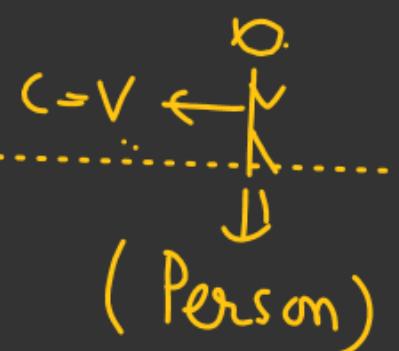
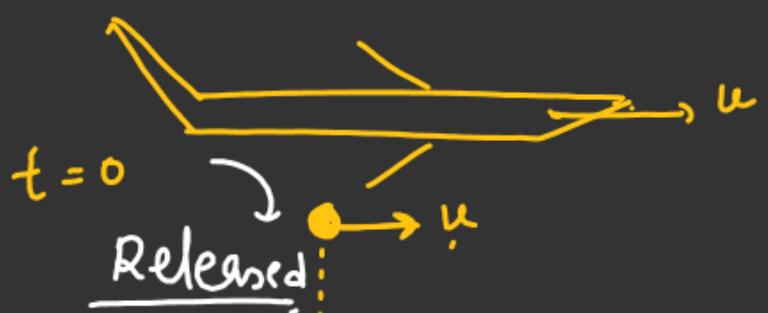




$$\begin{aligned}\vec{v}_{\text{Person}} &= \vec{v}_P - \vec{v}_{\text{person}} \\ &= u\hat{i} - (-v)\hat{i} \\ &= (u+v)\hat{i}.\end{aligned}$$



$$\begin{array}{l}t=0 \rightarrow v \\ u_y=0 \rightarrow u \Rightarrow (u+v) \\ | \downarrow a_y=g.\end{array}$$



$$\begin{aligned}-H &= u_y T - \frac{1}{2} g T^2 \\ T &= \sqrt{\frac{2H}{g}}.\end{aligned}$$

$$x = (u+v) \sqrt{\frac{2H}{g}}$$

$$v = \sqrt{u^2 + v_y^2} \quad v_y = g \sqrt{\frac{2H}{g}}$$

$$v_y = \sqrt{2gH}.$$

u (stop)

