dy}{dt} = x$ -(ii)

(ii)/(i) $\frac{dy}{dx} = \frac{x}{2}$

$$\frac{dy}{dx} = \frac{x}{2}$$

$$\int 2\,dy = \int x\,dx$$

$$2y = \frac{x^2}{2} + c$$

General 2-D Motion

$$\vec{r} = x\hat{i} + y\hat{j}$$

Position of object

Diff^n w.r.t. time

$$\frac{d\vec{r}}{dt} = \left(\frac{dx}{dt}\right)\hat{i} + \frac{dy}{dt}\hat{j}$$

$$\vec{v} = \vec{v}_x\hat{i} + \vec{v}_y\hat{j}$$

magnitude of velocity

speed $v = \sqrt{v_x^2 + v_y^2}$ ✓

Direction of motion.

$$\tan\theta = \frac{v_y}{v_x}$$ ✓

velocity in vector form

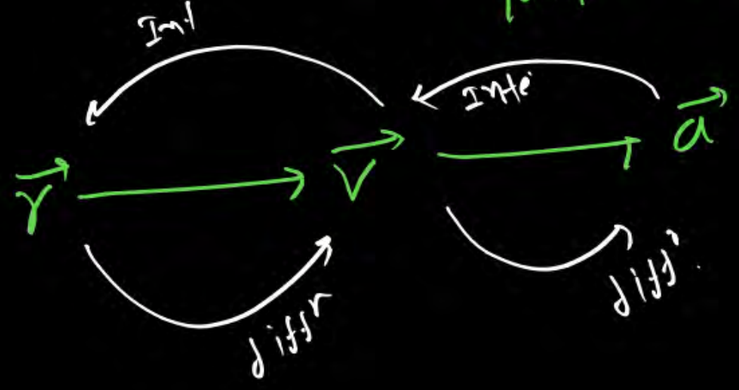
$$\vec{v} = v_x\hat{i} + v_y\hat{j}$$

Diff^n w.r.t. time

$$\frac{d\vec{v}}{dt} = \frac{d\vec{v}_x}{dt}\hat{i} + \frac{d\vec{v}_y}{dt}\hat{j}$$

$$\vec{a} = a_x\hat{i} + a_y\hat{j}$$ ✓

$$|\vec{a}| = \sqrt{a_x^2 + a_y^2}$$



$$2\text{-}D = [1\text{-}D]_x + [1\text{-}D]_y = 1\text{-}D \text{ motion with concept of vector}$$

$$\vec{a} = a_x \hat{i} + a_y \hat{j}$$

$$a_x = \frac{dv_x}{dt} \qquad a_y = \frac{dv_y}{dt}$$

$$\int_{u_x}^{v_x} dv_x = \int a_x\, dt \qquad dv_y = a_y\, dt$$

$$v_x - u_x = \int a_x\, dt \qquad v_y - u_y = \int a_y\, dt \quad *$$

$$\vec{v} = v_x \hat{i} + v_y \hat{j}$$

$$v_x = \frac{dx}{dt} \qquad v_y = \frac{dy}{dt}$$

Motion in plane with Constant acc^{n}. { Equation of motion }

x-axis

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

$$\vec{S}_x = \vec{u}_x t + \frac{1}{2}\vec{a}_x t^2$$

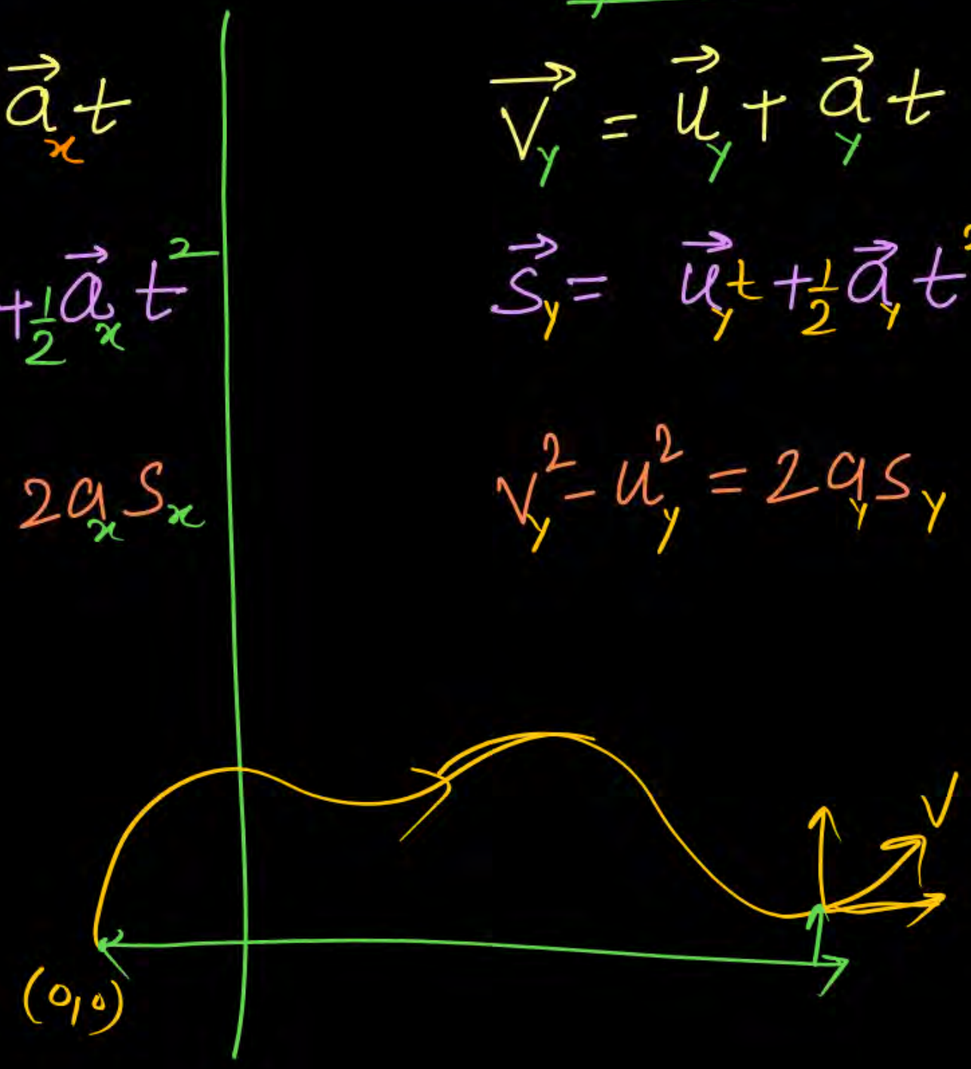
$$V_x^2 - u_x^2 = 2a_x S_x$$

y-axis

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

$$\vec{S}_y = \vec{u}_y t + \frac{1}{2}\vec{a}_y t^2$$

$$V_y^2 - u_y^2 = 2a_y S_y$$



MR* Box for 2-D motion

→ question se sare physical quantity ko x and y axis me seprate karo (component)

→ x and y me seprate equation of motion lagao

→ vector ke concept se vmko add karo

→ time dono axis me same hi hai

mR* Box

$\vec{a}_x = 0$ $\quad \vec{v}_x = \text{Cost}^n$

uniform motion in x axis

$\vec{a}_y \neq 0$ $\quad \vec{v}_y = \text{varible}$

Non-uniform Motion

$\vec{S}_x = x_f - x_i = u_x t$

disp^n in (x) $= S_x$

$\vec{S}_y = y_f - y_i = u_y t + \frac{1}{2} a_y t^2$

x ka kisi P.Q. ka effect y me nahi hoga

y ke kisi P.Q. ka effect x me nahi hoga

(Q) Position $\vec{r} = 3t^2\hat{i} + 2t\hat{j}$ find velocity and acceleration at $t = 2$ sec

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Soln

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

$$\frac{d\vec{r}}{dt} = v = 3(2t)\hat{i} + 2\hat{j}$$

$$\vec{v} = 6t\hat{i} + 2\hat{j}$$

$$\vec{v}_{(t=2)} = 12\hat{i} + 2\hat{j} \longrightarrow \text{speed} = \sqrt{(12)^2 + (2)^2}$$ ✓

diff^n w.r.t. time

$$\frac{d\vec{v}}{dt} = \vec{a} = 6\hat{i} + 0$$

$\vec{a} = 6\hat{i}$ ↓ = Const^n

(Q) Initial velocity of object $\vec{v} = 3\hat{i} + 4\hat{j}$ and $\vec{a} = 0.4\hat{i} + 0.3\hat{j}$ then find velocity after $t = 10$ sec

$$\vec{v}_x = u_x + a_x t$$

$$= 3 + 0.4 \times 10$$

$$\# \ \vec{v}_x = (3+4)\hat{i} = 7\hat{i}$$

$$v_y = u_y + a_y t$$

$$v_y = 4 + 0.3 \times 10$$

$$\# \ v_y = 4 + 3 = 7\hat{j}$$ ✓

(Q) $\vec{u}_{t=0} = 2\hat{i}$ & $\vec{a} = 3\hat{j}$ find disp^n in 2-sec.

$u_x = 2\,m/s\,\hat{i}$ | $u_y = 0$

$a_x = 0$ | $a_y = 3$

$\Delta x = u_x t$

$= 2 \times 2$

$\Delta x = 4m$

$\Delta x = 4m$

$\Delta y = u_y t + \frac{1}{2} a_y t^2$

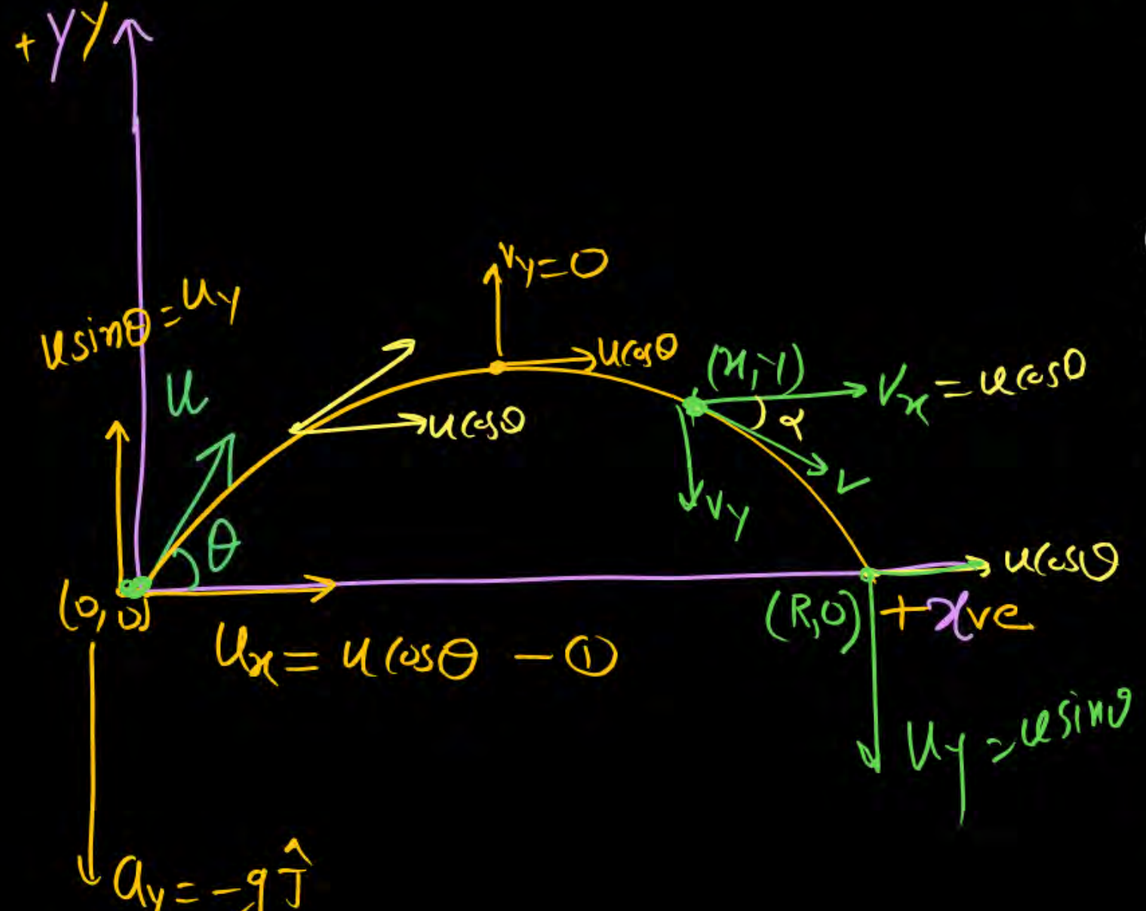
$= 0 + \frac{1}{2} 3 (2)^2$

$y = \frac{1}{2} 3 \times 4^2$

$\Delta y = 6j$

$dis = 4i + 6\hat{j}$

Projectile motion : 2D Non uniform motion [variable velocity] with uniform acceleration. ($a_y = g$ downward)



	Physical Quantity	x-axis	y-axis	Net
①	initial velocity	$\vec{u}_x = u\cos\theta\, i$	$\vec{u}_y = u\sin\theta\, \hat{j}$	$\vec{v} = u_x \hat{i} + u_y \hat{j}$
②	acc^n	$\vec{a}_x = 0$	$\vec{a}_y = -g\hat{j}$	$\vec{a} = -g\hat{j}$
③	velocity at time 't'	$\vec{v}_x = u\cos\theta\hat{i}$ (cosn)	$\vec{v}_y = \vec{u}_y - gt\hat{j}$	$\vec{v} = u_x\hat{i} + (u_y - gt)\hat{j}$
④	Disp^m at 't'	$x = u_x t$	$y = \vec{u}_y t - \frac{1}{2}gt^2$	$\vec{r} = x\hat{i} + y\hat{j}$
⑤	velocity at max^m height	$u_x = u\cos\theta$	$v_y = 0$	$\vec{v}_{at\ max} = u_x\hat{i}$
⑥	Velocity of collision at gm	$\vec{u}_x = u\cos\theta$	$\vec{v}_y = -u_y\hat{j}$	$\vec{v} = u_x\hat{i} - u_y\hat{j}$
⑦	eqn of Traject^y	$y = u_y t - \frac{1}{2}gt^2 =$		

$$\therefore y = u_y\frac{x}{u_x} - \frac{1}{2}g\left(\frac{x}{u_x}\right)^2$$ Parabolic

① Velocity of maximum height :- $u_x = u\cos\theta\,\hat{i}$ ✓

② Velocity of collision :- $\vec{V_c} = u\cos\theta\,\hat{i} - u\sin\theta\,\hat{j}$ ✓ (at ground)

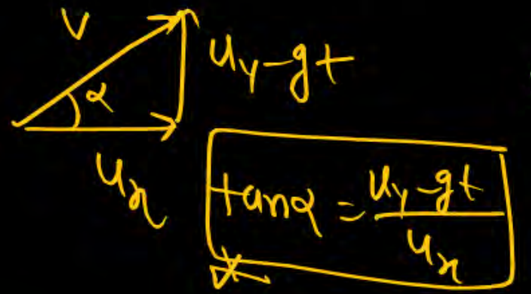
③ change in velocity in compt motion :- $\vec{V_f} - \vec{V_i} = (u\cos\theta\,i - u\sin\theta)\hat{j} - (u\cos\theta\,i + u\sin\theta\,\hat{j})$

$= -2u\sin\theta\,\hat{j}$ ✓✓

④ Average velocity in compt motion :→ $\boxed{\vec{V}_{Ay} = \frac{\vec{u_i} + \vec{V_f}}{2}}$

$= \frac{2u\cos\theta}{2} = u\cos\theta = \boxed{\frac{R}{T_f}}$

⑤ velocity at time 't' $\vec{V} = u_x\hat{i} + (u_y - gt)\hat{j}$



$\tan\alpha = \frac{u_y - gt}{u_x}$

$\tan\theta = \frac{u_y}{u_x}$ at $t=0$

Angle of Projn

⑥ Angle OF Projection

⑦ Direction of motion at time 't'

⑧ Time of flight

$$T_f = \frac{2u_y}{g} = \frac{2u\sin\theta}{g}$$

feel of motion under gravity

⑨ Maximum Height

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

Consider motn in y-axis

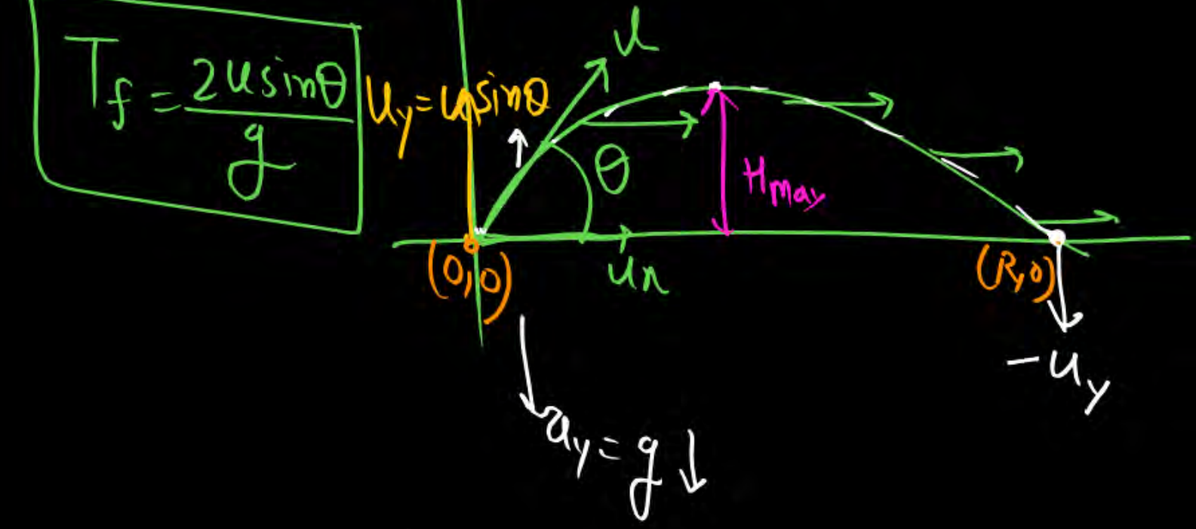
$$y = u_y t - \frac{1}{2}a_y t^2$$

$$0 = u_y t - \frac{1}{2}g t^2$$

$$u_y t = \frac{1}{2}g t^2$$

$$t = \frac{2u_y}{g}$$ Time of flight.

