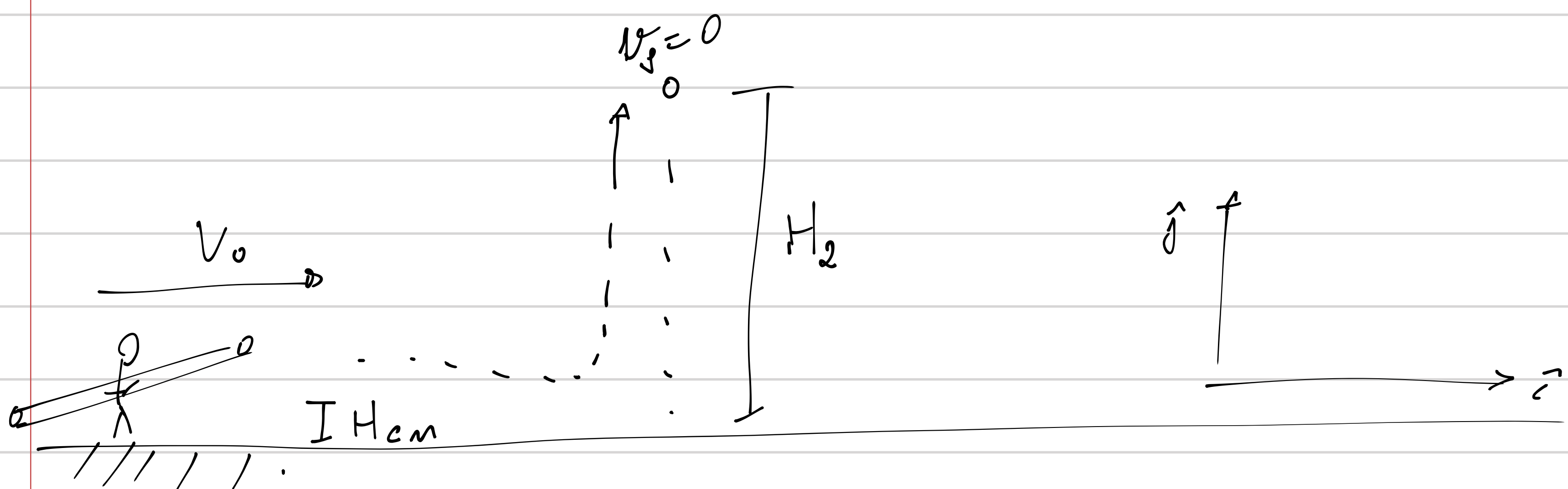
Salto com Vara



Vara → Converter $\underbrace{V_0 = V_0\,\hat{i}}_{\text{antes}}$ em $\underbrace{V_y = V_y\,\hat{j}}_{\text{depois}}$

E_T antes $= \frac{1}{2} m V_0^2 + m g H_{cm}$ ⇒

E_T depois $= \frac{1}{2} m V_y^2 + m g H_2$ ⇒

Se a conversão for eficiente totalmente elástica

$\boxed{E_{TA} = E_{TD}}$ V_y no ponto $H_2 = 0$

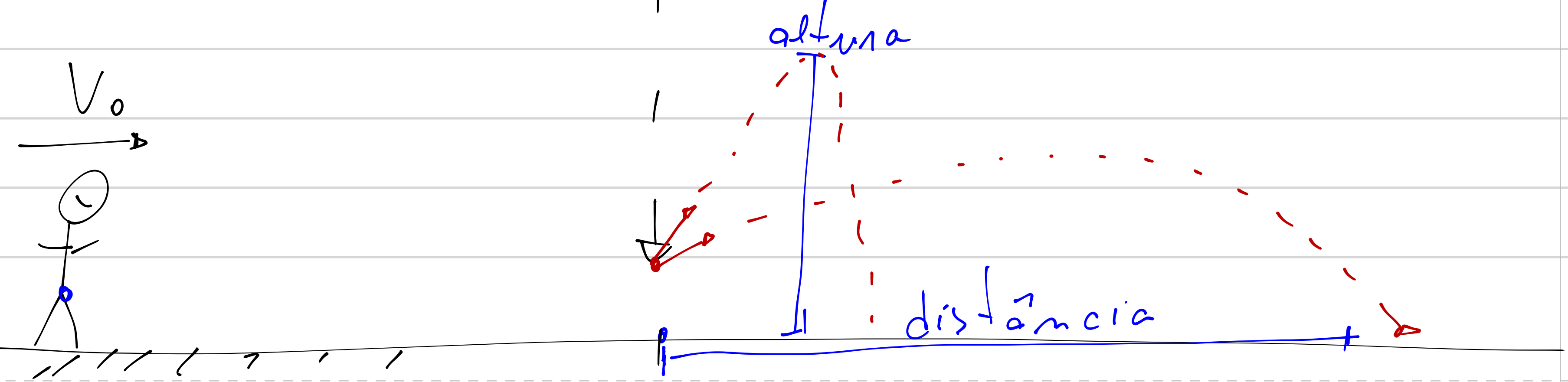
$$\frac{1}{2} \cancel{m} V_0^2 + \cancel{m} g H_{cm} = \cancel{m} g H_2$$