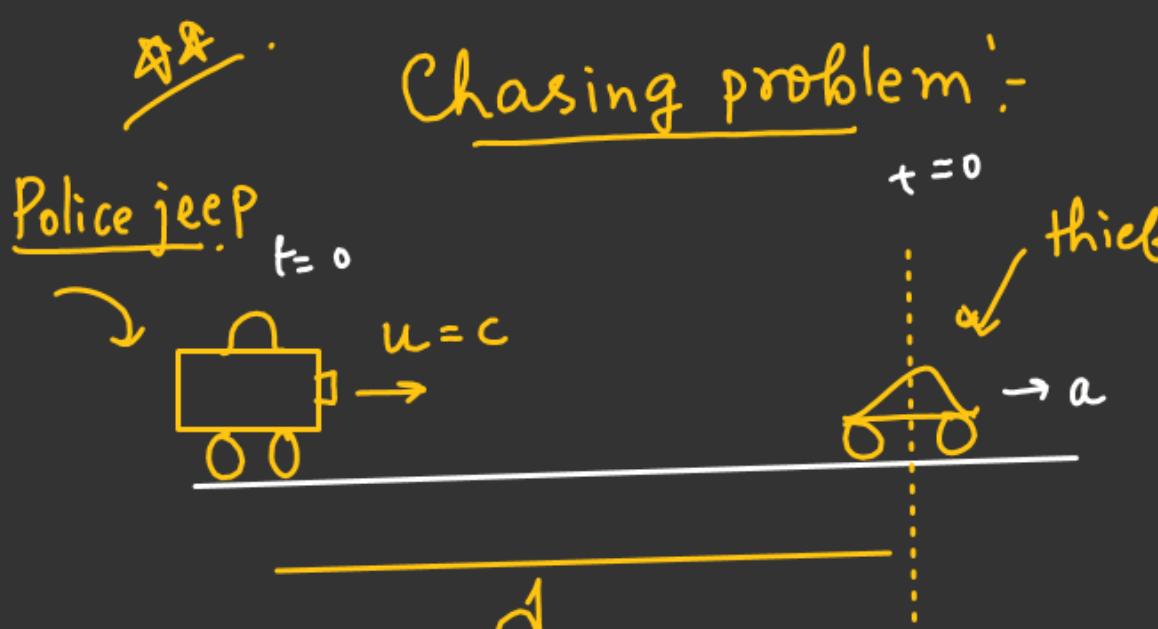
v_y

θ

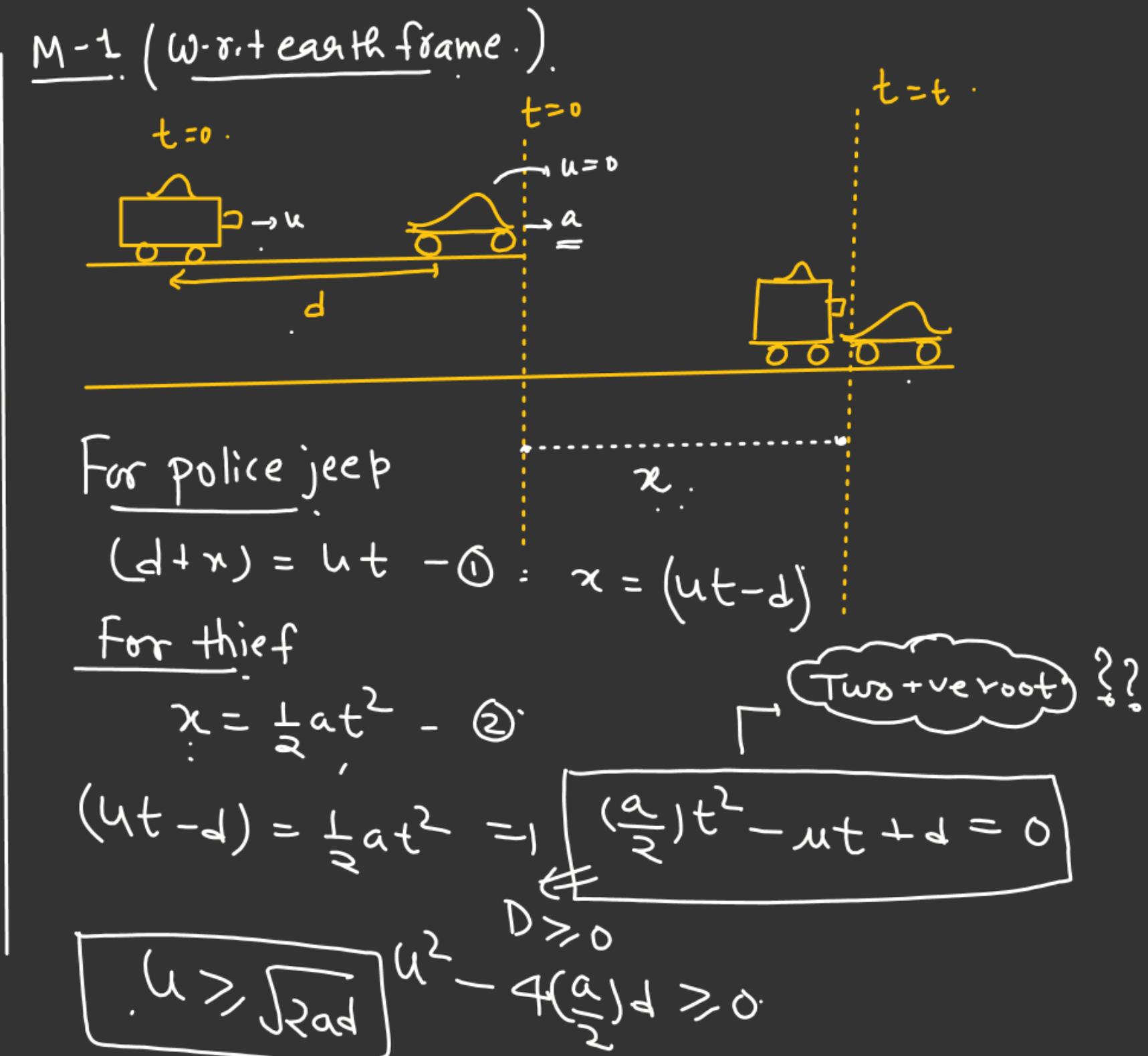
$\tan \theta = \left(\frac{v_y}{u}\right) = \left(\frac{\sqrt{2gH}}{u+v}\right)$