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



(10) Horizontal Range $R_{Req} = u_x T_f = u_x \times \left[\frac{2u_y}{g}\right] = \frac{2u_x u_y}{g}$

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

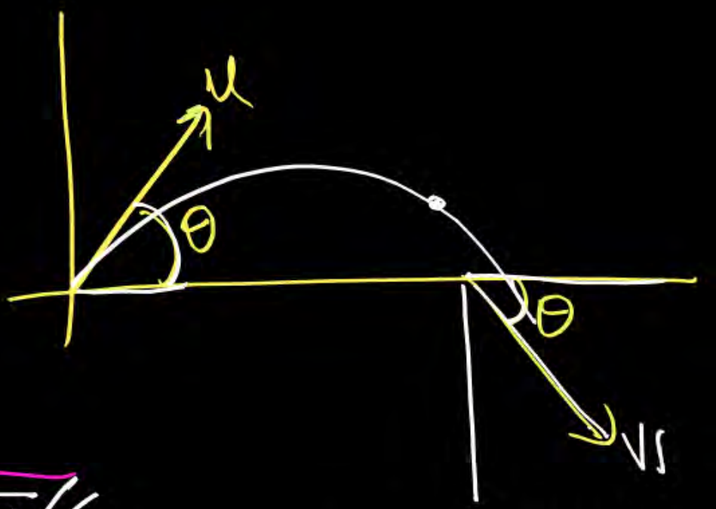
(11) Time when velocity is ⊥r to intial velocity of Projection

↳ only Possible ($\theta \geq$ Angle of Projection.)

$\vec{u} = u_x \hat{i} + u_y \hat{j}$

$\vec{v} = u_x \hat{i} + (u_y - gt)\hat{j}$

$\vec{v} \perp_r \vec{u}$ $\quad \boxed{\vec{v} \cdot \vec{u} = 0}$



(12) equation of Trajectory

$x = u_x t$

$y = u_y t - \frac{1}{2} g t^2$

$y = u_y \frac{x}{u_x} - \frac{1}{2} g \left(\frac{x}{u_x}\right)^2$

$$\# \quad \boxed{y = x \tan\theta - \frac{1}{2} g \frac{x^2}{u^2 \cos^2\theta}}$$

$$\boxed{t = \frac{u}{g \sin\theta}} \quad A_f$$

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

(Q) $y = \sqrt{3}x - 4x^2$

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

$\tan\theta = \sqrt{3} \Rightarrow \theta = 60°$

(13) Relation between H and R

$$\left[\begin{array}{l} H = \frac{u_y^2}{2g} \\ R = \frac{2u_x u_y}{g} \end{array}\right]$$

$$\frac{H}{R} = \frac{\frac{u_y^2}{2g}}{\frac{2u_x u_y}{g}} = \frac{u_y}{4u_x} = \frac{\tan\theta}{4}$$

$$\boxed{H = \frac{R\tan\theta}{4}} \quad *$$

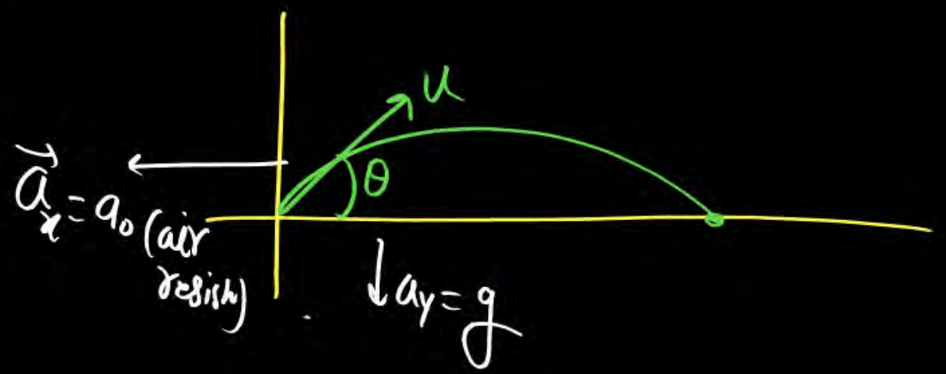
(14) Condition of maximum Range :-

$$R_{max} = \frac{u^2 \sin(2\theta)_{max}}{g} = \frac{u^2}{g}$$

$\sin(2\theta)_{max} = 1$

$2\theta = 90$ $\boxed{\theta = 45^\circ}$

(15) if air Resistance in x-axis only



$T_f = \frac{2u_y}{g}$ (same)

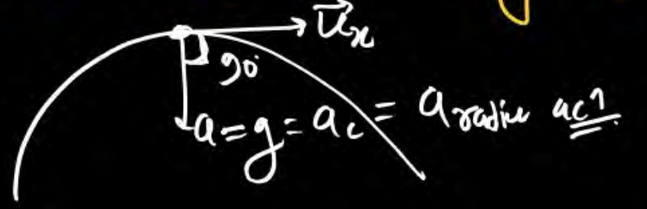
$H_{max} = \frac{u_y^2}{2g}$ (same)

R → change

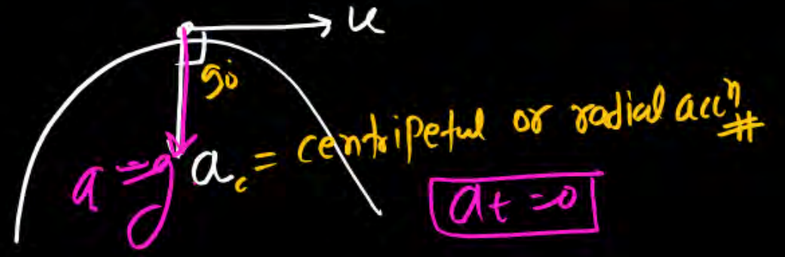
$$R = u_x t + \frac{1}{2} a_{avg} t^2$$

(16) Angle b/w acc^n & velocity at maximum Height

$\theta = 90°$ *



(17) Tangential and centripetal acc^n at maximum Height

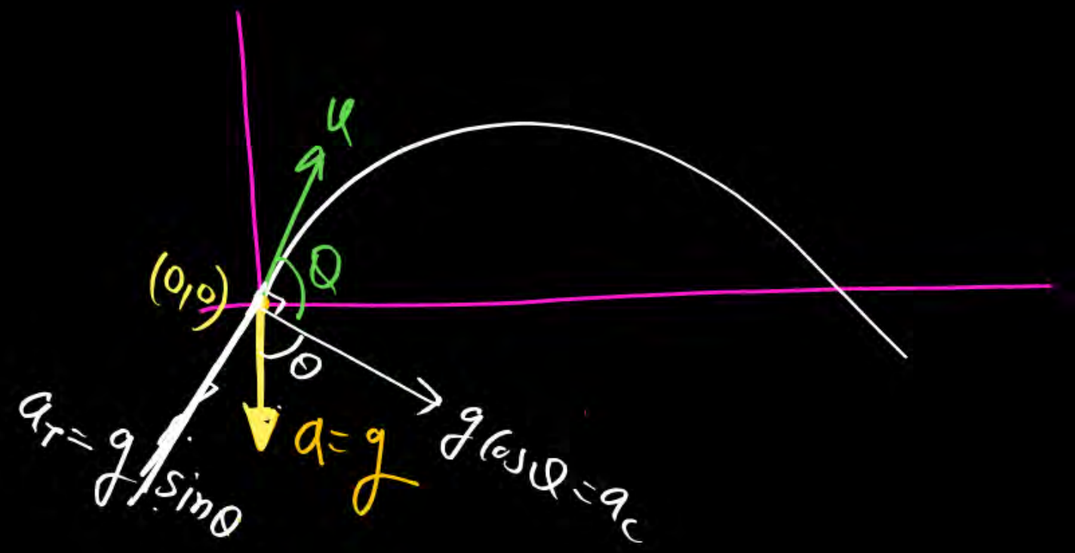


(18) complementry Angle :-

Object is Projected with same speed at two diff^n angle α & β but Range are same.

$\alpha + \beta = 90°$

$\alpha = 30$ / $\beta = 60$



(19) Ball is projected with **same speed** at α and β such that Range are same then :-

$$\frac{H_1}{H_2} = \frac{\frac{u^2\sin^2\alpha}{2g}}{\frac{u^2\sin^2\beta}{2g}}$$

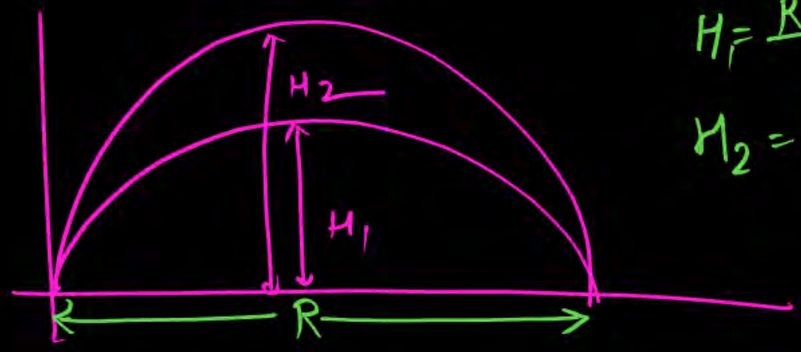
$$\frac{H_1}{H_2} = \frac{\sin^2\alpha}{\sin^2\beta} \qquad \boxed{\alpha+\beta=90}$$

IIT Adv 2016

$$\boxed{\frac{H_1}{H_2} = \tan^2\alpha}$$

$$\frac{T_1}{T_2} = \frac{\frac{2u\sin\alpha}{g}}{\frac{2u\sin\beta}{g}} = \frac{\sin\alpha}{\sin(90-\alpha)}$$ tend:

$(\beta = 90-\alpha)$



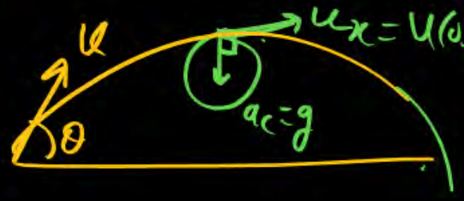
$$H_1 = \frac{R\tan\alpha}{4}$$

$$H_2 = \frac{R\tan\beta}{4}$$

$$H_1H_2 = \frac{R^2\tan\alpha\tan\beta}{16}$$

$$\boxed{\frac{R^2}{16} = H_1H_2} \quad \text{proved}$$

(20) Radius of curvature at maximum Height :-



$$a_c = \frac{v^2}{R}$$

$$\boxed{R_{max} = \frac{u^2}{a_c} = \frac{u^2\cos^2\theta}{g}}$$

(21) Rate of change in velocity V at time t

$$\vec{a} = g \text{ (downward)}$$

(22) Rate of Chage in moment

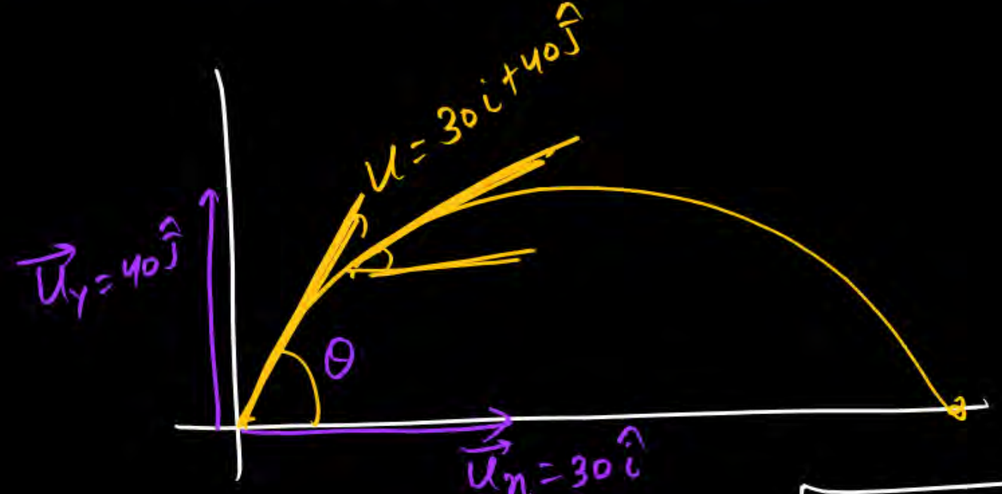
$$\vec{F}_{orce} = \frac{dP}{dt} = mg \text{ (downw)}$$

Object is Projected at $\vec{u} = 30\hat{i} + 40\hat{j}$ then find :-

① Angle of Projection

$$\tan\theta = \frac{u_y}{u_x} = \frac{40}{30} = \frac{4}{3}$$

$$\boxed{\theta = 53^\circ}$$



② $T_f = \frac{2u_y}{g} = \frac{2 \times 40}{10} = 8\,\text{sec}$

③ $H_{max} = \frac{u_y^2}{2g} = \frac{(40)^2}{2\times 10} = \frac{40 \times 40}{2 \times 10} = 80\,\text{m}$

④ $R_{ay} = u_x T_f = 30 \times 8 = 240\,\text{m}$

⑤ Velocity at Max^n Height $= u_x = 30\,\text{m/s}$

⑨ $t = \frac{u}{g\sin\theta}$ ⇒ time whe velocity

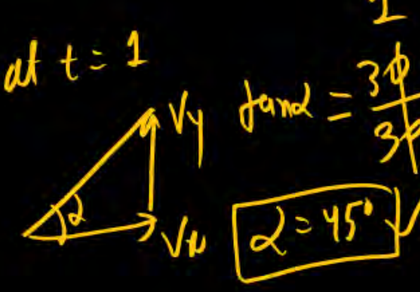
⑥ velocity at time $\boxed{t = 1\,\text{sec}}$

$\vec{u}_x = 30\,\text{m/s}\,\hat{i}$

$\vec{V}_y = 40 - 10\times 1 = 40 - 10 = 30\hat{j}$

$\vec{V} = 30\hat{i} + 30\hat{j}$

④ dirn of motion at $t = 1$



$\tan\alpha = \frac{30}{30} = \frac{1}{1}$

$\boxed{\alpha = 45^\circ}$

H/ω

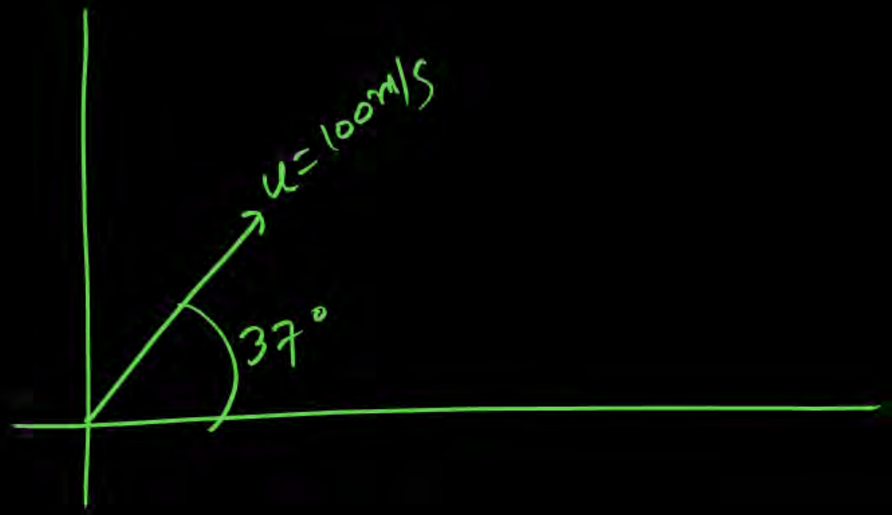
(I) T_f

(II) R_r

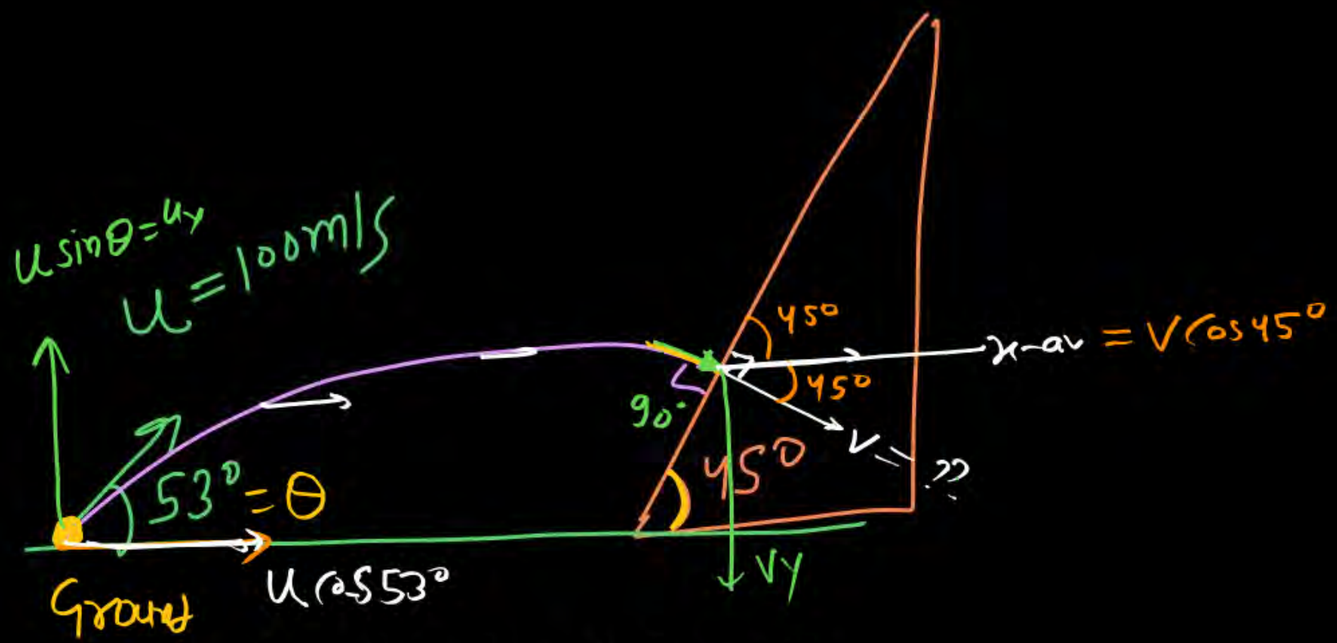
(III) H_{max}

(IV) velocity at $t = 1$ sec.

(VII) velocity at $t = 4$ sec



find velocity of collision & Time of collision ??