$$\boxed{H_2 = \underline{H_{cm}} + \frac{V_0^2}{2g}}$$

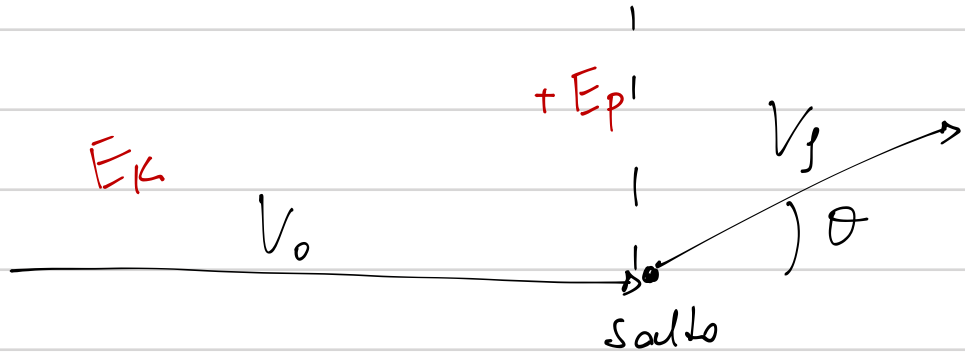
$\boxed{V_0 \text{ alta}}$

$V_0 \simeq 8\text{–}10\ m/s$

Modelo p/ salto em altura e em distância



modelo p/ o salto



Energia contida nas pernas durante o salto

V = decolagem do pulo (calculado na aula anterior)

$$\boxed{\vec{V}_{típico} = 2,5\,\hat{j}}$$

Como varia o valor de V_f p/ diferentes valores de θ

θ = ângulo de ataque do salto

$\theta = 0$ (ñ pulo) $\qquad \vec{V}_0 = \vec{V}_f$

$\theta = \pi/2 \qquad \vec{V}_f = 0 + 2,5\,\hat{j}$

$V_f \Rightarrow$ depende de V_0 e θ $\therefore$

$$\boxed{V_f = V_0\left(1 - \frac{\theta}{\pi/2}\right)} \qquad \theta = \text{rad}$$

$\rightarrow$ modelo p/ a conversão de energia cinética antes p/ depois do salto

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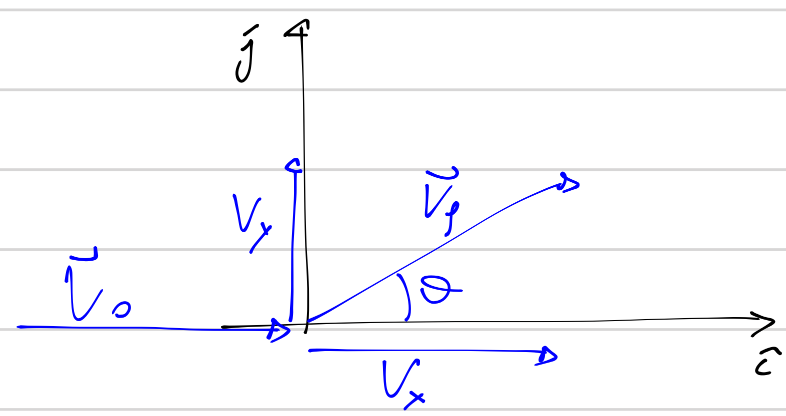
$$\vec{V}_x = V_0\left(1 - \frac{\theta}{\pi/2}\right)\cos\theta\,\hat{i}$$

$$\vec{V}_y = \left[V_0\left(1 - \frac{\theta}{\pi/2}\right)\operatorname{sen}\theta + 2,5\right]\hat{j}$$



um valor típico da corrida antes do salto $V_0 = 10$ m/s

$$\boxed{\vec{V} = 10\left(1 - \frac{\theta}{\pi/2}\right)\cos\theta\,\hat{i} + \left[10\left(1 - \frac{\theta}{\pi/2}\right)\operatorname{sen}\theta + \boxed{2,5}\right]\hat{j} \neq 0}$$

p/ $\theta = 0,71$ rad

p/ salto em altura $V_y \Rightarrow$ máximo

$$\frac{dV_x}{d\theta} = 0 \Longrightarrow \theta \text{ q gerará } V_y \text{ MAX}$$

$$V_y = 10\,\text{sen}\,\theta - \frac{10\,\theta}{\pi/2}\,\text{sen}\,\theta + 2{,}5$$

$$\frac{dV_y}{d\theta} = \frac{10\cos\theta}{\cos\theta} - \frac{20}{\pi/2}\left(\frac{\text{sen}\,\theta}{\cos\theta} + \frac{\theta\cdot\cos\theta}{\cos\theta}\right) + 0 = 0 \quad +2{,}5$$