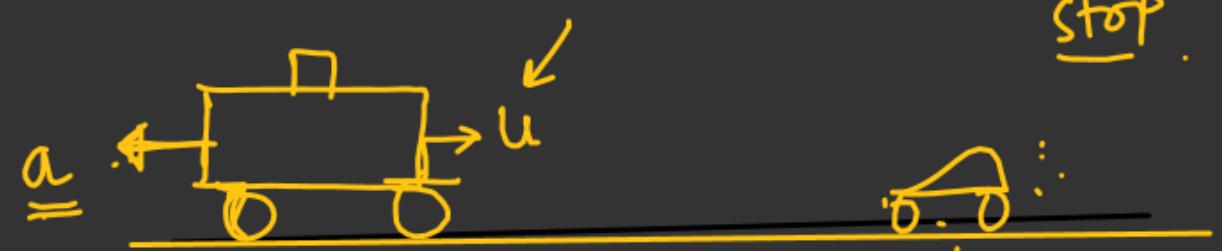
$\theta = \tan^{-1} \left(\frac{\sqrt{2gH}}{u+v}\right)$

$u+v$ correction



When police jeep at a distance ' d ' apart from the thief. it starts its bike with constant acceleration ' a '. What should be the min speed of police jeep to catch the thief.



M-2.By relative velocity

$\leftarrow \frac{d}{\text{Relative distance}} \rightarrow$
 $t=0$

$$V^2 = u^2 - 2ad.$$

$$V = \sqrt{u^2 - 2ad}.$$

$$V > 0.$$

$$u^2 > 2ad$$

$u > \sqrt{2ad}$

At $t=0$.

$$\vec{v}_{\text{police jeep/thief}} = \vec{v}_{\text{police jeep/e}} - \vec{v}_{\text{thief/e}}$$

$$= \underline{\underline{u\hat{i}}}.$$

$$\vec{a}_{\text{police jeep/thief}} = \vec{a}_{\text{police jeep/e}} - \vec{a}_{\text{thief/e}}$$

$$= \underline{\underline{-a\hat{i}}}$$

River Swimmer problem

V_R = velocity of river

V_s = [Velocity of Swimmer w.r.t River
or
Velocity of Swimmer in Still water]

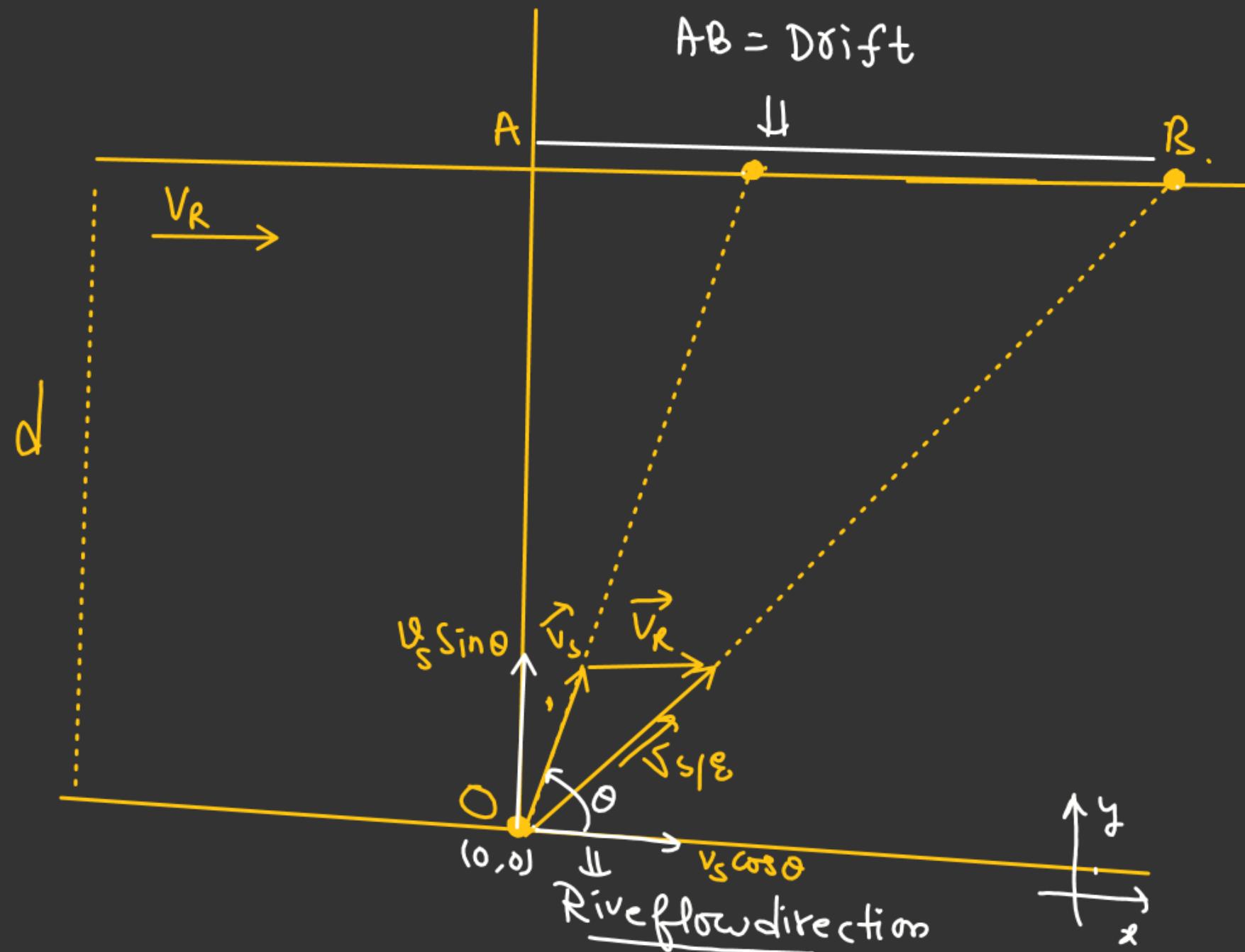
d = width of the river.

