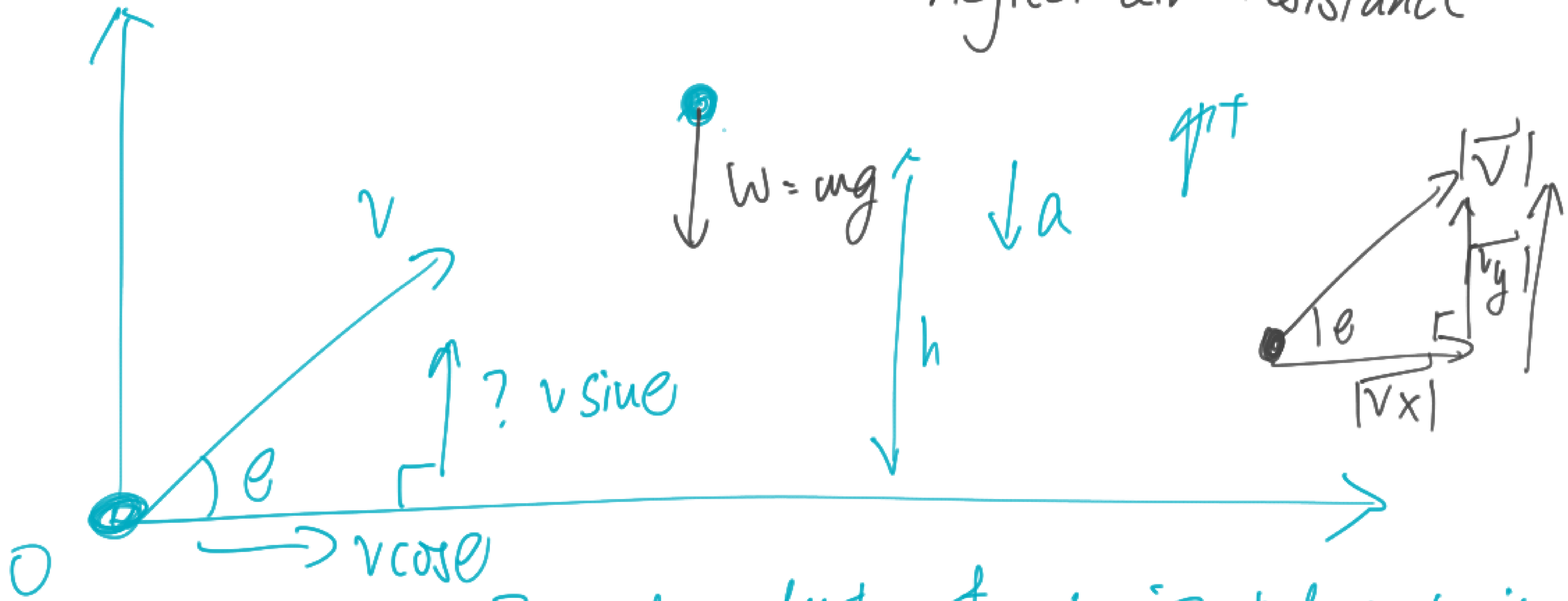
neglect air resistance



vertical velocity is independent of horizontal velocity

y - direction: uv av tv.

$F = mg = ma$

$a = g$

ΔS_y: $\Delta S_y = v\sin\theta\, t - \frac{1}{2} g t^2$

v_y: $v' = u + at$

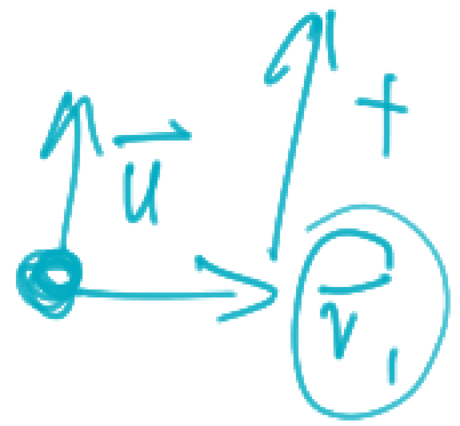
$v' = v\sin\theta\,\cancel{t} - gt$ $\quad a = -g \downarrow \vec{a}$

$F = \frac{GmM}{r^2}$ → distance between 2 obj.