$100\cos 53^\circ = V\cos 45^\circ$

$\cancel{100}^{20} \times \frac{3}{5} = V \times \frac{1}{\sqrt{2}}$

$60\sqrt{2} = V$ Ans

$\cos 53^\circ = \frac{3}{5}$

at $t=0$ $u_y = u\sin 53^\circ = \cancel{100}^{20} \times \frac{4}{\cancel{5}} = 80\ m/s\ \hat{j}$

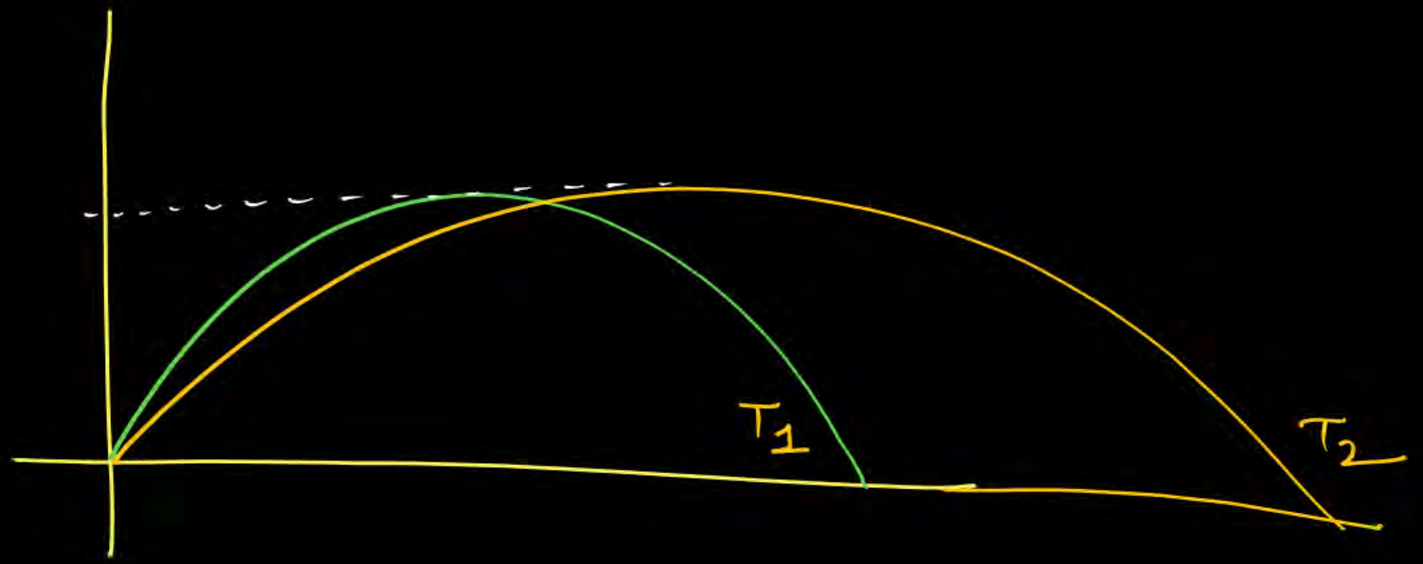
$V_y = V\sin 45^\circ = 60\sqrt{2} \times \frac{1}{\sqrt{2}} = -60\hat{j}$

$\vec{v} = \vec{u} + at$

$-60 = 80 - 10t$

$140 = 10t$

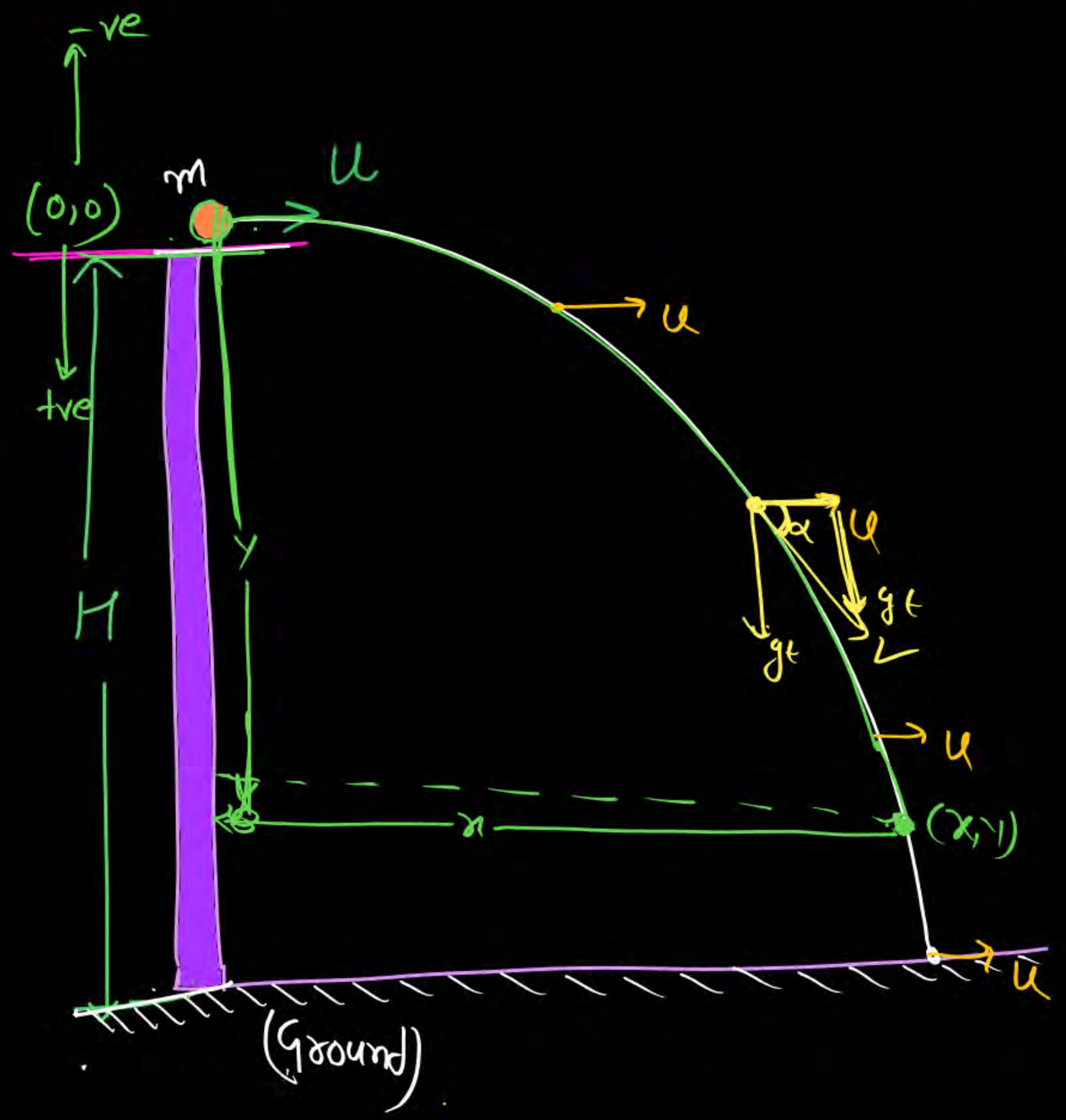
$t = 14\ sec$ Ans



dono Path me H_{max} hai :—

$\Rightarrow$ $T_1 = T_2$ Same time of flight hoga ✓

Horizontal Projectile Motion → 2-D motion → Non-uniform motion! — acc^n due to gravity = g (cost^n) uniform acc^n



x-axis

$\vec{u}_x = u$

$a_x = 0$

$\vec{v}_x = u$

uniform motion in x ✓

$x = u_x \times t$

Y-axis

$u_y = 0$ ✓

$a_y = g$ ✓

$v_y = gt\hat{j}$

$y = \frac{1}{2}gt^2$

$\vec{v}_{t=0} = u\hat{i} + 0\hat{j}$

$\vec{a} = 0 + g\hat{j}$

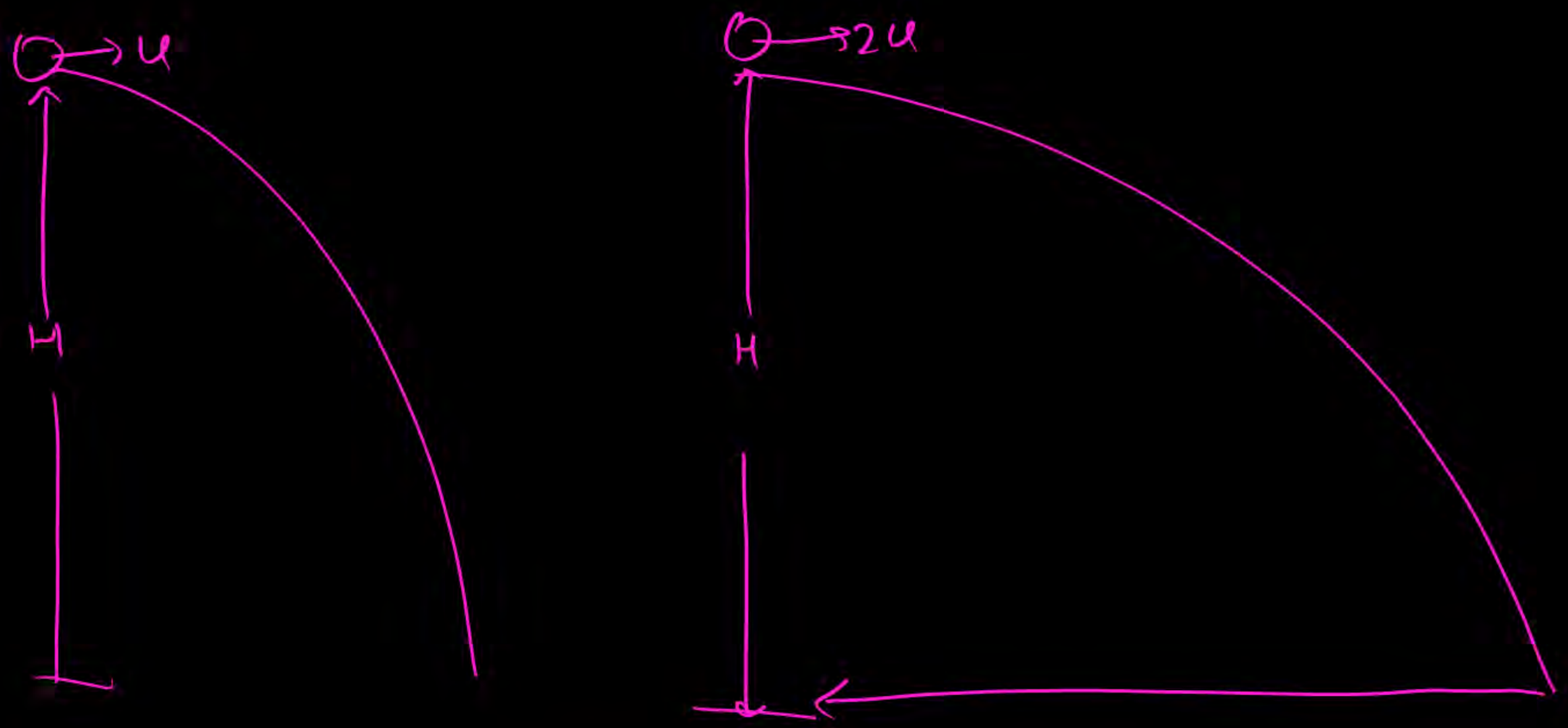
$\vec{v} = u\hat{i} + gt\hat{j}$ → $\tan\alpha = \frac{gt}{u}$ *

$T_f = \sqrt{\frac{2H}{g}}$

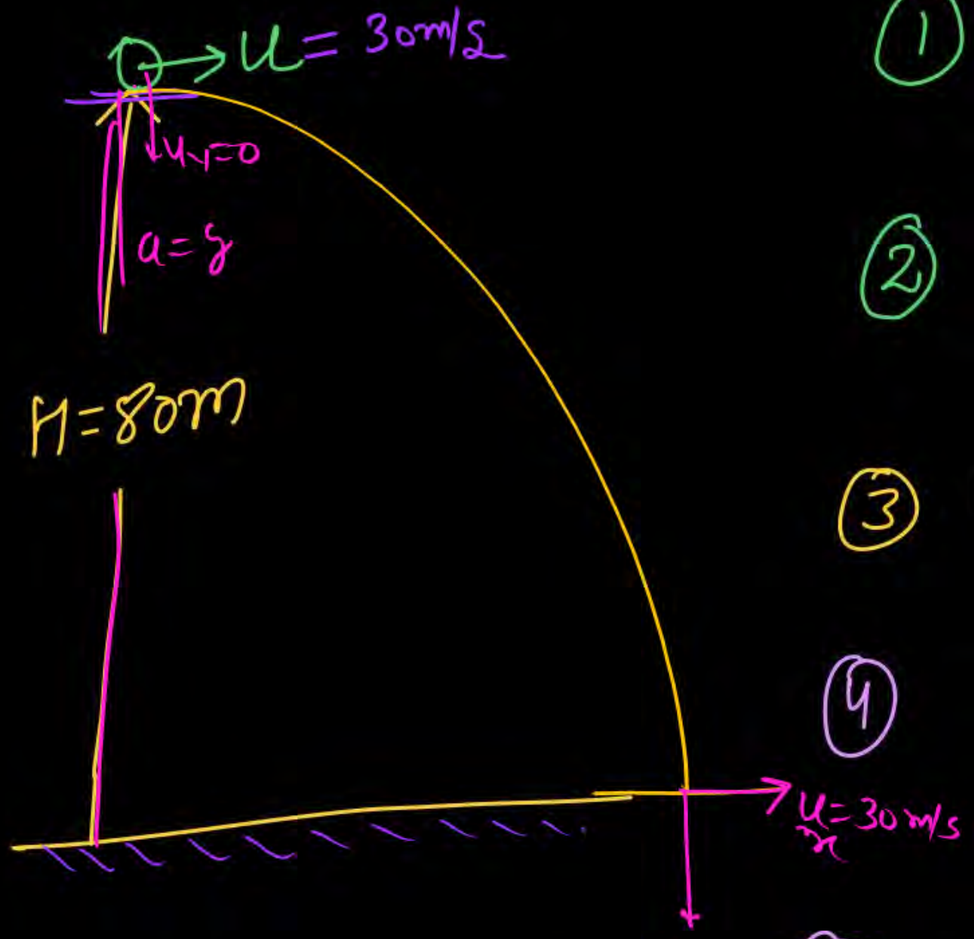
$R = u\sqrt{\frac{2H}{g}}$

$y = \frac{1}{2}g(t)^2$ *

$y = \frac{1}{2}g\left(\frac{x}{u}\right)^2$



$$T_1 = T_2$$



① Time of flight $T_f = \sqrt{\frac{2H}{g}} = \sqrt{\frac{2\times 80}{10}} = \sqrt{16} = 4\ sec$

② Range $R = u_x T_f = 30 \times 4 = 120\ m$

③ Velocity at ground $\vec{V} = 30\hat{i} + 40\hat{j}$

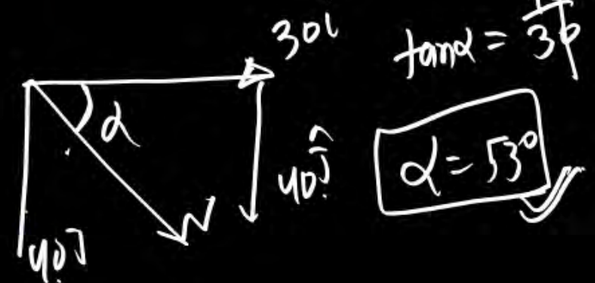
④ velocity at $t = 2\ sec$ $\vec{V} = 30\hat{i} + 20\hat{j}$

⑤ dirn of motion at $t = 4\ sec$ ✓ $\vec{V} = 30\hat{i} + 40\hat{j}$

3rd eqn of motn in y-axis → $V_y = \sqrt{2gH}$

$V_y = \sqrt{2\times 10\times 80}$

$V_y = \sqrt{160} = 40\ m/s$



(6) Position of object at $t = 3\,sec$

$x = u_x t = 30 \times 3 = 90\,m\,\hat{i}$

$y = u_y t + \frac{1}{2} g t^2 = \frac{1}{2} 10 (3)^2 = 5 \times 9 = 45\,\hat{j}$