[V_R and V_s uniform velocity]

$$\overrightarrow{V_s/\epsilon} = (\overrightarrow{V_s} + \overrightarrow{V_R})$$

$$= V_s \cos \theta \hat{i} + V_s \sin \theta \hat{j} + V_R \hat{i}$$

$$= (\underline{V_R + V_s \cos \theta} \hat{i}) + \underline{V_s \sin \theta \hat{j}}$$



Time of crossing :-

$$T = \frac{d}{|\vec{v}_{s/\epsilon}|_y}$$

$$T = \left(\frac{d}{v_s \sin \theta} \right)$$

Drift :- [Net horizontal distance covered by the swimmer from its starting point]

$$\begin{aligned} \text{Drift} &= (v_{s/\epsilon})_x \times T \\ &= \left[(v_R + v_s \cos \theta) \times \frac{d}{v_s \sin \theta} \right] \end{aligned}$$

Case of Minimum time Crossing

$$T = \frac{d}{v_s \sin \theta}$$

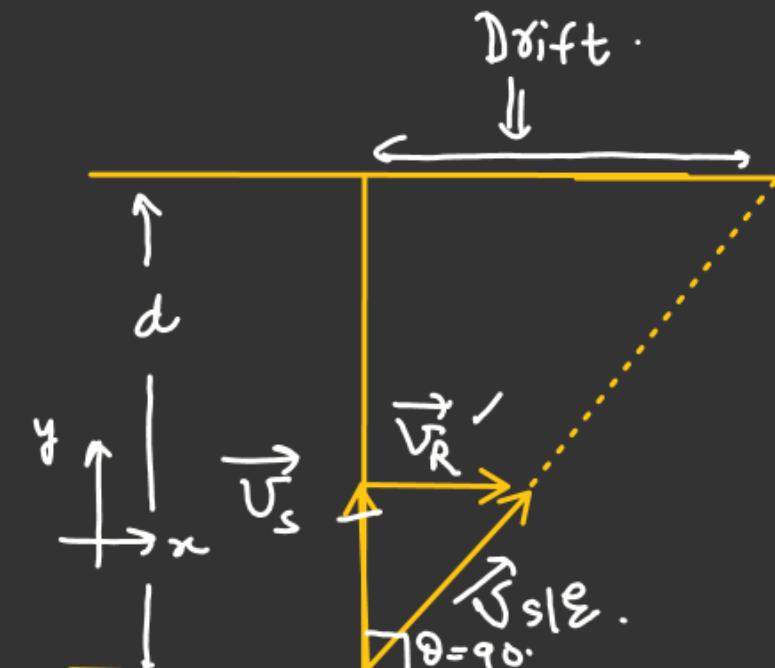
$$T_{\min}, \quad \sin \theta = +1 \quad \theta = 90^\circ$$