$F = \frac{GmM}{(r+h)^2}$ → $(r+h)(r+h)$ ↓ $r(1+\frac{h}{r})$

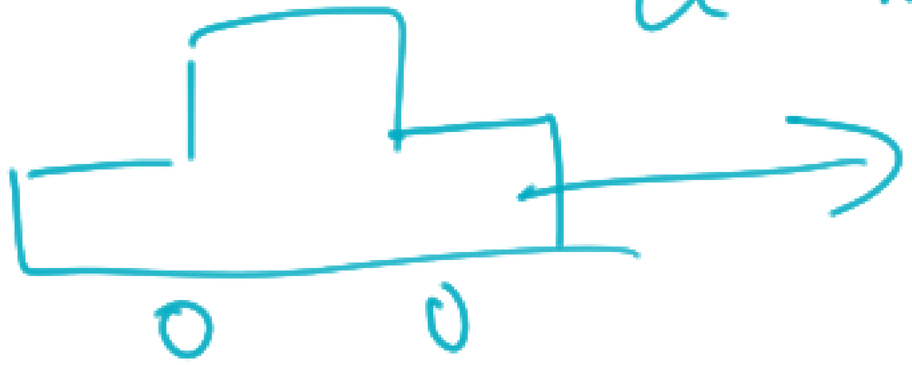
$F = \frac{GmM}{r^2(1+\frac{h}{r})^2}$

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



$t = 0$

$a = 1ms^{-1}$



at rest

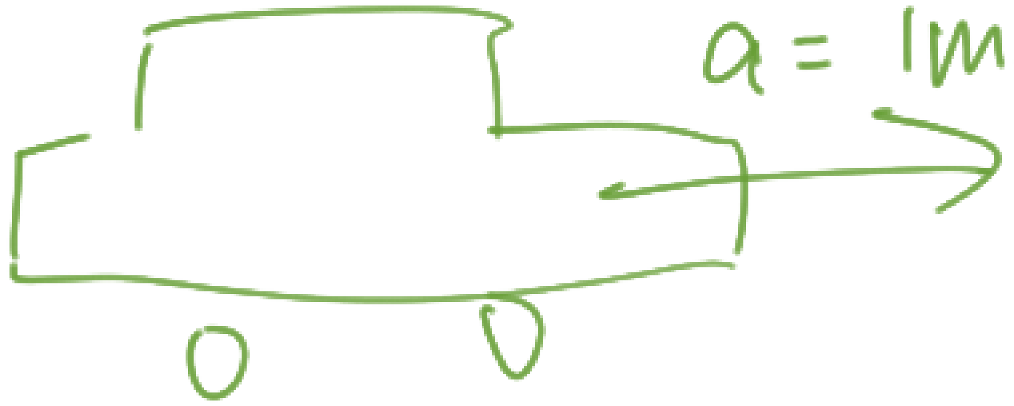
$$\Delta S = \cancel{ut} + \frac{1}{2}at^2$$

(0)

$t = 0$

$v_0 = 1ms^{-1}$

$a = 1ms^{-1}$



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

$$\Delta S(t) = (1)t + \frac{1}{2}(1)t^2$$

y:

$$\Delta S_y = v\sin\theta\, t - \tfrac{1}{2} g t^2$$

$$v_y = v\sin\theta - gt$$

$$\left[\vec{r}(t) = \boxed{\underbrace{v\cos\theta\, t}_{①}}\,\hat{i} + \underbrace{\left(v\sin\theta\, t - \tfrac{1}{2} g t^2\right)}_{\vec{r}(t_f)\cdot\hat{j} = 0}\hat{j}\right]$$

$t' = 0$?

x:

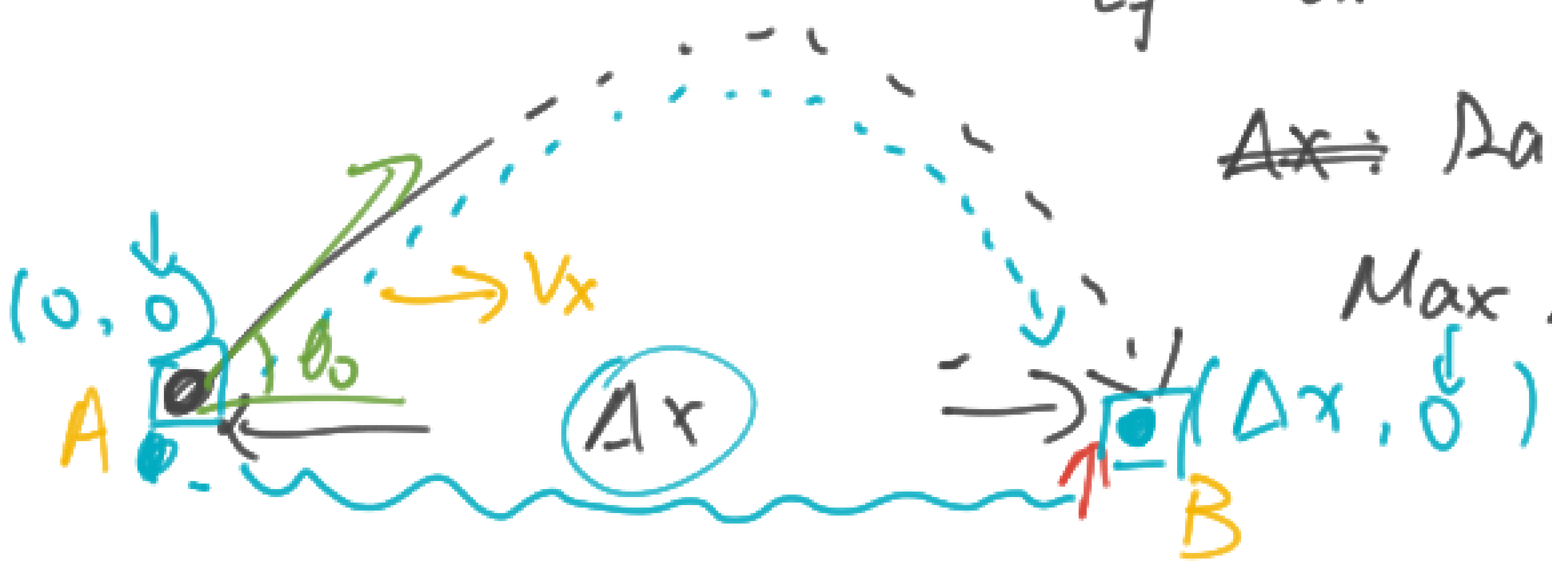
$$\left(\Delta S_x : v\cos\theta\, t\right)$$