$\vec{r} = 90\,m\,\hat{i} + 45\,m\,\hat{j}$

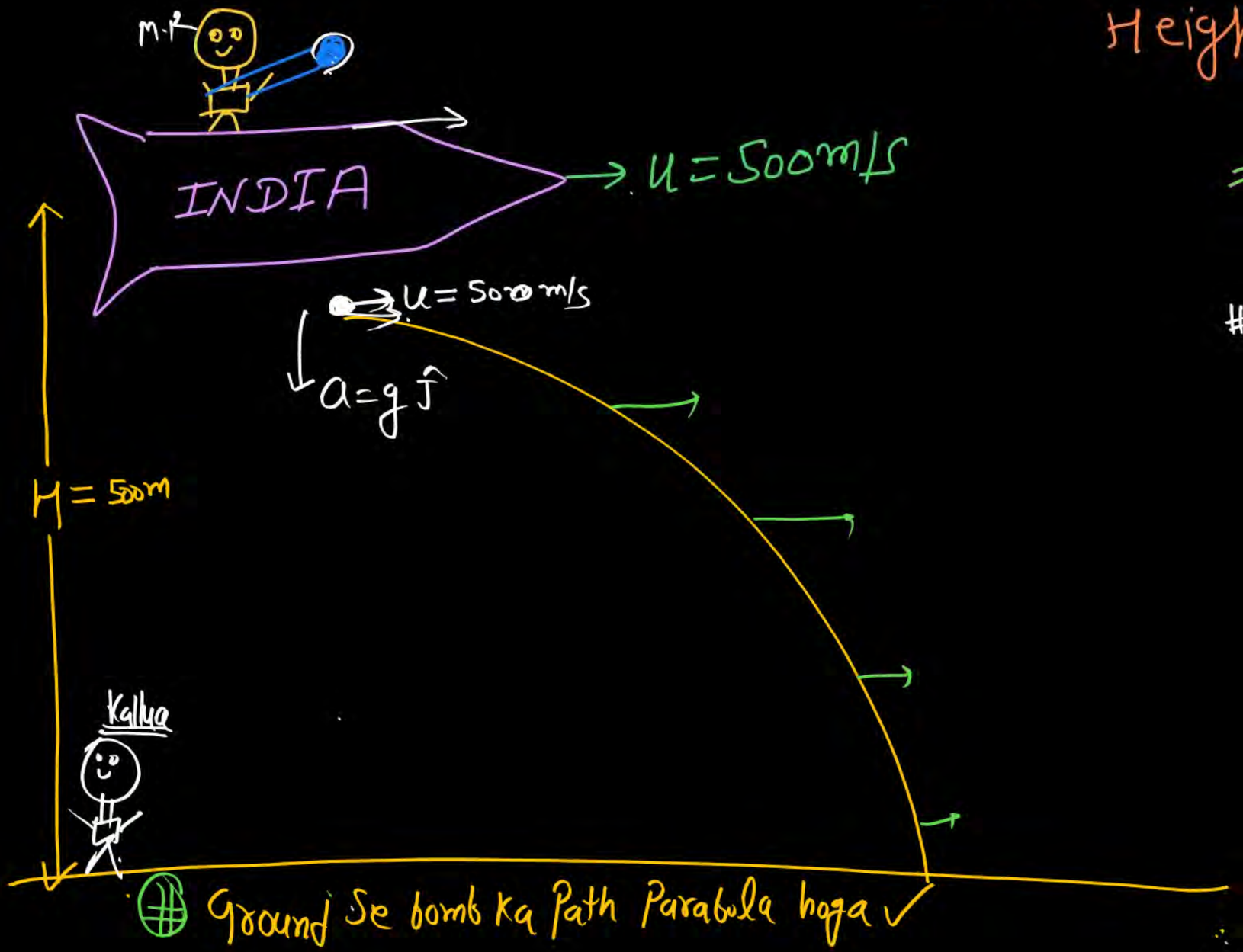
(7) Position vector at t

$\vec{r} = ut\,\hat{i} + \frac{1}{2} g t^2 \hat{j}$

(8) Equation of Trajectory

$y = \frac{1}{2} g t^2$ $\boxed{x = ut}$

bomb is droped from 500m Height then Range of bomb



Path of bomb is Parabolic

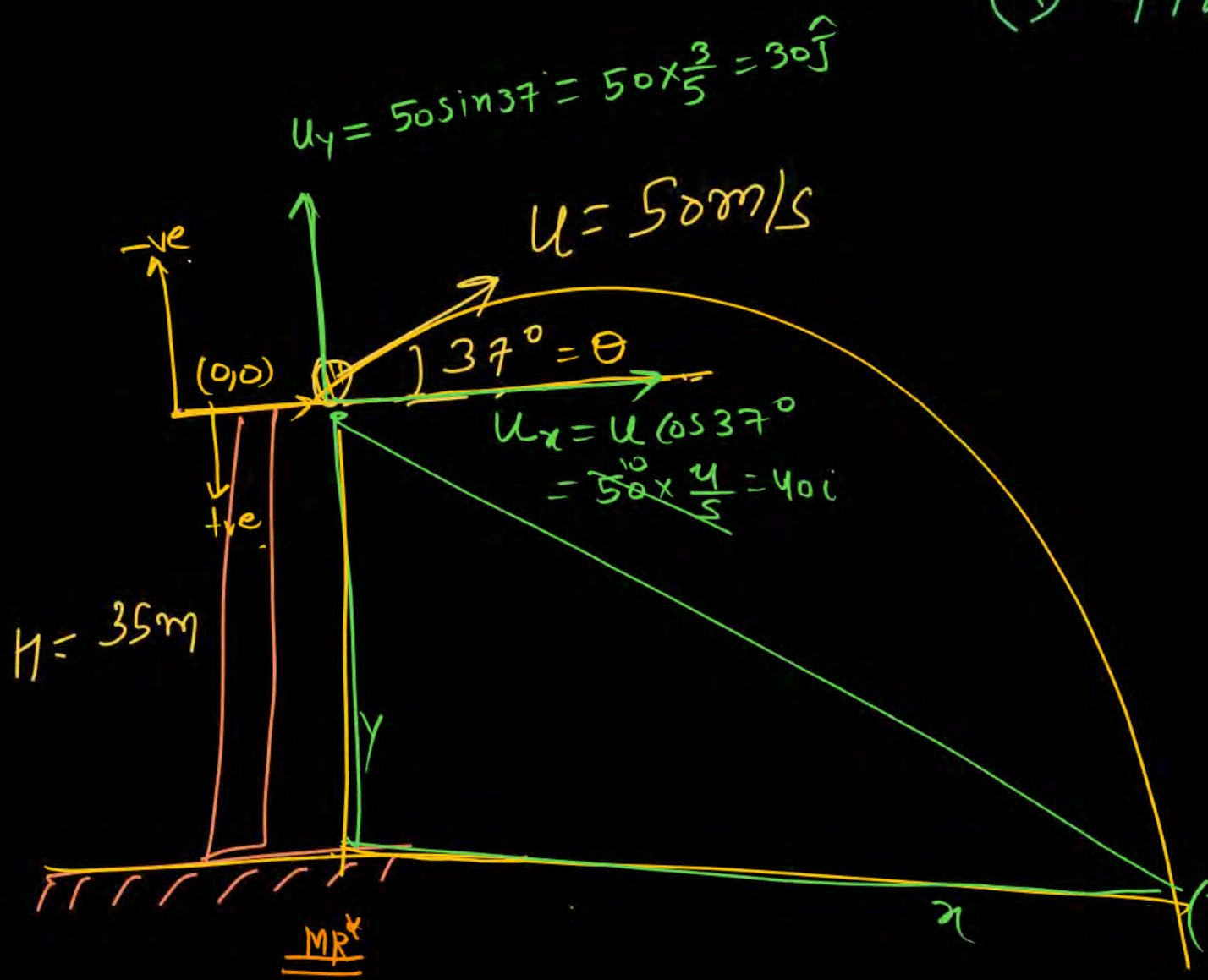
$T_f = \sqrt{\frac{2H}{g}} = \sqrt{\frac{2\times 500}{10}} = \sqrt{100} = 10\,sec$

$R = u_x T_f$

$= 500 \times 10$

$= 5000\,m$ # Answer

(Q) find Time of flight and Range :-



Consider motion in y-axis

$u_y = -30$

$a_y = +10$

$s_y = +35m$

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

$35 = -30t + \frac{1}{2}10t^2$

$\Rightarrow 7p = -6pt + 1pt^2$

$t^2 - 6t - 7 = 0$

$t^2 - 7t + t - 7 = 0$

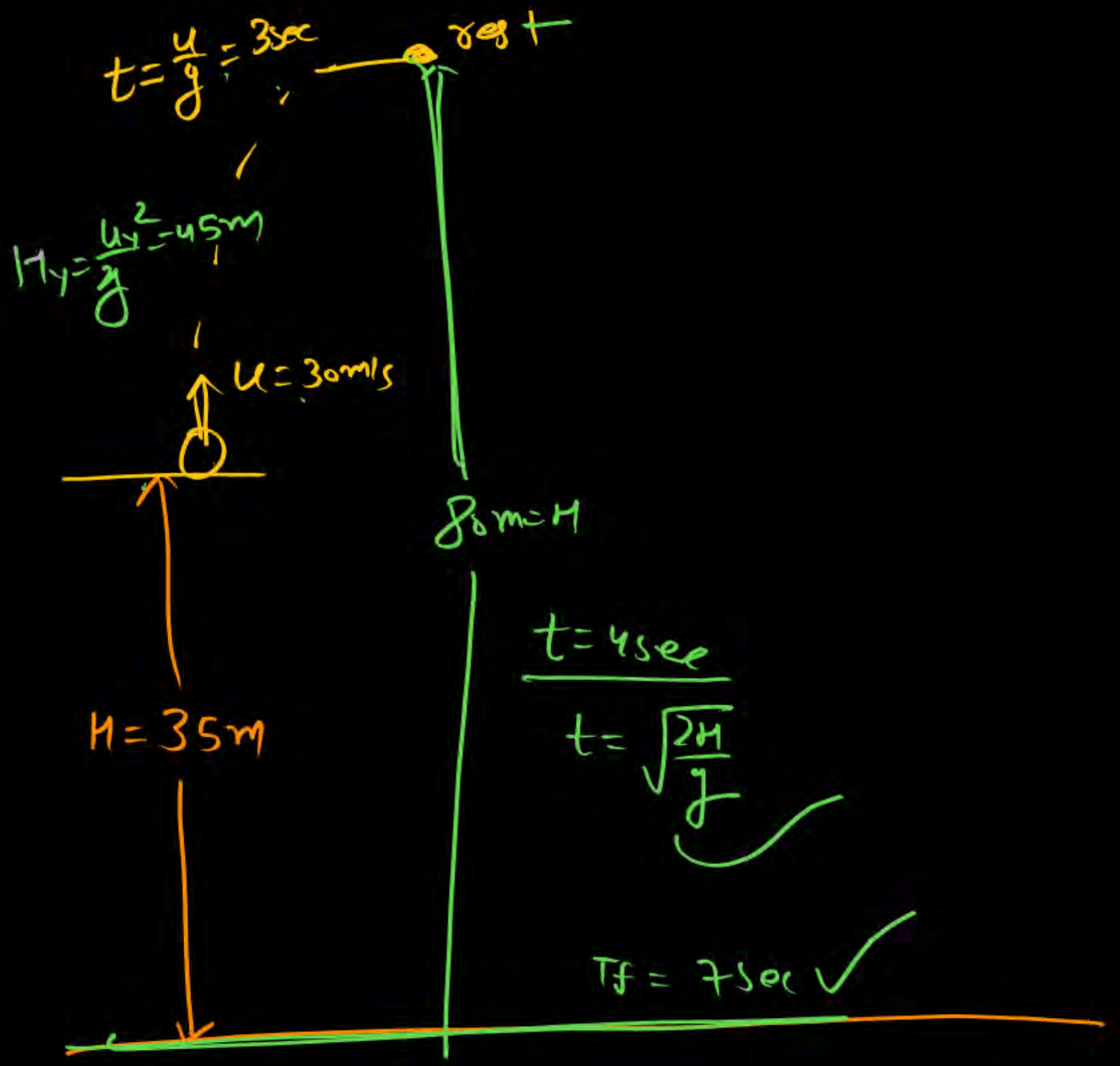
$t(t-7) + 1(t-7) = 0$

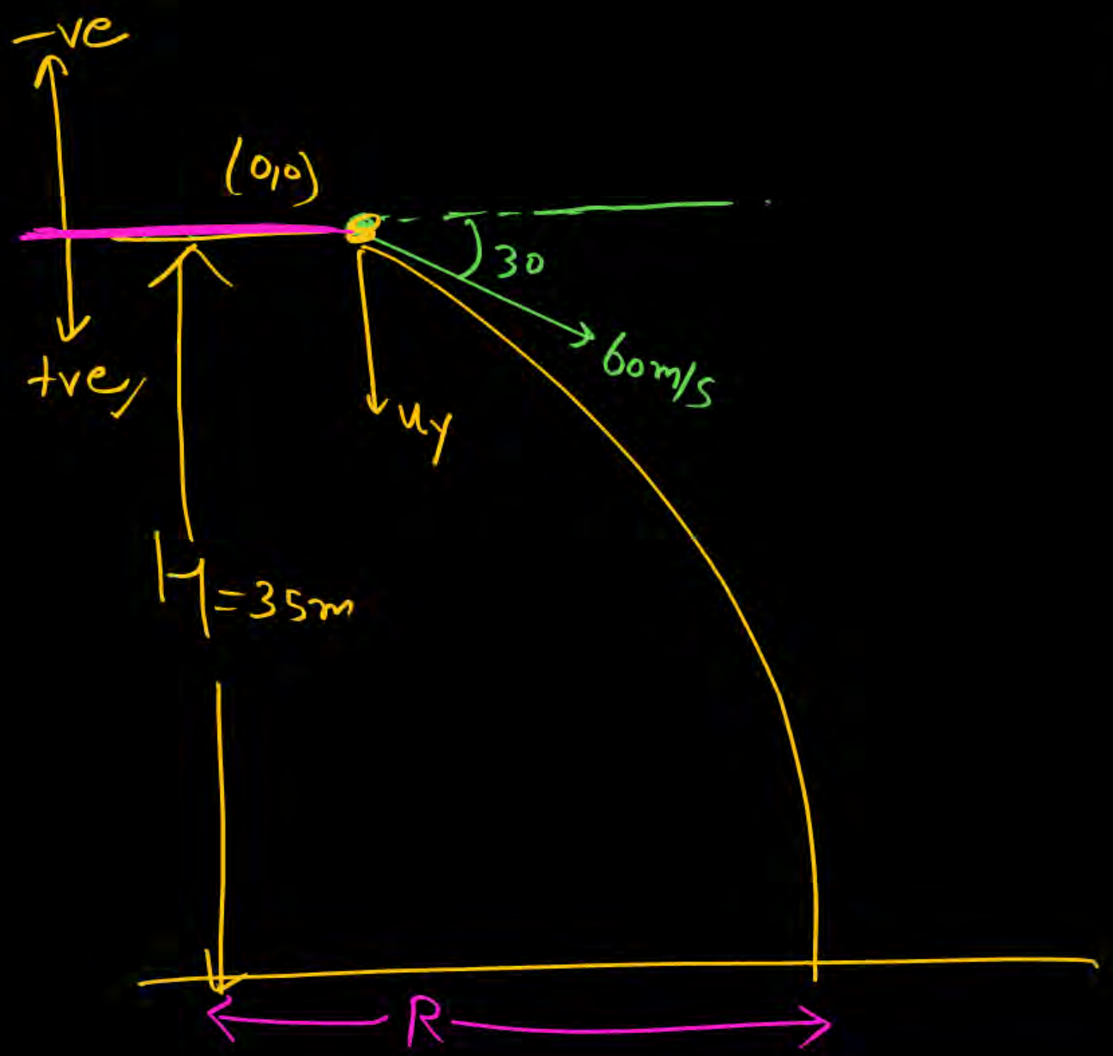
$(t-7)(t+1) = 0$

$t = 7$ ✓ $t = -1$ ✗

Range $= u_x T_f = 40 \times 7$

$= 280 m$ ✓


$t = \frac{u}{g} = 3sec$
neg +
$H_y = \frac{u_y^2}{g} = 45m$
$u = 30m/s$
$80m = H$
$H = 35m$
$t = 4sec$
$t = \sqrt{\frac{2H}{g}}$
$T_f = 7sec$ ✓

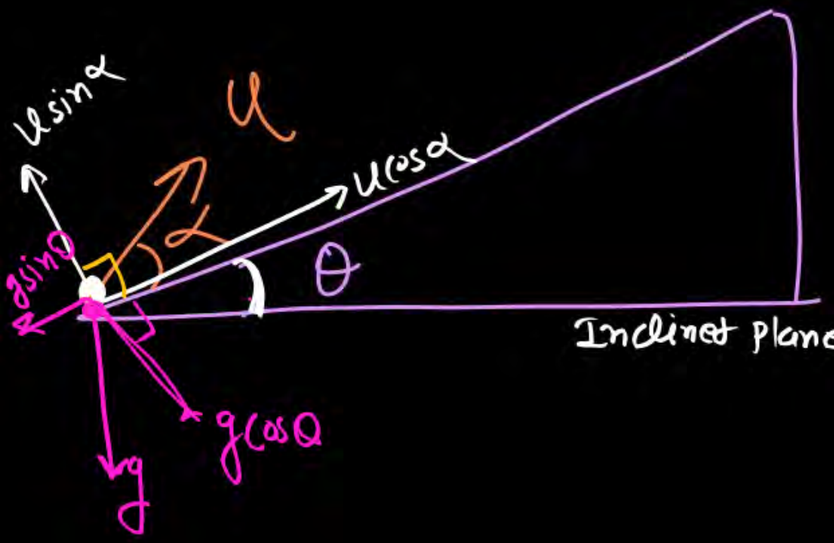


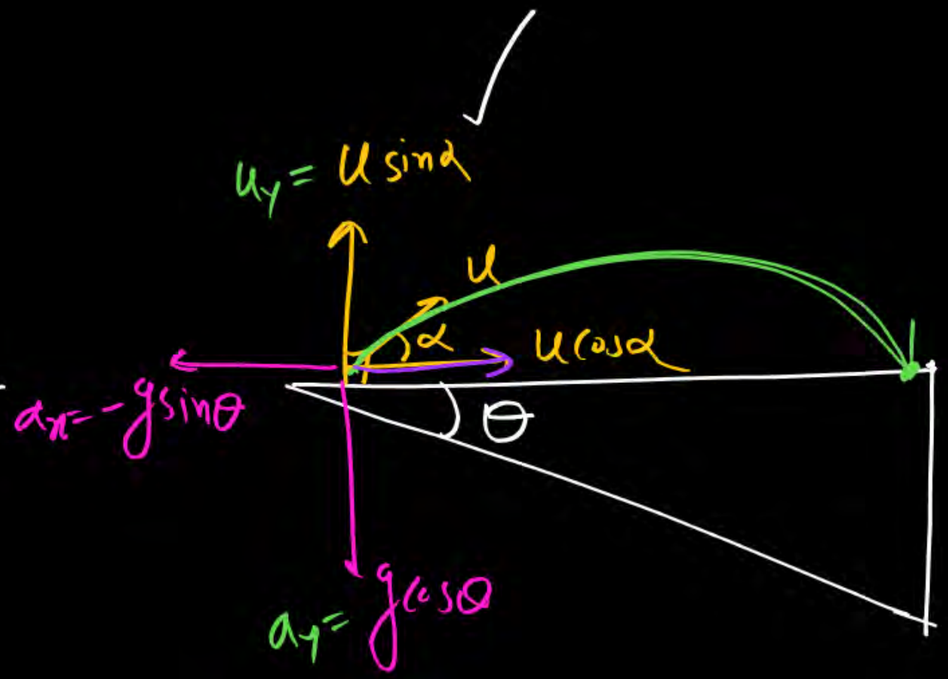
$\vec{u}_y = 60\sin 30 = 60 \times \frac{1}{2} = 30\hat{j}$

$y = 35m$

$a = 10 m/s^2$

Projectile on Inclined :-





Time of flight :-

Consider motn in y-axis :-

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

along Inclined Plane :-

$u_x = u\cos\alpha \quad a_x = -g\sin\theta$

$$x = u_x t_f + \frac{1}{2} a_x t_f^2$$

$$R = u\cos\alpha\, t_f - \frac{1}{2} g\sin\theta\, t_f^2$$

Relative velocity :— Velocity ka vector subtraction.