$$T_{\min} = \frac{d}{v_s}$$

Drift in case of minimum time of crossing :-

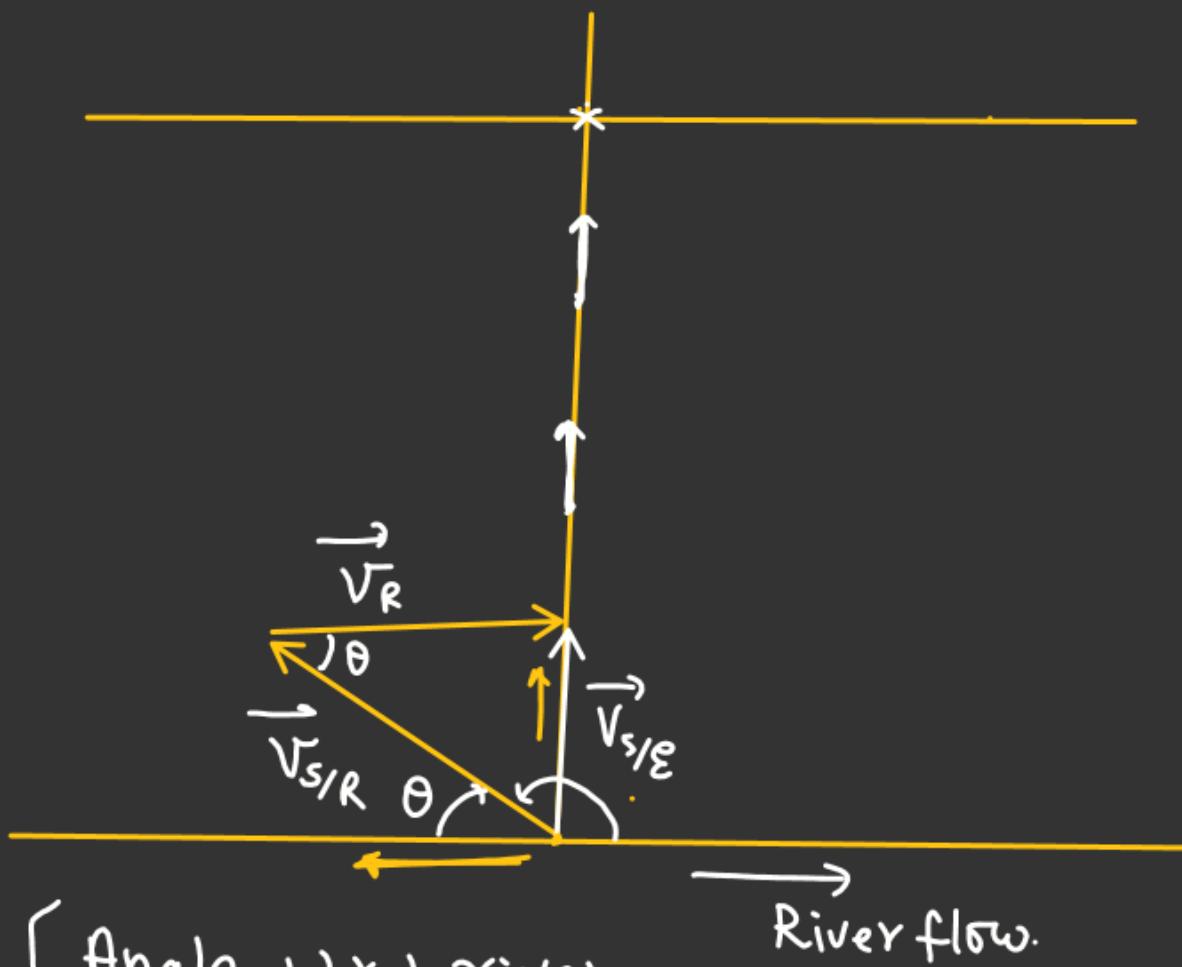
$$D = (v_{s/\epsilon})_x \times T$$

$$D = v_R \times T_{\min} = \left(v_R \times \frac{d}{v_s} \right)$$



$$\begin{aligned} \vec{v}_{s/\epsilon} &= \vec{v}_{s/R} + \vec{v}_{R/\epsilon} \\ &= \underline{\vec{v}_s} + \underline{\vec{v}_R} \end{aligned}$$