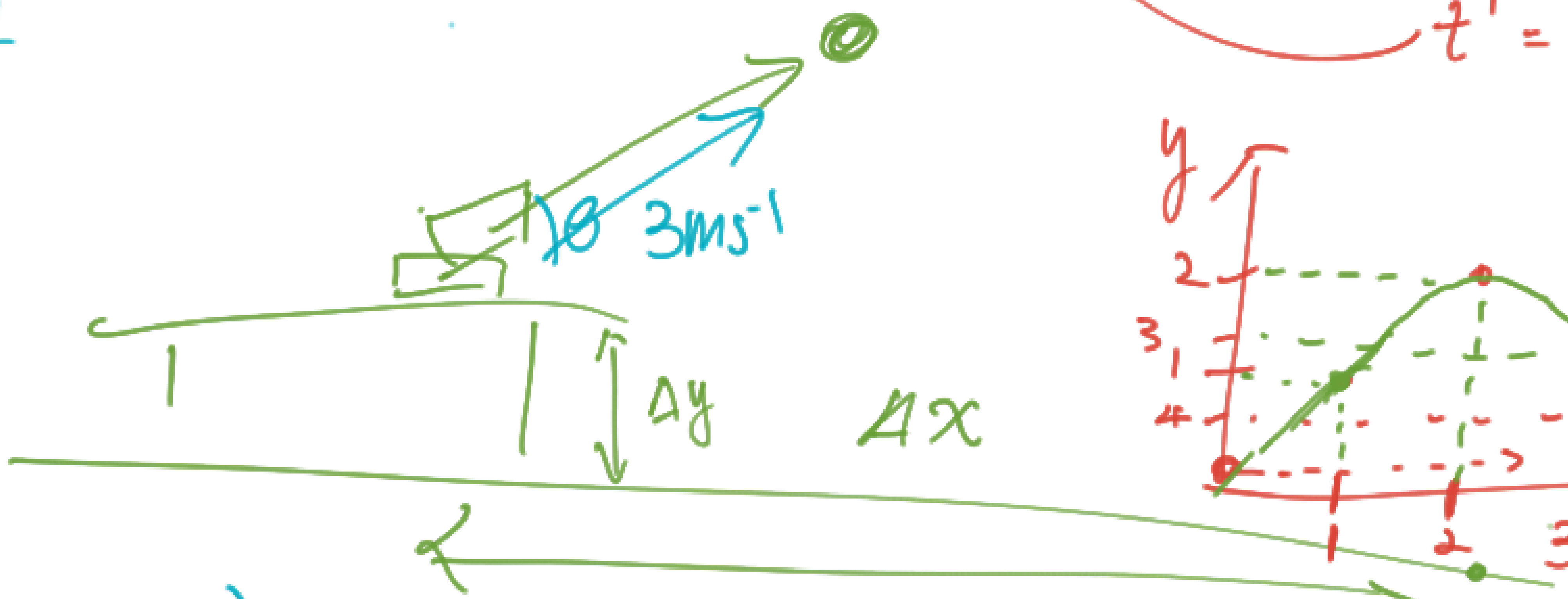
$$v_x : v\cos\theta$$

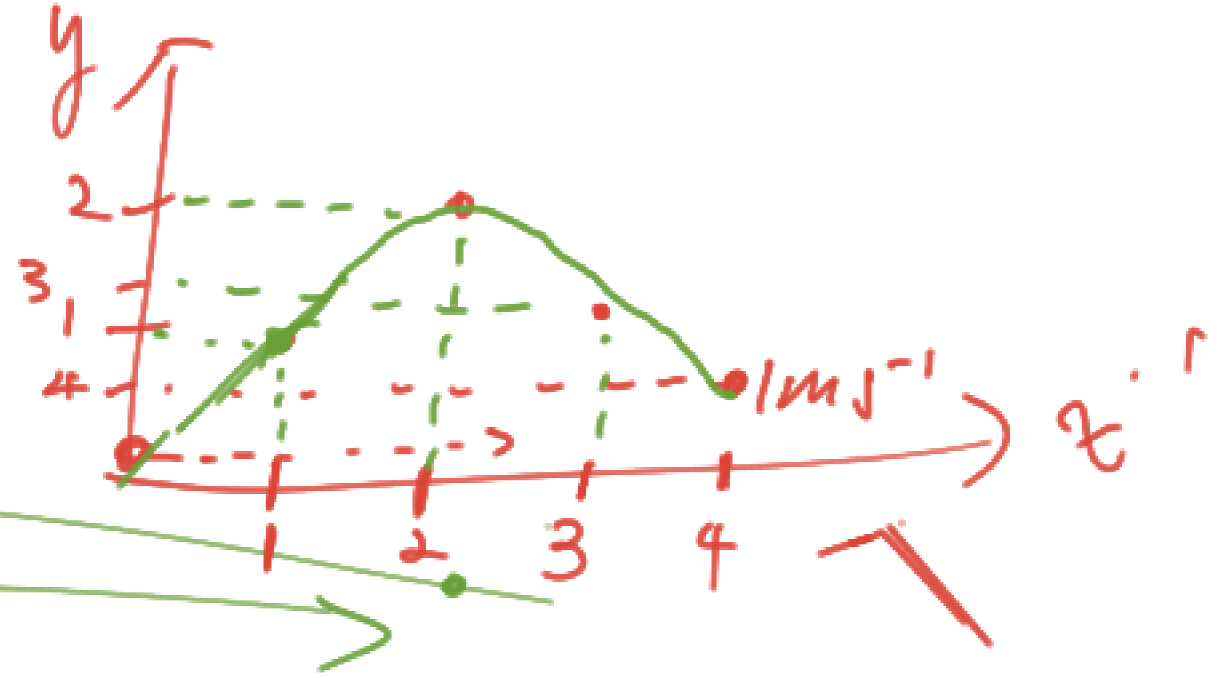
t_f : time of flight

~~Ax~~: Range

Max height







t_f:

$$\Delta S_y = v\sin\theta_0 t - \tfrac{1}{2} g t^2 \quad \{(y\text{-axis})$$

$$0 = v\sin\theta_0 t - \tfrac{1}{2} g t^2$$

$$\left[t\left(v\sin\theta_0 - \tfrac{1}{2} g t\right) = 0\right]$$

① $t = 0$ ② $t = \dfrac{2v\sin\theta_0}{g}$

Range (Δx)

We know:

① How fast the particle is travelling along the x-axis

② How it has been ~~been~~ flying

We want to find:

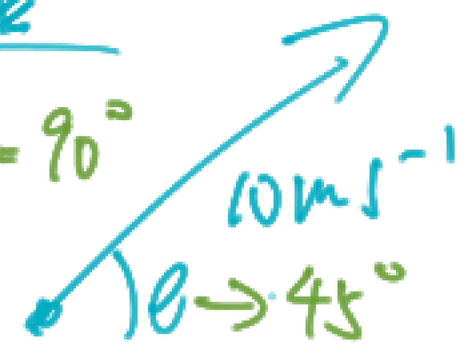
The distance.