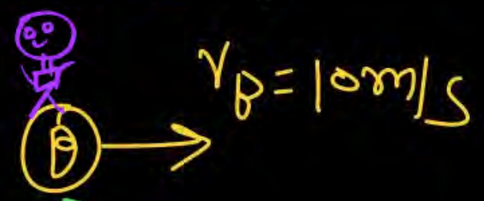
$$\vec{V}_{AB} = \vec{V}_A - \vec{V}_B$$

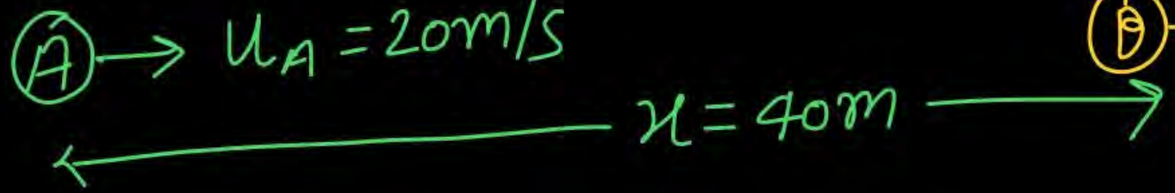
"Velocity of A w.r.t. B"

$$\vec{V}_{BA} = \vec{V}_B - \vec{V}_A$$

(Velocity of B w.r.t. A)

Observer





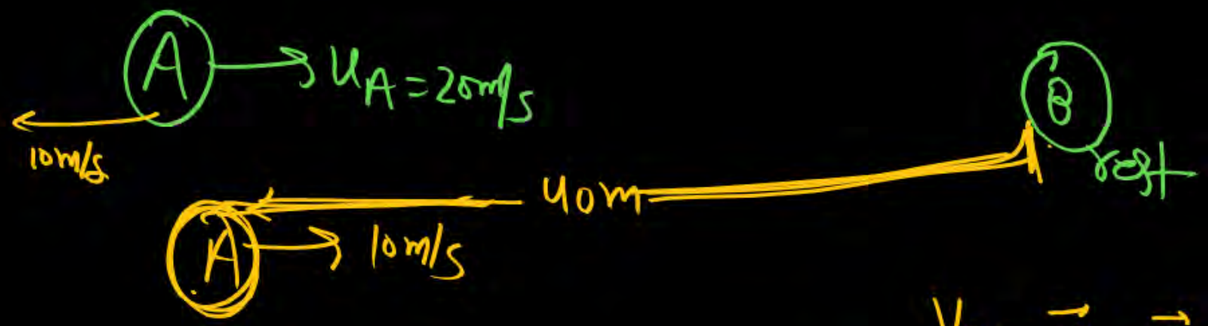
$$\vec{V}_{AB} = -\vec{V}_{BA}$$

$$\vec{\gamma}_{AB} = \vec{\gamma}_A - \vec{\gamma}_B$$

$$\vec{V}_{AB} = \vec{V}_A - \vec{V}_B$$

$$\vec{a}_{AB} = \vec{a}_A - \vec{a}_B$$

time of collision



$S_{AB} = 40m$

$a_{AB} = 0$

$V_{AB} = \vec{V}_A - \vec{V}_B = 20 - 10 = 10 m/s$

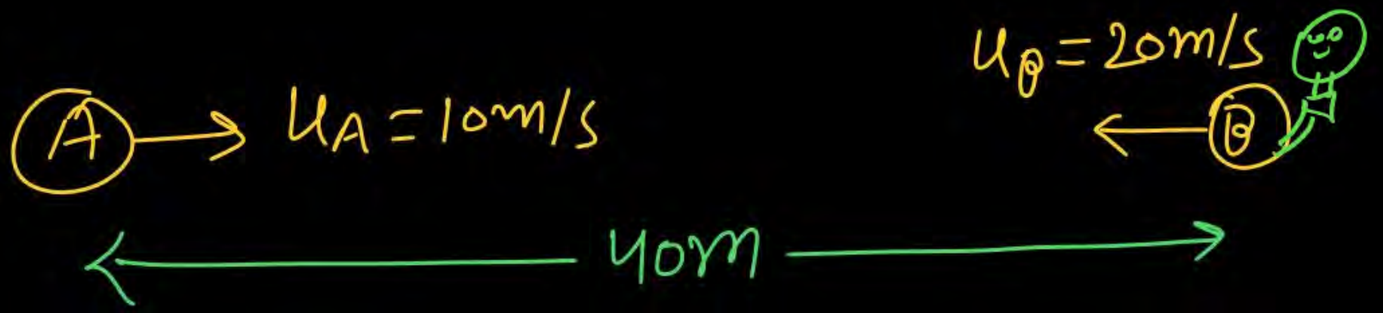
$S_{AB} = u_{AB} t$

$40 = 10 t$

$t = 4 sec$

MRP Box :— aage wale Par observer Bana kar baith Jao, usko rest me man lo, Pichhe wale ka displ, velo, acc^n relative nikalo & eq^n of motion se solve karo.

Time of collision.



$$S_{AB} = 4\not{0} = 3\not{0}\, t$$

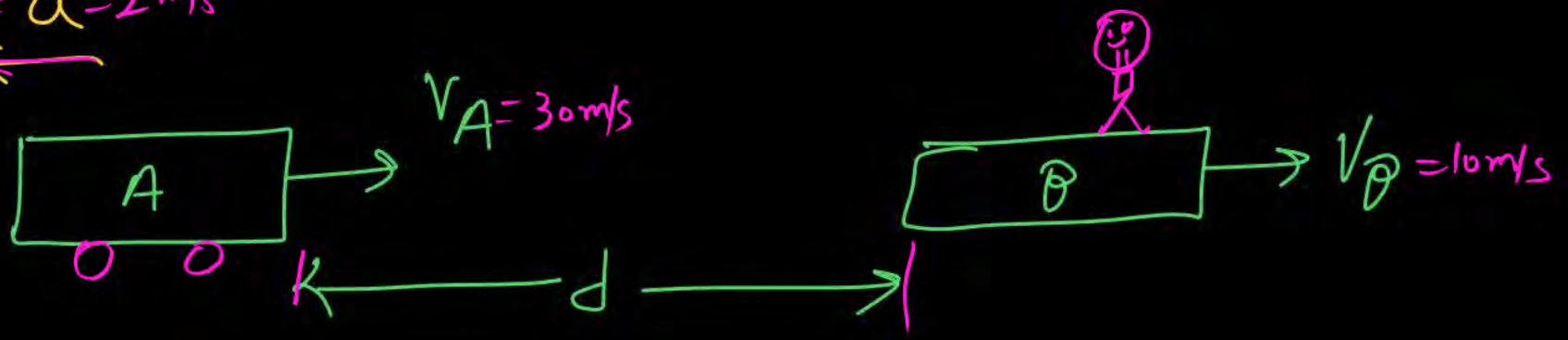
$$t = \frac{4}{3} \text{ sec} \checkmark$$

(Q) If $V_A > V_B$; time when train A will overtake :—

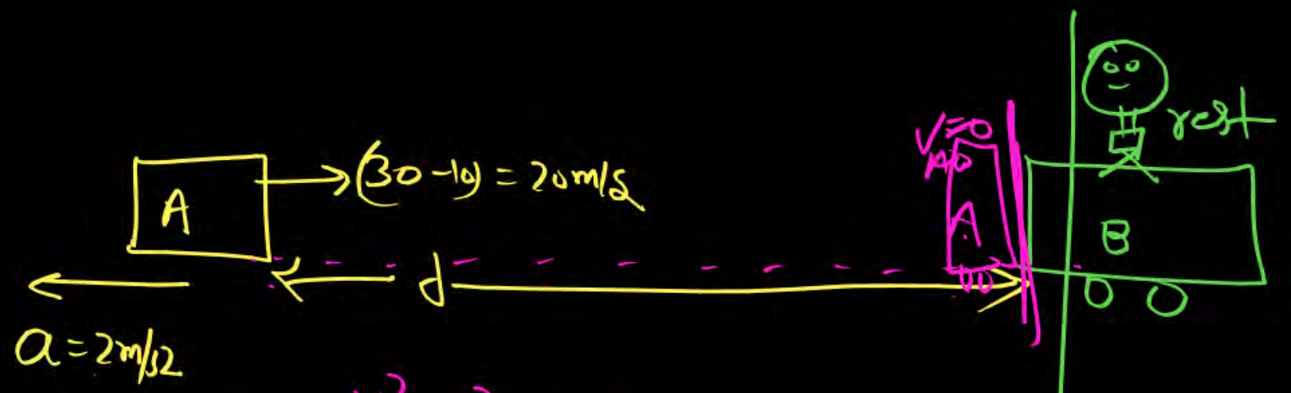
$$t_{overtake} = \frac{l_A + l_B}{V_A - V_B}$$

$$t_{cross} = \frac{l_A + l_B}{V_A + V_B}$$ ✓

(Q) retardⁿ = $a = 2\,m/s^2$ ⟵



Condition for No Collision :-

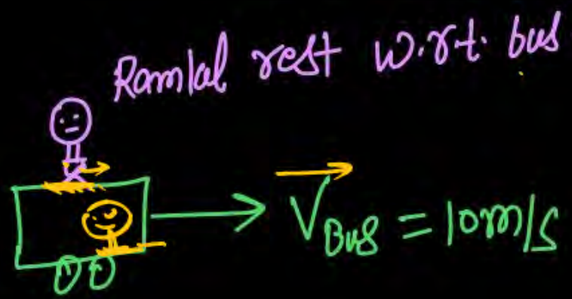


$V^2 - u^2 = 2as$

$0 - (20)^2 = 2 \times 2 \times d$

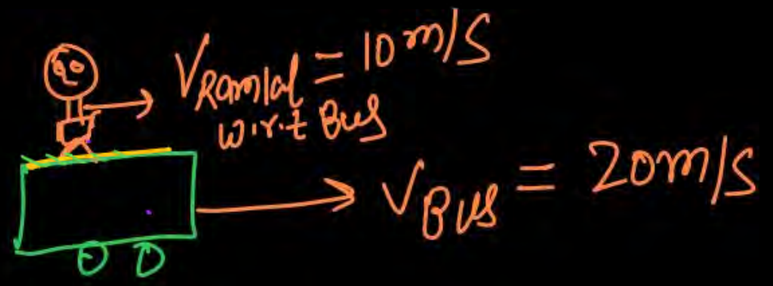
$d = \frac{20 \times 20}{4} = 100\,m.$

Relative Motion from moving frame :-



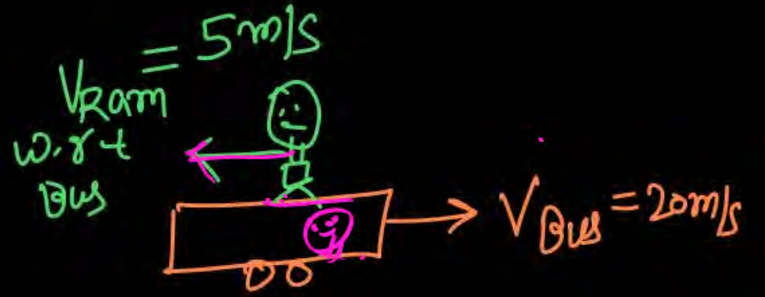
$\vec{v}_{Ramlal, Bus} = 0$ ✓

$\vec{v}_{Ram\ Group} = 10 m/s\ \hat{i}$ ✓



$v_{Ram\ Bus} = 10\ m/s$

$v_{Ram\ Grou} = 30 m/s$.

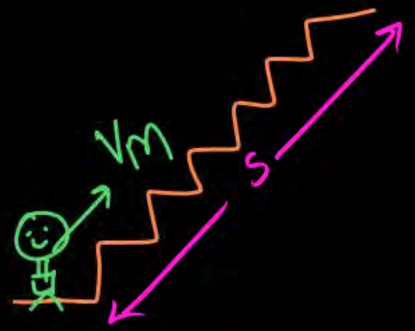


$v_{Ram\ Bus} = -5 m/s\ \hat{i}$

$V_{Ram\ Grou} = 15 m/s$

MR* Box :—
Jab bhi koi object moving frame me hai to wo object frame ki velocity as it is copy kar lega but acch copy vahi karega.

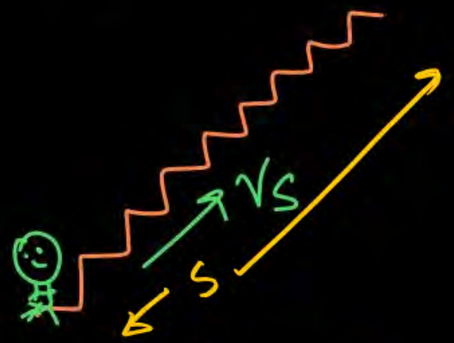
escalator at rest



Man is moving

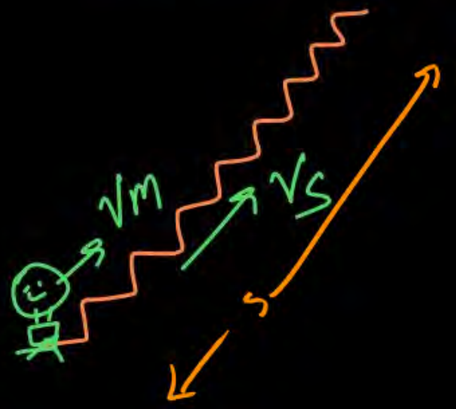
$$t_1 = \frac{s}{V_M}$$

escalator moving (man at rest)



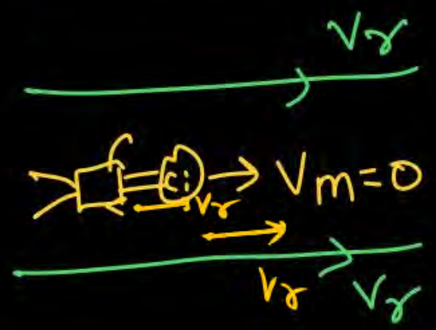
$$t_2 = \frac{s}{V_s} \quad -(ii)$$

escalator & man both are moving



$$t = \frac{s}{(V_m + V_s)} \quad -(i)$$

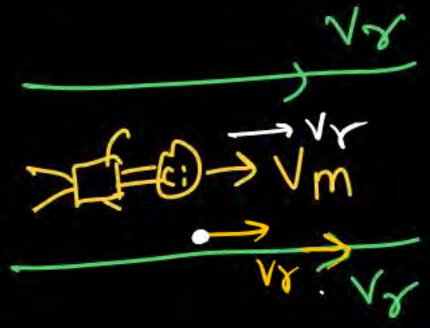
River man in 1-D



(man is not swiming)

$$V_{man\ riv_2} = 0 \checkmark$$

$$V_{man\ Ground} = V_r \quad -(1)$$

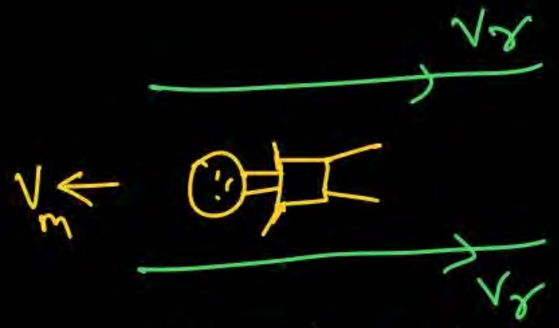


man is swiming with V_m

$$V_{man\ riv_2} = V_m \checkmark$$

Velocity by which man swim $= V_m$

$$V_{man\ Gro} = V_m + V_r \quad -(11)$$



Man is swiming backward.

$V_m > V_r$ ✓

$$\vec{V}_{man\ riv_2} = -\vec{V}_m$$

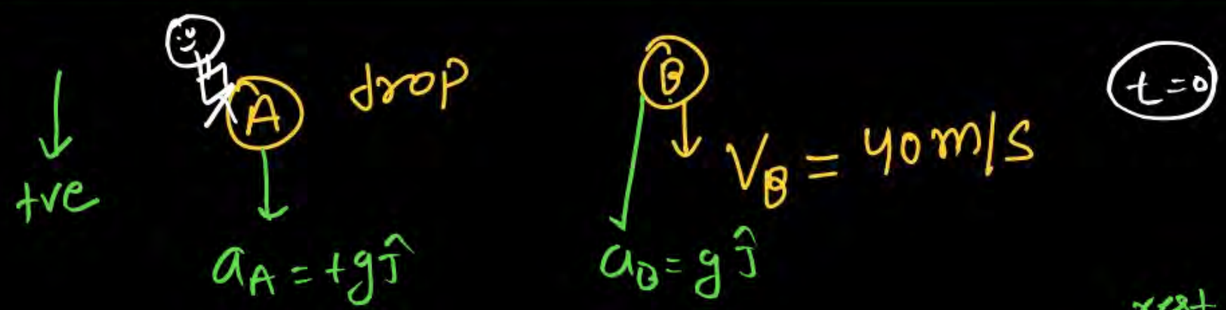
Back

$$\vec{V}_{man\ Grou} = \vec{V}_m - \vec{V}_r$$

(Back)

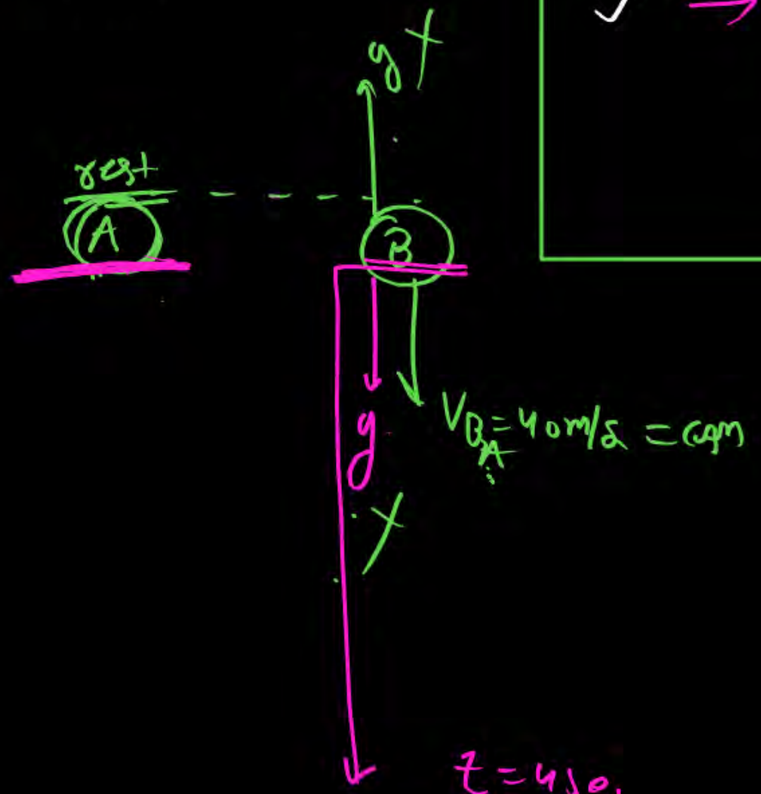
$$\vec{V}_{man\ Gro} = \vec{V}_r - \vec{V}_m \quad V_r > V_m$$

Relative motion in motion under gravity :-



✓ → motion under gravity of a object is Non-uniform motion

✓ → Motion under gravity of one object w.r.t other object who also in motion under gravity is uniform motion ✓



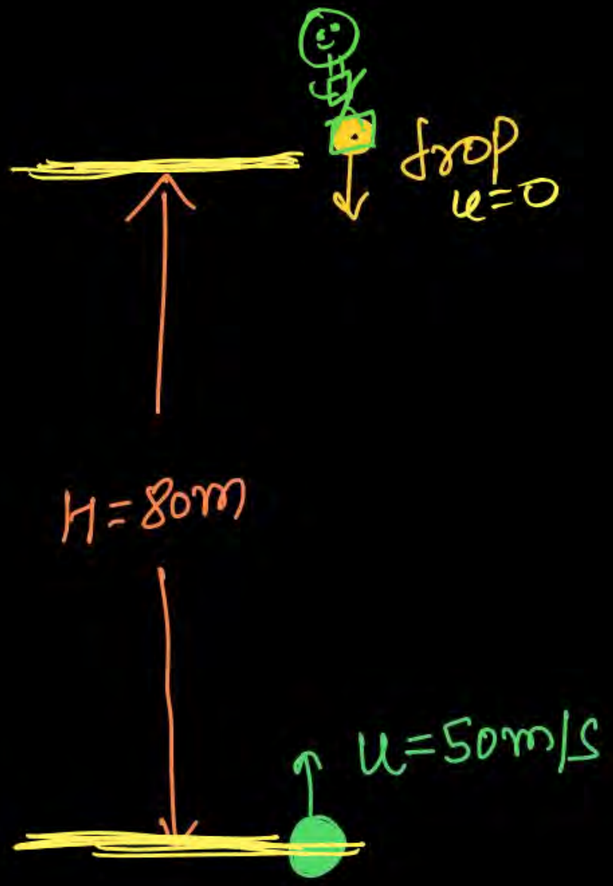
☆ $\vec{a}_{BA} = \vec{a}_B - \vec{a}_A$

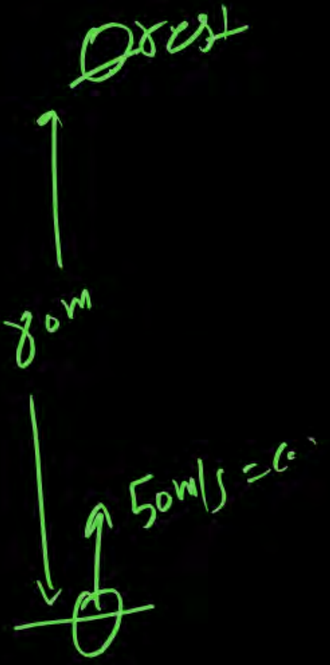
$= g\hat{j} - g\hat{j}$

$= 0$

gf relative acc^n is zero, then relativ velocity cost^n hence relativ motion uniform

find time of collision.