Case when Swimmer Reaches directly opposite to bank:-



$$\left[\text{Angle w.r.t. river flow} = (\pi - \theta) \right]$$

$$\vec{V}_{S/R} = -V_s \cos \theta \hat{i} + V_s \sin \theta \hat{j}$$

$$\vec{V}_{R/E} = V_R \hat{i}$$

$$\vec{V}_{S/E} = \vec{V}_{S/R} + \vec{V}_{R/E}$$

$$\vec{V}_{S/E} = (V_R - V_s \cos \theta) \hat{i} + V_s \sin \theta \hat{j}$$

For directly reaching opposite to the bank $(\vec{V}_{S/E})_x = 0$

$$V_R - V_s \cos \theta = 0$$

$$\boxed{\cos \theta = \frac{V_R}{V_s}} \quad \star \star$$

possible only when
 $V_R < V_s$

Time of Crossing

$$T = \frac{d}{V_s \sin \theta}$$



$$\sin \theta = \frac{V_R}{\sqrt{V_s^2 - V_R^2}}$$

$$T = \frac{d \times V_s}{V_s \sqrt{V_s^2 - V_R^2}}$$

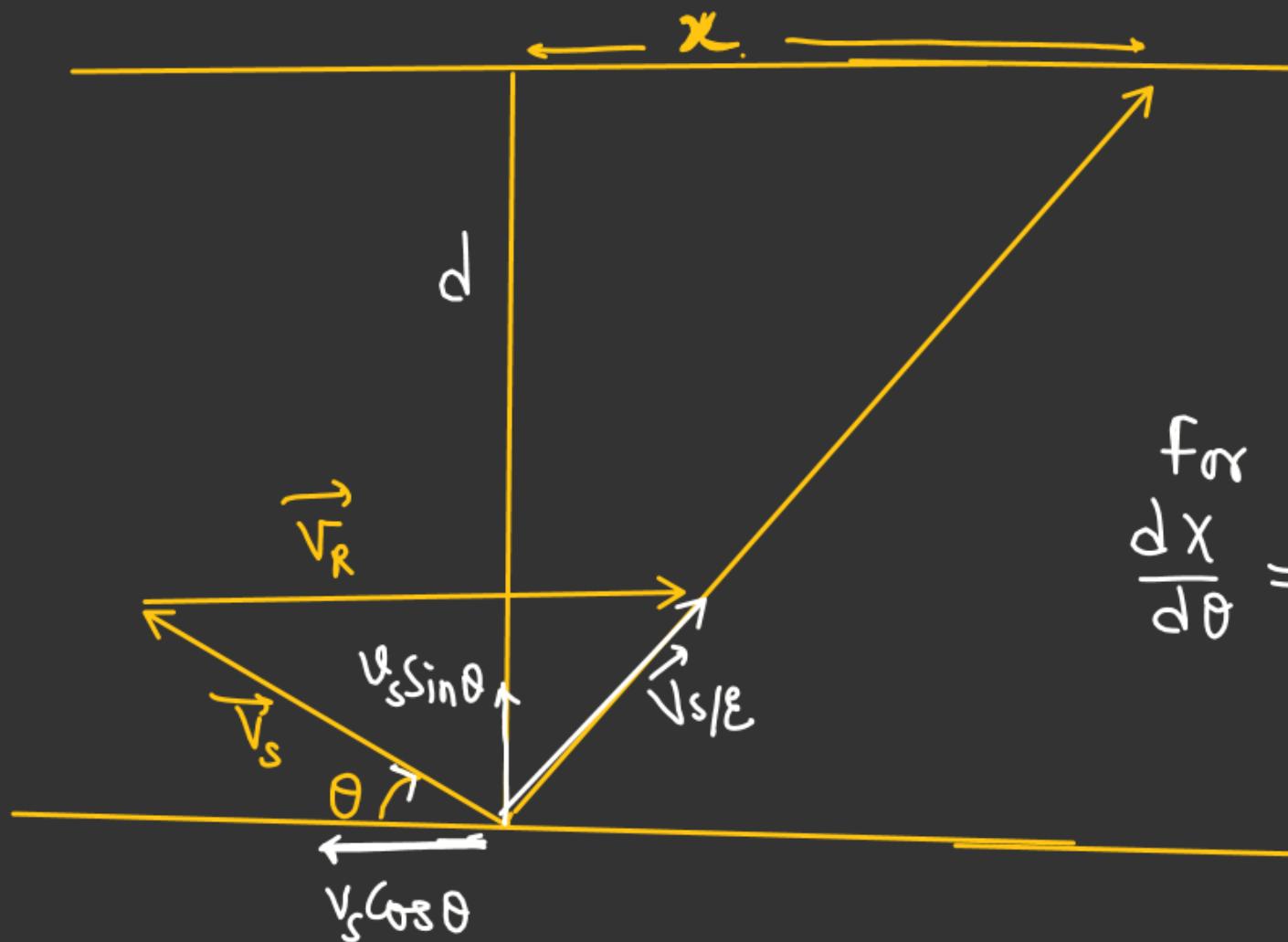
$$\boxed{T = \frac{d}{\sqrt{V_s^2 - V_R^2}}} \quad \star \star$$