$$x(t) = (v\cos\theta)\, t$$

$$x(t_f) = \frac{2v^2[\sin\theta\cos\theta]}{g}$$

$$= \boxed{\frac{v^2\sin 2\theta}{g}}$$

$2\theta = 90°$



Conservation of energy

$$KE \longrightarrow GPE$$

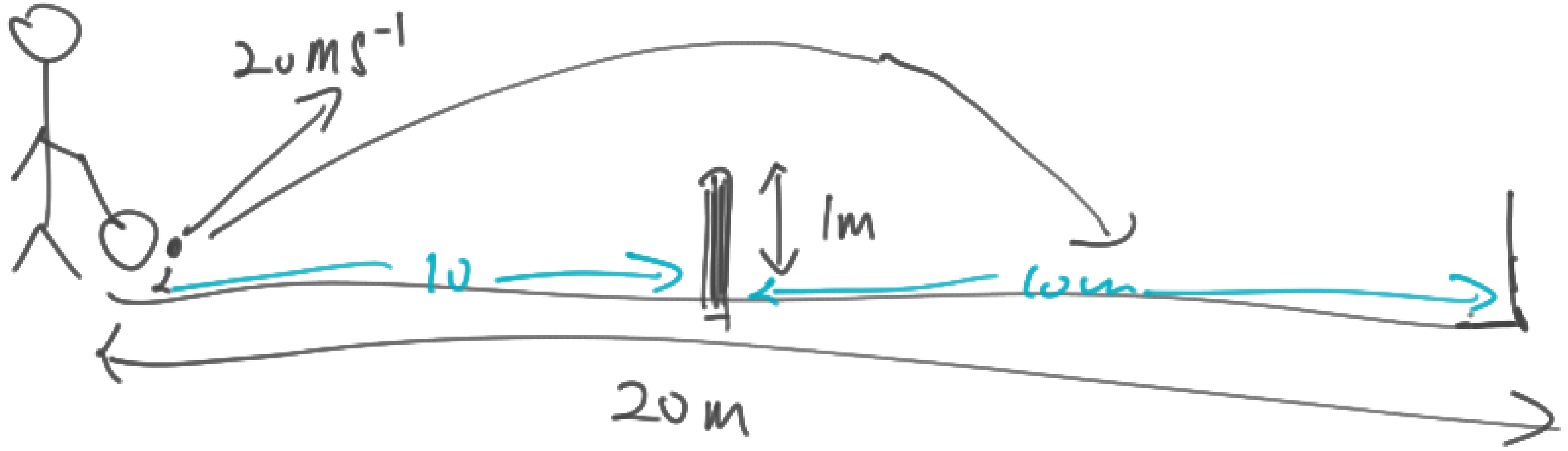
$$\frac{1}{2}\cancel{m}u^2 = \cancel{m}gh$$

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

$$h = \frac{(v\sin\theta)^2}{2g}$$

$$\frac{1}{2}mv^2 = \frac{1}{2}m(v_y)^2 + \frac{1}{2}m(v_x)^2$$

$$\frac{1}{2}mv^2\underbrace{(\cos^2\theta + \sin^2\theta)}_{1}$$



Can it go out of bounds?
(is it possible)

Range? $\frac{v^2 \sin 2\theta}{g}$ ↗ 1

① at what θ does it pass the net?

$$v \cos\theta\, t = 10$$

$$t' = \frac{10}{v \cos\theta}$$

$$S_y = v\sin\theta\, t - \frac{1}{2} g t^2$$

$$1 = \frac{v \sin\theta\, 10}{v\cos\theta} - \frac{1}{2} g \frac{100}{v^2\cos^2\theta}$$