$t = \frac{80}{50}$

$t = \frac{8}{5}$ sec ✓

Same in Projectile motⁿ relative accⁿ one object in Projective motion w.r.t. to other object in Projectile motion is zero, then relative velocity is uniform,

hence, relative Motion steady line

Relative motion in 2-D :-

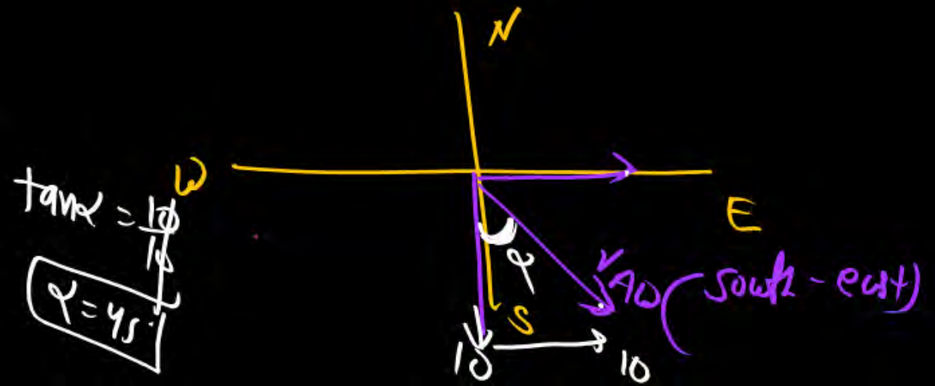
Same as 1-D bas vector ka feel dalna hai :-

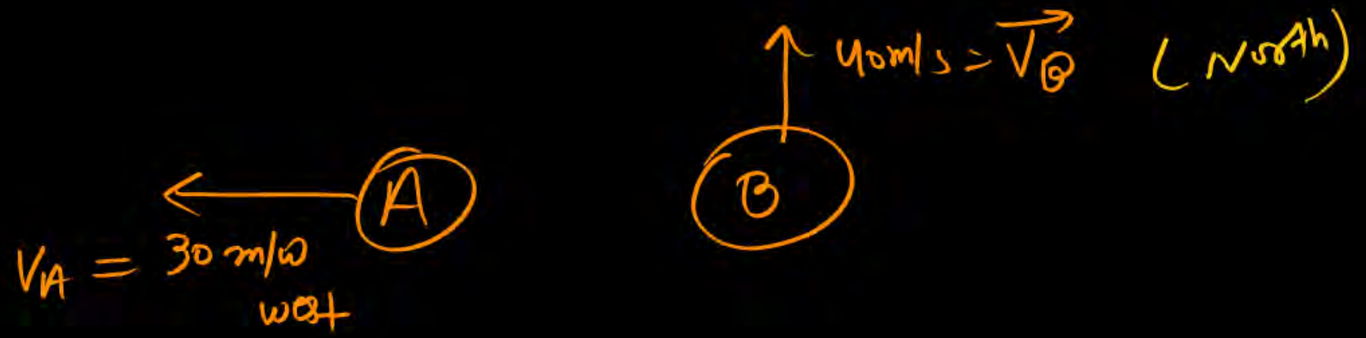
(A) ⟶ $v_A = 10\,m/s\,\hat{i}$ (east)

$v_B = 10\,m/s\,\hat{j}$ (North)

$$\vec{V}_{AB} = \vec{V}_A - \vec{V}_B$$

$$\vec{V}_{AB} = 10\hat{i} - 10\hat{j}$$





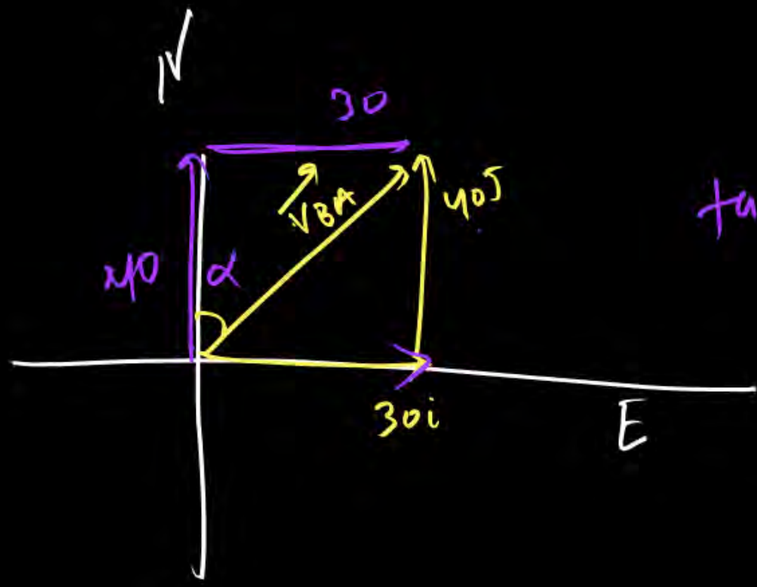
$\vec{V_{BA}} = ??$

Soln $\quad \vec{V_{BA}} = \vec{V_B} - \vec{V_A}$

$= 40\hat{j} - (-30\hat{i})$

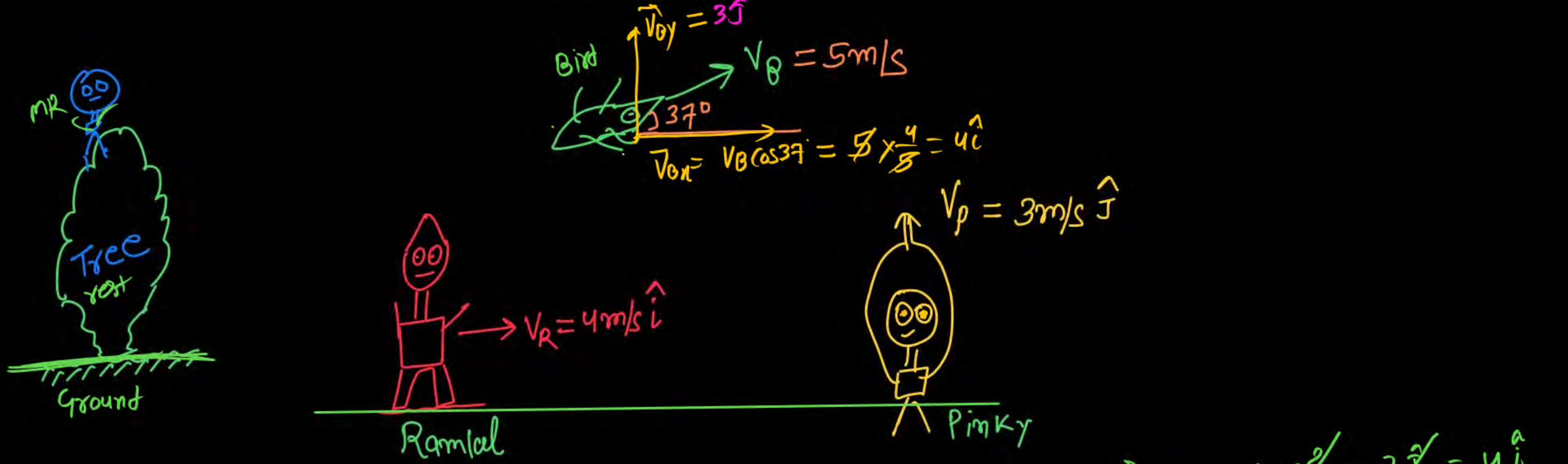
$= 40\hat{j} + 30\hat{i}$

$|\vec{V_{BA}}| = \sqrt{(40)^2 + (30)^2} = 50 \text{ m/s}$



$\tan\alpha = \frac{3}{4}$

$\alpha = 37°$



$$\vec{V}_{B\,Ramlal} = \vec{V}_B - \vec{V}_R$$

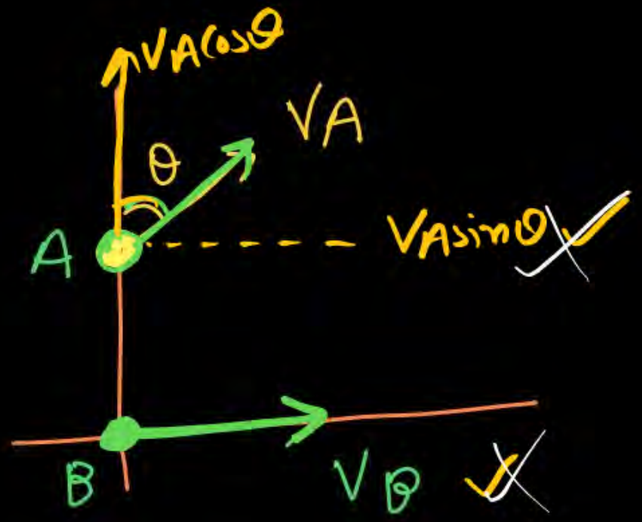
$$= 4\hat{i} + 3\hat{j} - 4\hat{i}$$

$$\boxed{\vec{V}_{B\,Ramlal} = 3\hat{j}}$$

$$\vec{V}_{Ramlal\,Bird} = -3\hat{j}$$

$$\vec{V}_{B\,Pinky} = \vec{V}_B - \vec{V}_P = 4\hat{i} + 3\hat{j} - 3\hat{j} = 4\hat{i}$$

$$\vec{V}_{Pinky\,Bird} = -4\hat{i}$$



(Q) find $\frac{V_A}{V_B}$ so that A appears to move in vertically upward w.r.t. B.

$$\vec{V}_{AB} = V_A - V_B$$

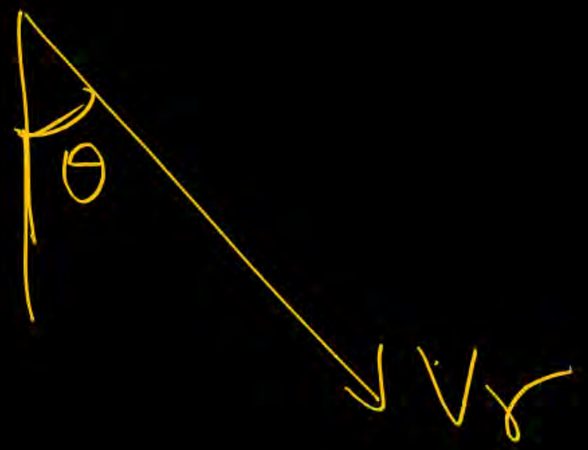
$$\vec{V}_{AB}\hat{j} = V_A\sin\theta\,\hat{i} + V_B\cos\theta\,\hat{j} - V_B\,\hat{i}$$

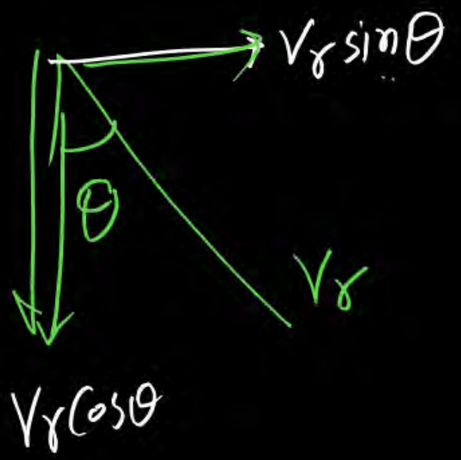
$$= V_B\cos\theta\,\hat{j} + (V_A\sin\theta - V_B)\,\hat{i}$$

$$V_A\sin\theta - V_B = 0$$

$$V_A\sin\theta = V_B$$

$$\frac{V_A}{V_B} = \frac{1}{\sin\theta} = \operatorname{cosec}\theta$$



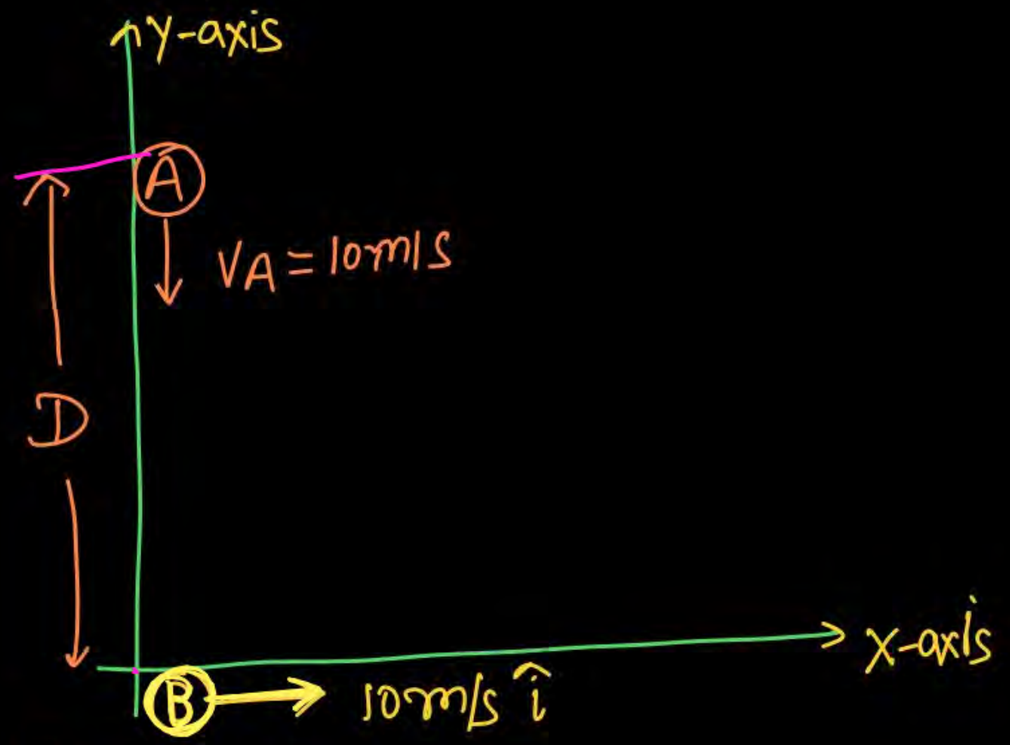


$V_m = V_r \sin\theta$

for this condⁿ rain appr to fall vertically downwards

Minimum Sepration :-

MR* Box:- Kisi ek par Ramlal ko bitha ke dusre object ka relative velocity likho, dusra object relative velocity ke direction me Jayga. relative velocity ke direction se A par perpendicular line hi minimum sepration hoga.



at which they are at min^m sepn

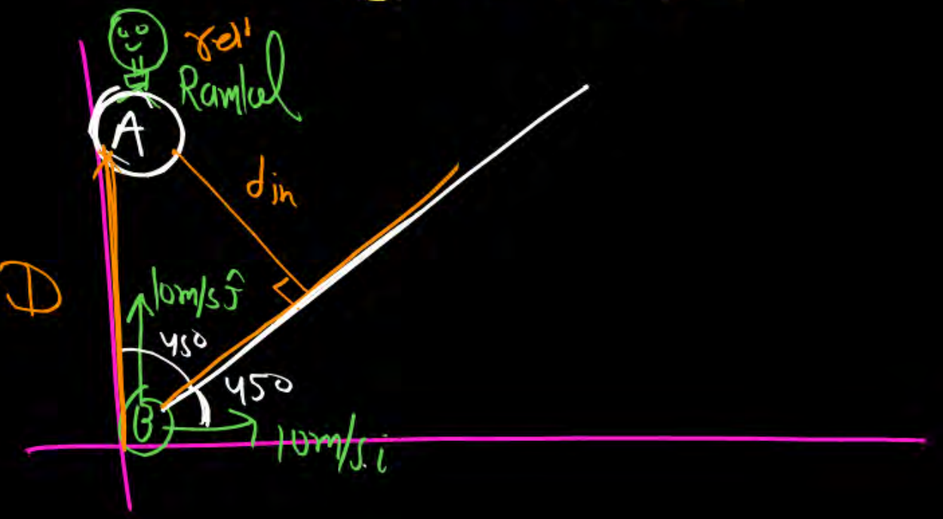
$$t = \frac{D}{\sqrt{2}(10\sqrt{2})} = \left(\frac{D}{2\times 10}\right)$$