Condition for minimum drift

① $V_s > V_R \Rightarrow \text{Drift} = 0$

if $V_s < V_R$



$$\vec{V}_{s/\epsilon} = \frac{\vec{V}_{s/R}}{d} + \vec{V}_{R/\epsilon}$$

$$= -V_s \cos \theta \hat{i} + V_s \sin \theta \hat{j} + V_R \hat{i}$$

$$\vec{V}_{s/\epsilon} = (V_R - V_s \cos \theta) \hat{i} + V_s \sin \theta \hat{j}$$

$\frac{d(\cot \theta)}{d\theta} = -\operatorname{cosec}^2 \theta$
$\frac{d(\operatorname{cosec} \theta)}{d\theta} = -\operatorname{cosec} \theta \cdot \cot \theta$

$$\text{Drift} = (V_{s/\epsilon})_x \times T$$

$$\text{II} = (V_R - V_s \cos \theta) \times \left(\frac{d}{V_s \sin \theta} \right)$$

$$X = \left[\frac{V_R d}{V_s} \operatorname{cosec} \theta - d \cot \theta \right]$$

for X to be maximum or minimum

$$\frac{dX}{d\theta} = 0.$$

$$\frac{V_R d}{V_s} \frac{d(\operatorname{cosec} \theta)}{d\theta} - d \frac{d(\cot \theta)}{d\theta} = 0.$$

$$\frac{V_R d}{V_s} (-\operatorname{cosec} \theta \cdot \cot \theta) + d \operatorname{cosec}^2 \theta = 0$$

~~$$d \csc^2 \theta = \frac{d V_R}{V_s} \csc \theta \cdot \cot \theta$$~~

$$\frac{V_s}{V_R} = \frac{\cot \theta}{\csc \theta}$$

$$\frac{V_s}{V_R} = \frac{\cos \theta}{(\sin \theta)} \times (\sin \theta)$$

** \Downarrow

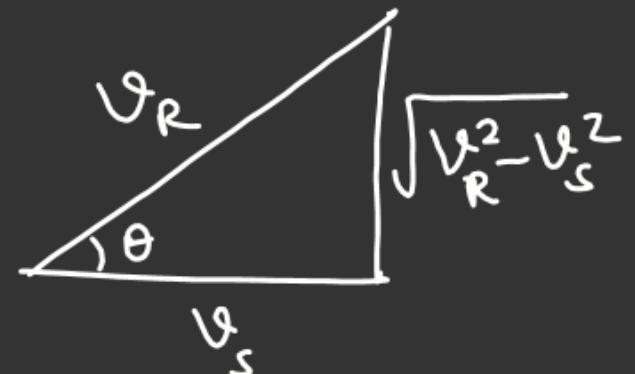
$$\cos \theta = \left(\frac{V_s}{V_R} \right)$$

Condition for minimum drift

Time of Crossing in Case of minimum drift:-

$$T = \left(\frac{d}{V_s \sin \theta} \right)$$

$$\sin \theta = \frac{\sqrt{V_R^2 - V_s^2}}{V_R}$$



$$T = \frac{d}{V_s \times \sqrt{V_R^2 - V_s^2}} \frac{V_R}{V_s}$$

$$\left(T = \frac{d V_R}{V_s} \frac{1}{\sqrt{V_R^2 - V_s^2}} \right)$$

✓