$$1 = 10\tan\theta - \frac{50g}{v^2} \sec^2\theta$$

$$1 = 10\tan\theta - \frac{50g}{v^2}(\tan^2\theta + 1)$$

$$\frac{\sin^2\theta + \cos^2\theta = 1}{\cos^2\theta}$$

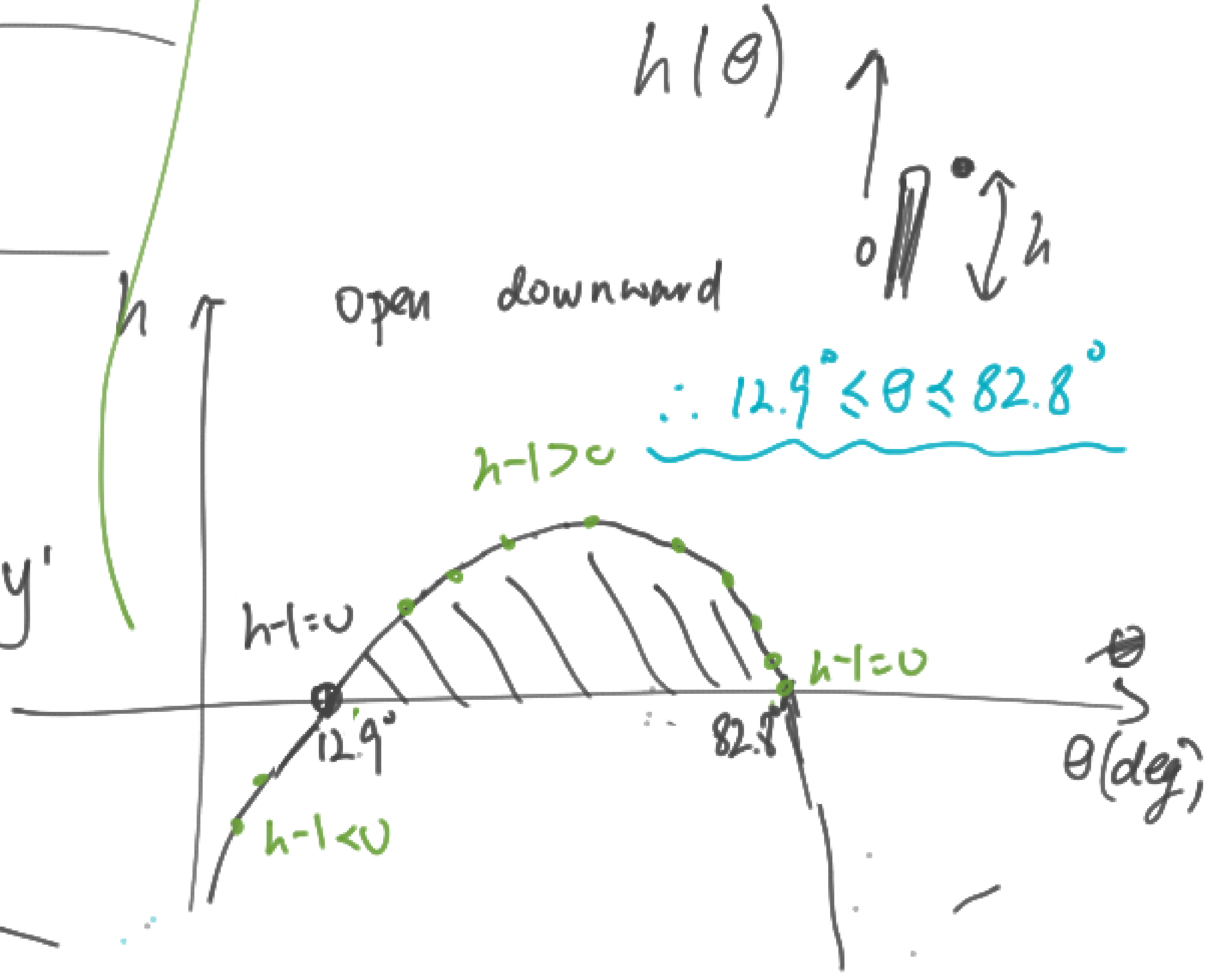
$$\tan^2\theta + 1 = \sec^2\theta$$

$$\cot^2\theta + 1 = \csc^2\theta$$

$$-\frac{50g}{v^2}\tan^2\theta + 10\tan\theta - \frac{50g}{v^2} - 1 = y'$$

$y' = 0$ when $\theta = 12.9^\circ$

or $\theta = 82.8^\circ$



$\therefore 12.9^\circ \leq \theta \leq 82.8^\circ$

$x = v\cos\theta\, t \longrightarrow t = \dfrac{x}{v\cos\theta}$

$y = v\sin\theta\, t - \frac{1}{2}gt^2$

$y = \cancel{v}\sin\theta \dfrac{x}{\cancel{v}\cos\theta} - \frac{1}{2}g \dfrac{x^2}{v^2\cos^2\theta}$

$y = -\dfrac{g}{2v^2}\sec^2\theta\, x^2 + x\tan\theta$ //

Finally, if you really wanted y in terms of x.

Fun Desmos graph

https://www.desmos.com/calculator/ptae5hmgix