$V_{BA} = 10\sqrt{2}$

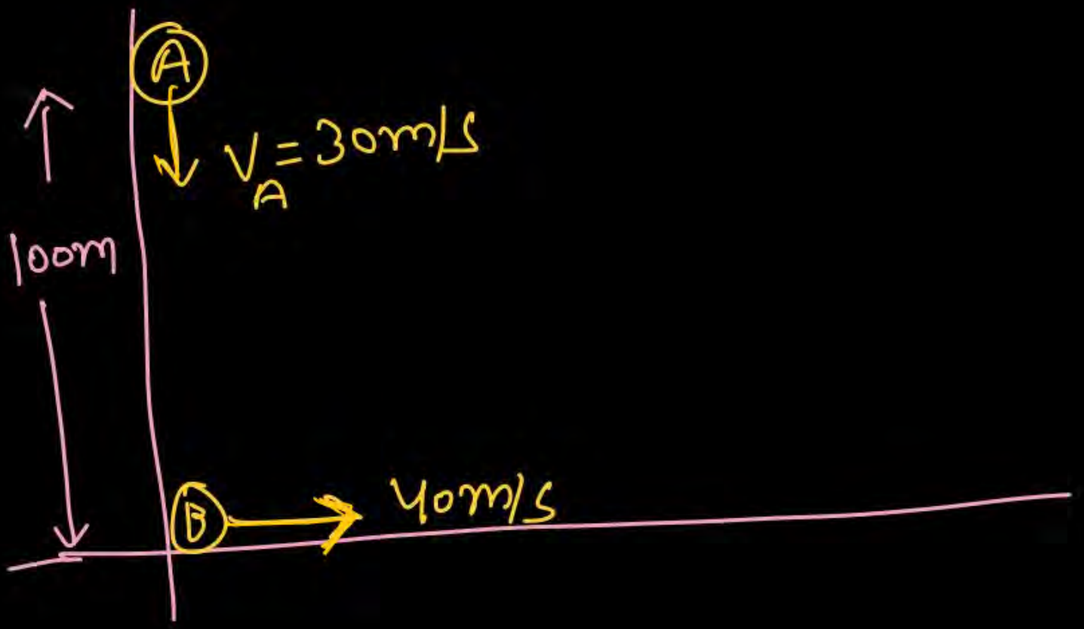
$\sin 45° = \frac{d_{min}}{D}$

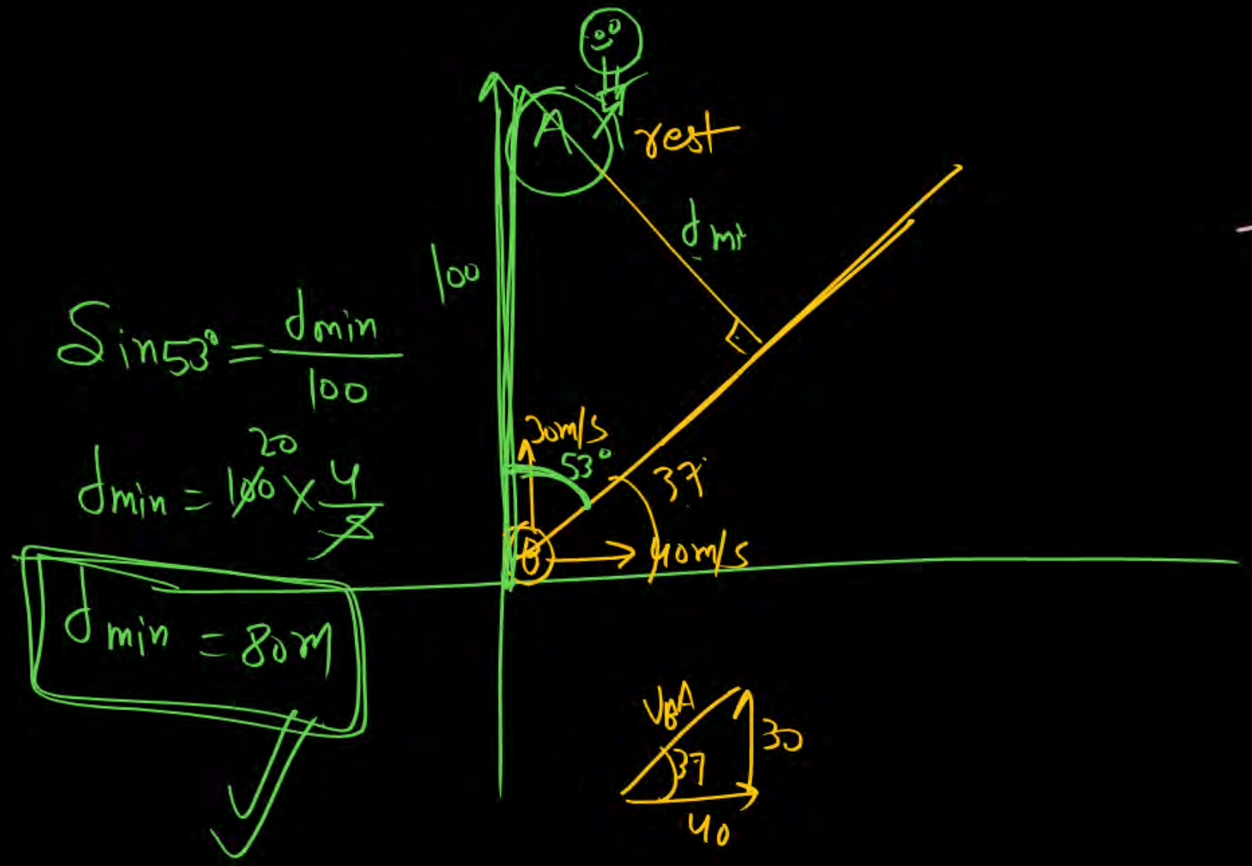
$D/\sqrt{2}$

$$d_{min} = D \times \frac{1}{\sqrt{2}}$$



find minimum sepration :-





$$\sin 53^\circ = \frac{d_{min}}{100}$$

$$d_{min} = \frac{20}{100} \times \frac{4}{5}$$

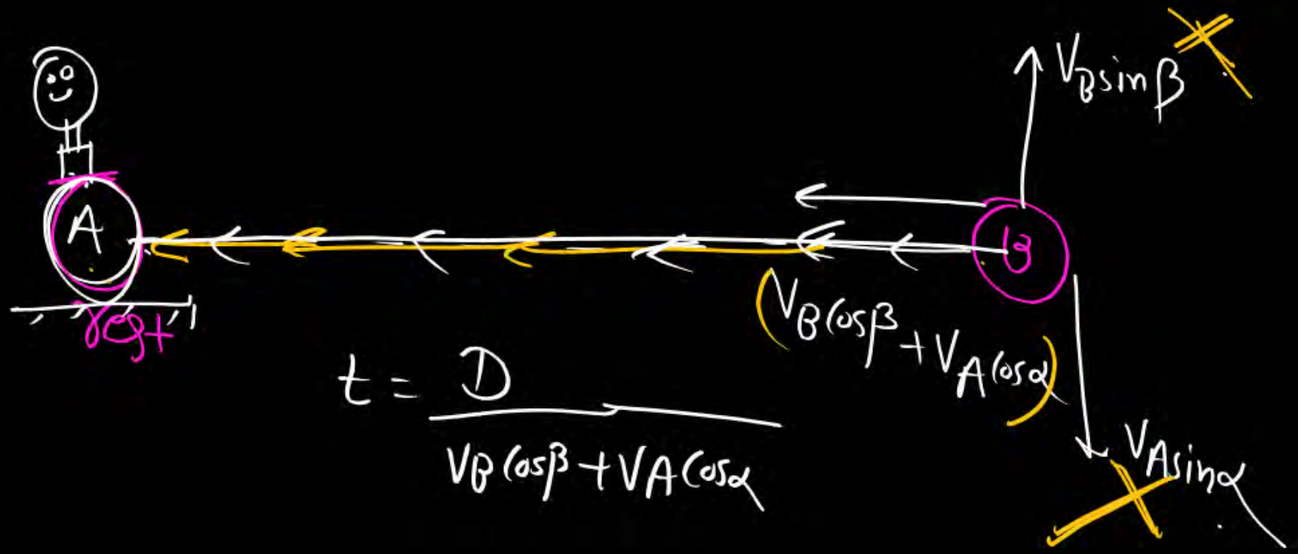
$$d_{min} = 80m$$

Condition of collision

MR* Box :—

(1) relative velocity must be along line of Joining.

(2) Relative velocity must be zero Perpendicular to the line Joining of object



$$t = \frac{D}{V_B\cos\beta + V_A\cos\alpha}$$

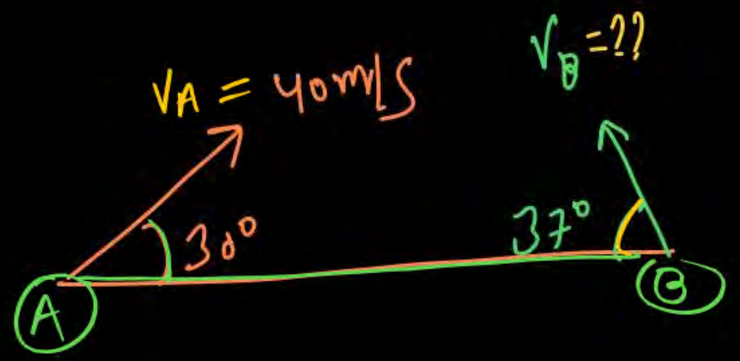
Cond^n of Collision (AIPMT -2015)

$$\{\hat{r}_{BA} = -\hat{V}_{BA}\}$$

→ Comp^n of their velocity must be same $\perp^r$ to line Joining ✓

Projectile motion:-

$\longrightarrow \vec{a}_{AB} = 0$

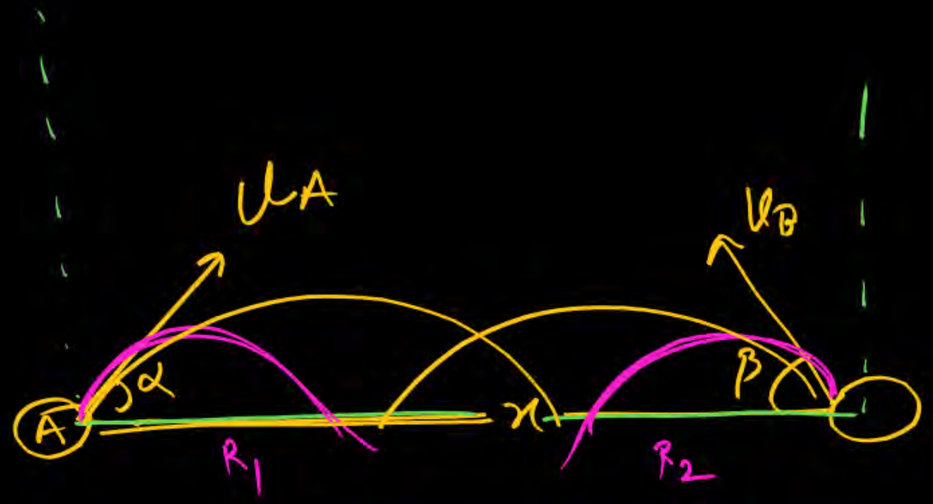


Cond^{n} of Collsion

$$40 \sin 30 = V_B \sin 37°$$

$$\cancel{40} \times \frac{1}{\cancel{2}} = V_B \times \frac{3}{5}$$

$$\frac{100}{3} = V_B$$



→ $u_A \sin\alpha = u_B \sin\beta$ # $R_1 + R_2 \geq x$

→ Condⁿ of collision

$\Rightarrow x > R_1 + R_2 \longrightarrow$ No collsi

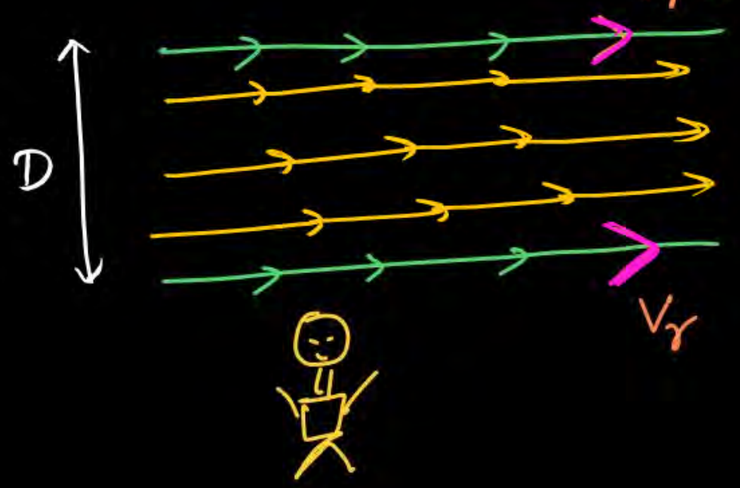
River Man Problem :—

River ka flow na to river ke across support karega na oppose.

River ka flow river ke along velocity deg

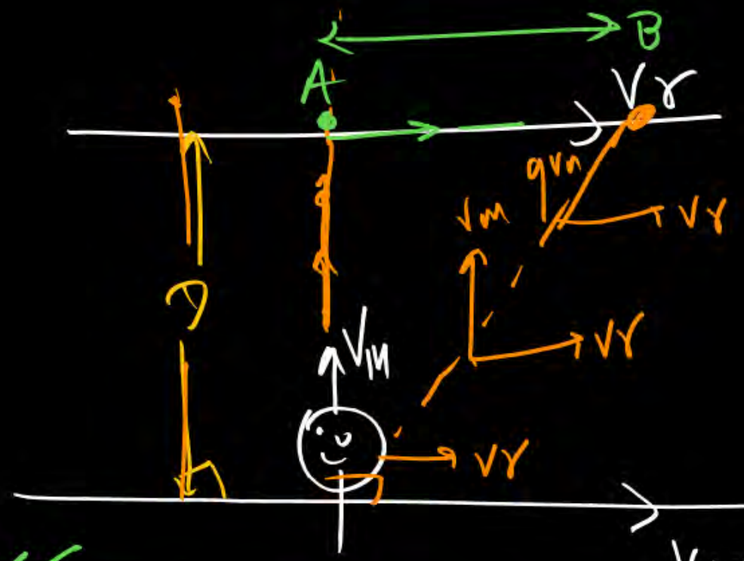
NEET

V_r = velocity of river



MP ✱ ✱ River ko apne dam par cross kiya jata hai, river ka flow na to support karega na oppose karega.

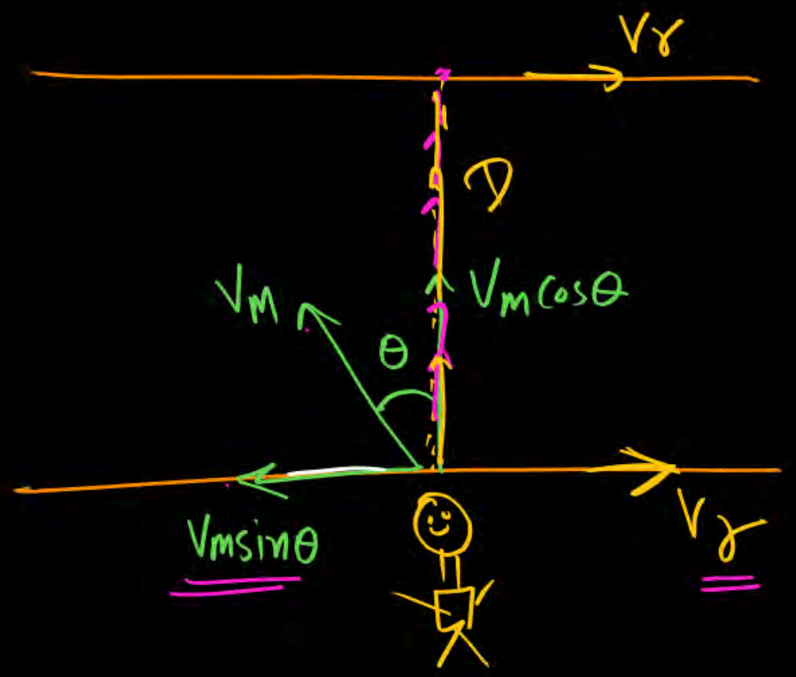
① Minimum time :—



$$\text{Drift} = V_r t = V_r \frac{D}{V_m}$$

$$t = \frac{D}{V_m}$$

(3) Man is swiming such that want to reach just opposite end of river :- $(V_m > V_R)$ {minimum path}.



Drift = 0

$V_m\sin\theta = V_r$

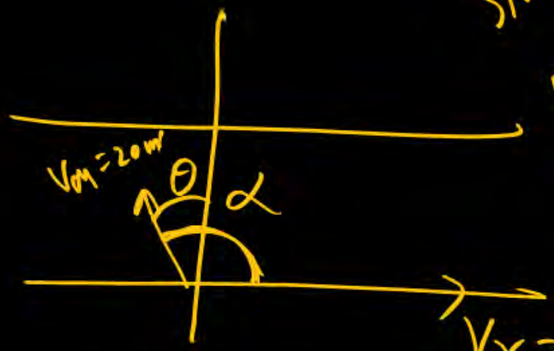
$\sin\theta = \frac{V_r}{V_m}$ $V_m > V_r$

$t = \frac{D}{V_m\cos\theta}$

$\sin\theta = \frac{V_r}{V_m}$

$\sin\theta = \frac{10}{20}$

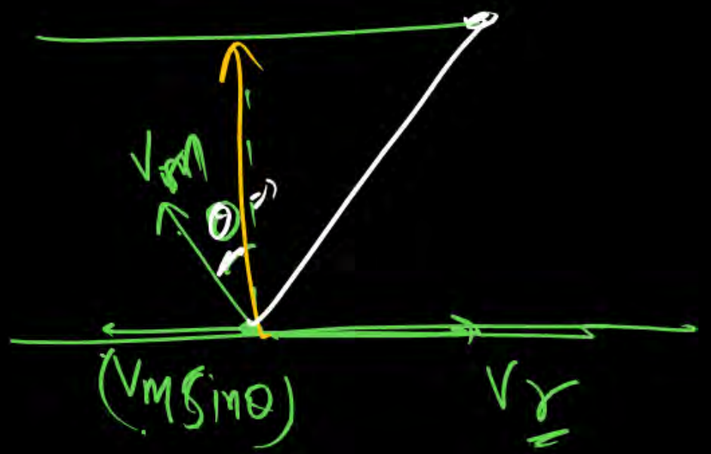
$\theta = 30$



$\alpha = 120$ obtuse angle

(4) If $V_r > V_m$ then find direction of swiming, for minimum Drift:-

Zero Drift is not Possible



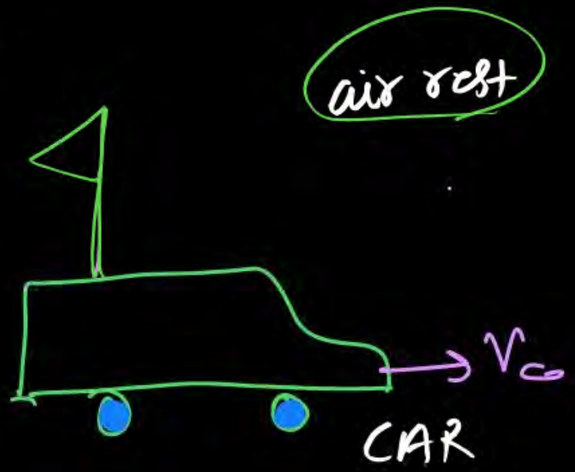
$$\sin\theta = \frac{V_m}{V_r} \quad \frac{\text{(Smaller)}}{\text{(Larger)}}$$

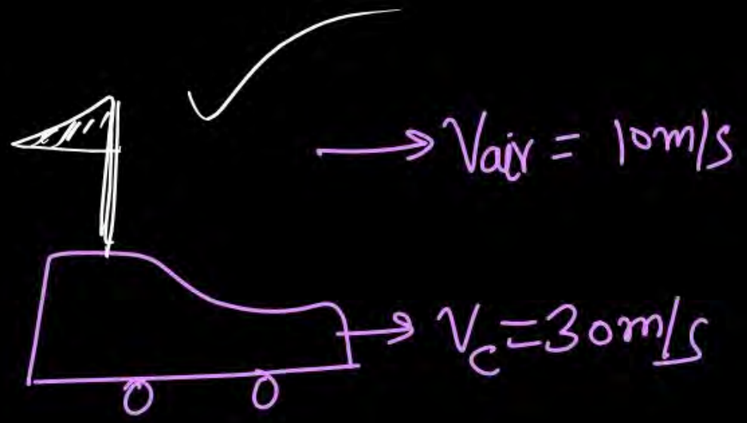
from across on

$$V_m < V_r$$

flag fluttering :—

→ air



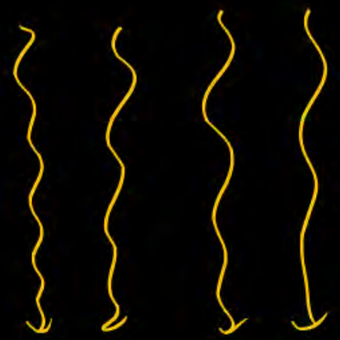


- flag flutters in the direction flow of air.

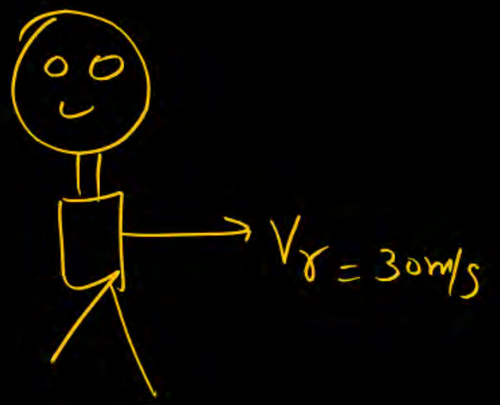
≠

flag flutters in the opposite dirn of motn of CAR

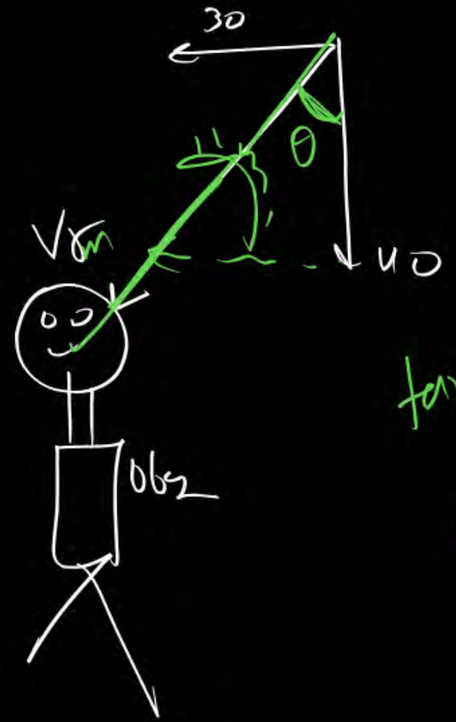
Rain - Man Problem :-



$V_{rain\ ground} = 40\ m/s$



$V_r = 30\ m/s$



$\tan\theta = \frac{30}{40}$

$\tan\theta = \frac{3}{4}$

$\theta = 37^\circ$

MR* Box :-

(1) find $\vec{V}_{Rain\ man}$

$\vec{V}_{RM} = \vec{V}_R - \vec{V}_M$

(2) Draw $\vec{V}_{RM}$ in vector form ⇒ find Angle using $\tan\theta$

(3) use umbrela in direction of $\vec{V}_{RM}$

(4) given velocity of ask kiske respect me hai, yeh thyan se dekhna. ✓

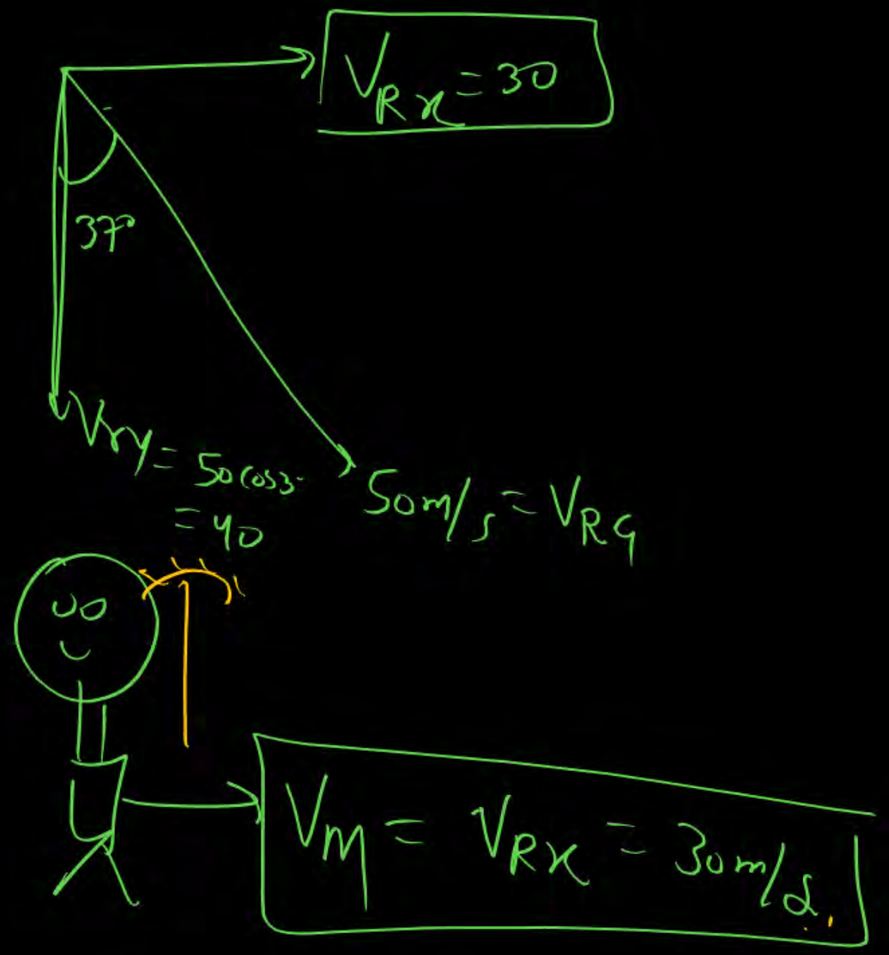
Answer

$\vec{V}_{RM} = -30\hat{i} - 40\hat{j}$

$|V_{RM}| = 50\ m/s$ Ans

Rain is falling with 50m/s at angle 37° from vertical towards east

- man starts running with v_m, then rain appers to fall vertically on his head then find v_m ??



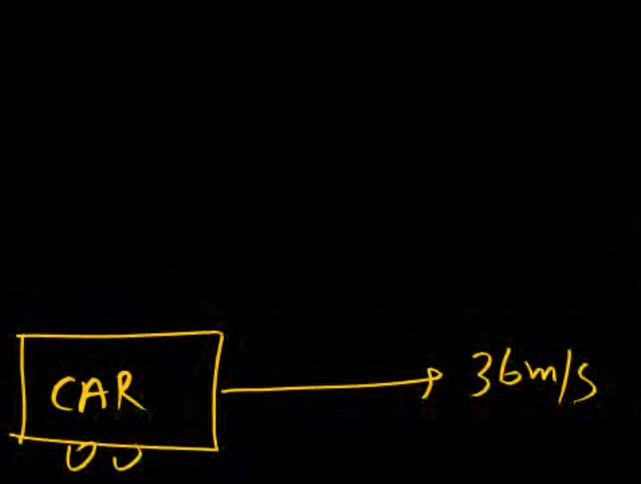
$$\vec{V}_{rm} = 40\ m/s$$

CAR is moving with speed 36 m/s in east & rain is falling at 72 km/hr vertically downward. find Angle at which rain strike to the vertical mirror of CAR.

$$V_{rg} = 72\ km/hr$$

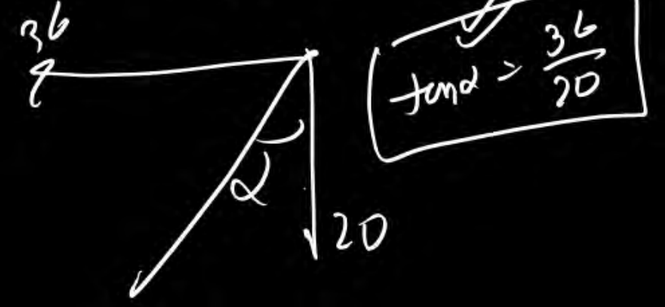
$$= 72 \times \frac{5}{18}$$

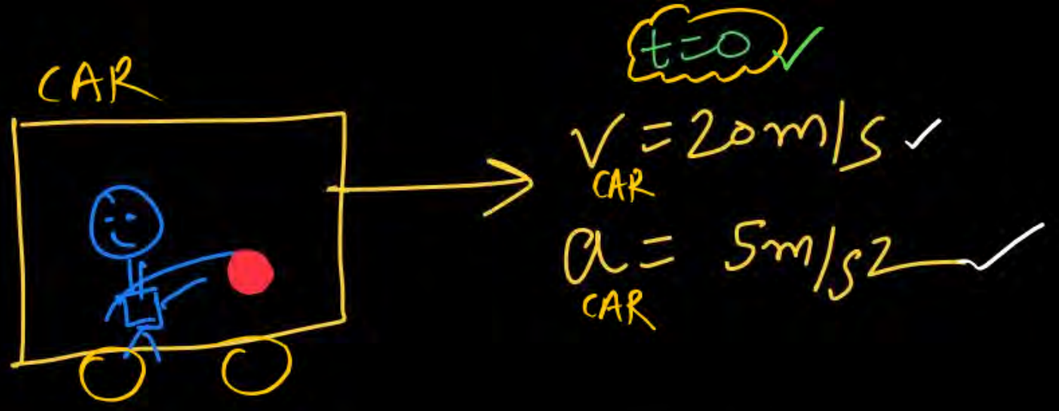
$$= -20\ m/s\ \hat{j}$$



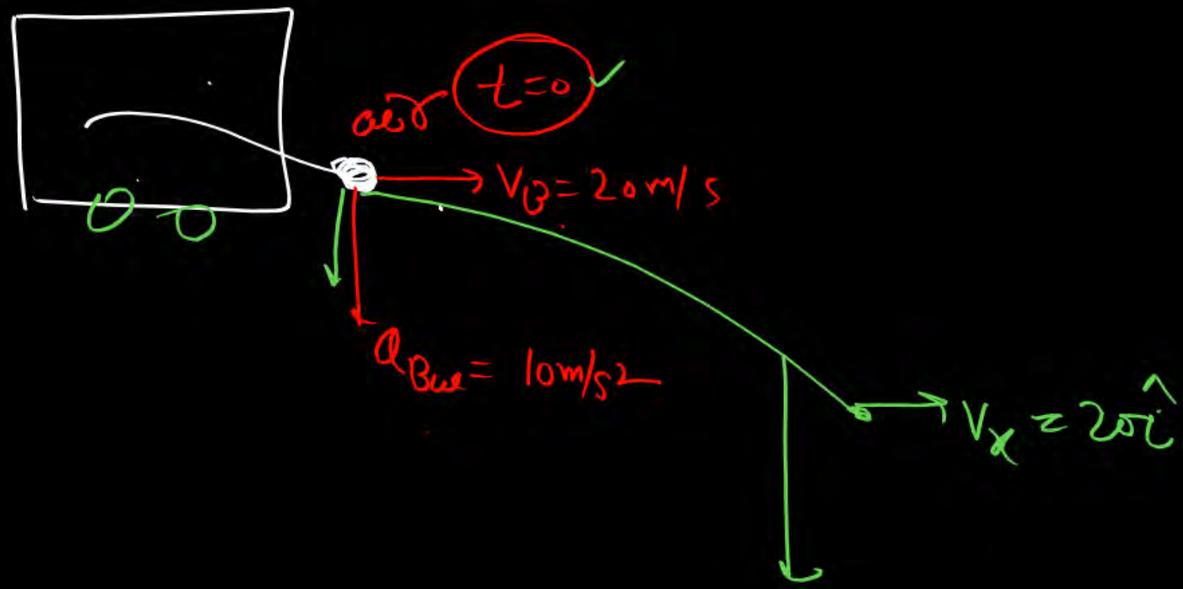
$$V_{R\text{ w.r.t. }CAR} = V_R - V_L$$

$$= -20\hat{j} - 36\ m/s\ \hat{i}$$





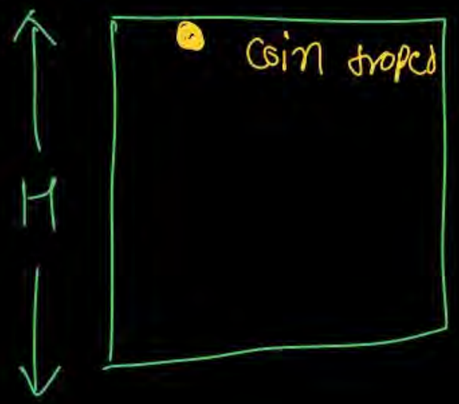
Ball is droped; then find its velocity and acceleration after $t = 4$ sec.



$\vec{V}_{t=4} = 20\hat{i} + 40\hat{j}$

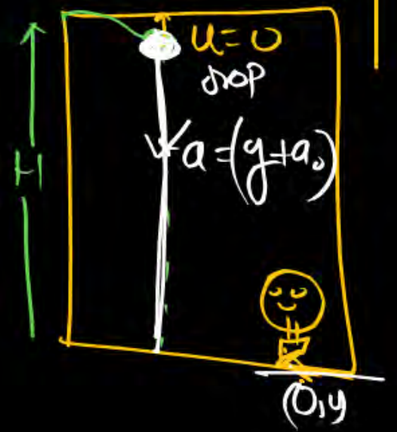
$\vec{a}_{t=4} = +g$ downwards

find time when coin reach to the base of lift.



$a_{lift} = a_0$

velocity of lift $= V_0$



$V_{lift} = V_0$

$a_{lift} = a_0$

$u_{ball\,lift} = 0$

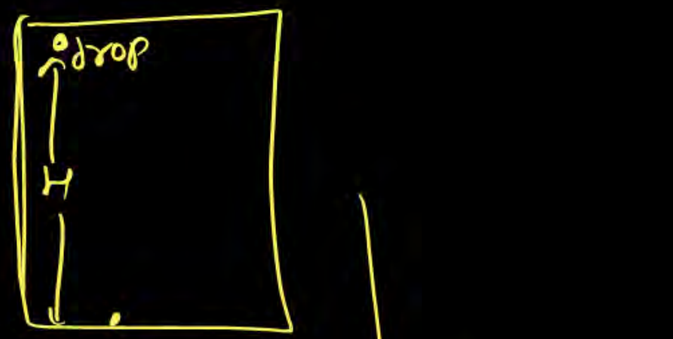
$a_{ball\,lift} = g + a$

$S_{ball\,lift} = H$

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

$H = \frac{1}{2}(g+a)t^2$

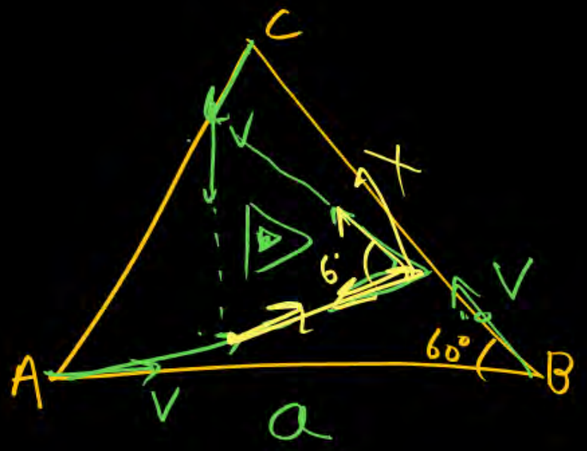
$t = \sqrt{\frac{2H}{g+a}}$ Ans

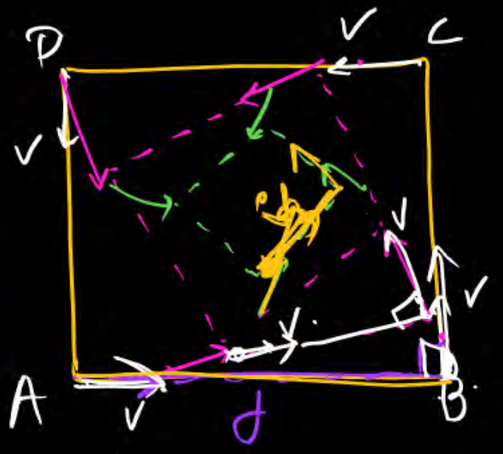


$a_{air} = a_0$

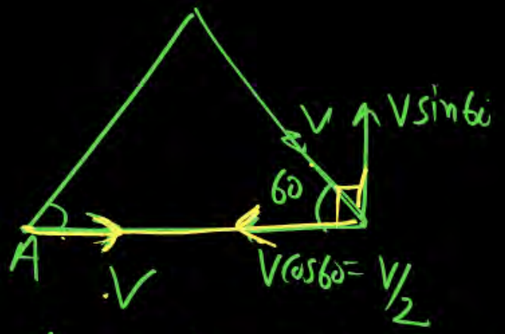
$$t = \sqrt{\frac{2H}{(g-a)}}$$

(Q) Three person standing on Corner of equilateral Triangle, start moving towards each other with speed V then find time when they will meet.

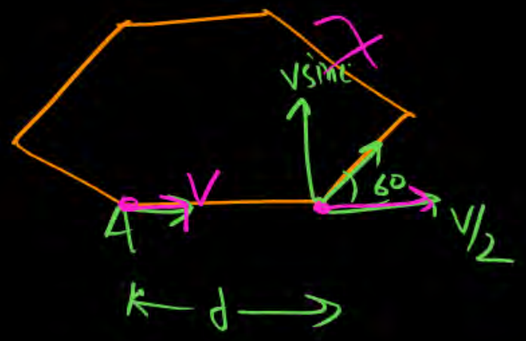




main alag line joinig



$$t = \frac{a}{V+V/2} = \frac{a}{3V/2}$$



$$t = \frac{d}{V - V/2}$$

$$t = \frac{d}{V}$$

THANK YOU