$\div \cos\theta \Rightarrow$

$$\frac{\pi \cdot (1)}{2} - \left(\frac{\text{sen}\,\theta}{\cos\theta} + \theta\right) = 0 \quad + \frac{2{,}5\cdot\pi}{2}$$

$$\pi/2 - tg\,\theta - \theta = 0 \qquad \boxed{tg\,\theta + \theta - \pi/2 = 0}$$

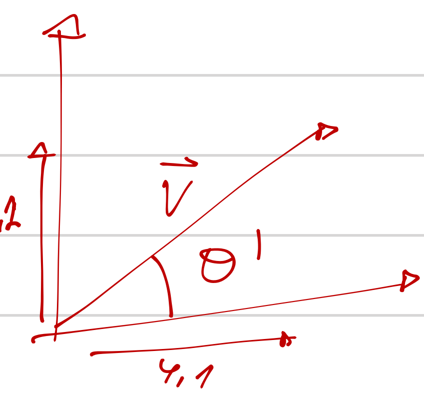
numericamente $\theta = 0{,}71$ rad ou 41°

$\theta =$ diferente

$$\vec{V} = V_x\hat{i} + V_y\hat{j} = 4{,}1\,\hat{i} + 6{,}1\,\hat{j}$$

$$V_j^2 = V_x^2 + V_y^2 = (4{,}1)^2 + (6{,}1)^2 = 7{,}34\ m/s$$

$$\cos\theta' = \frac{4{,}1}{7{,}34} = \boxed{\theta' = 56^\circ}$$



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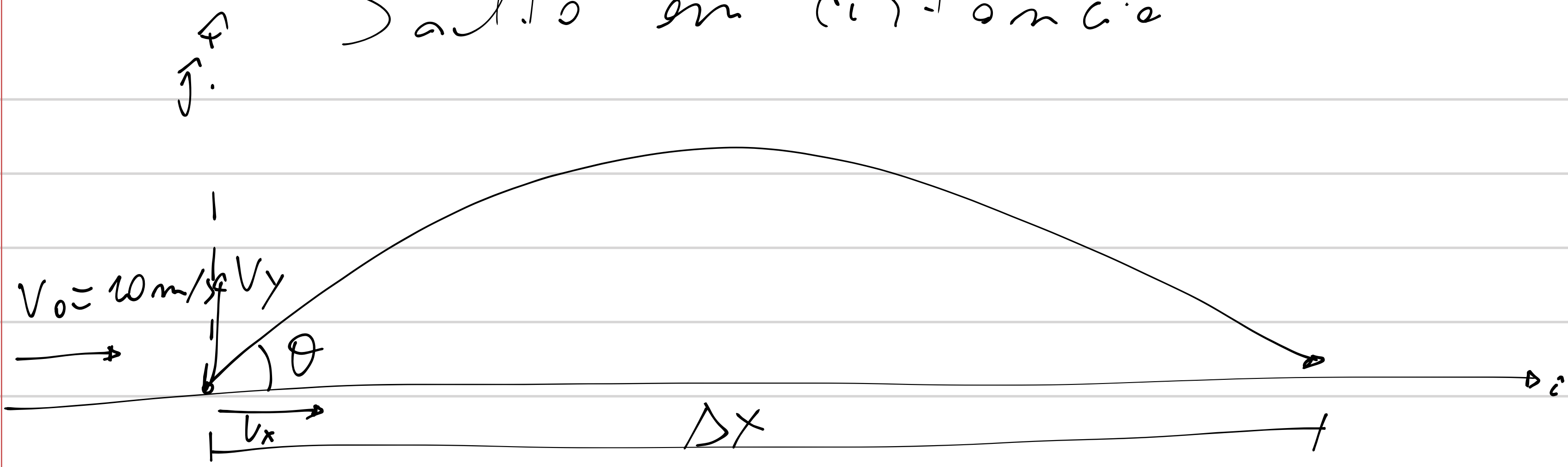
afinal em qual θ um atleta salta?

na prática $\Rightarrow$ saltam a 60°

Salto em distância



$$\vec{V} = \underbrace{10\left(1-\frac{\theta}{\pi/2}\right)\cos\theta\ \hat{i}}_{V_x} + \underbrace{\left[10\left(1-\frac{\theta}{\pi/2}\right)\operatorname{sen}\theta + 2{,}5\right]}_{V_y}\hat{j}$$

$$\boxed{\Delta X = V_x \cdot \Delta t}$$

para o salto $y = y_0$

$$y = y_0 + V_{0y}t + \frac{1}{2}at^2$$

$$0 = V_y \cancel{t} - \frac{g}{2}t^{\cancel{2}}$$

$$\boxed{t = \frac{2V_y}{g}}$$

Δt = tempo do voo (salto)

$$\Delta X = V_x\left[\frac{2V_y}{g}\right] =$$

$$\Delta X = \left[10\left(1-\frac{\theta}{\pi/2}\right)\cos\theta\right]\cdot\left[\frac{2}{g}\right]\cdot\left[10\left(1-\frac{\theta}{\pi/2}\right)\operatorname{sen}\theta + 2{,}5\right]$$

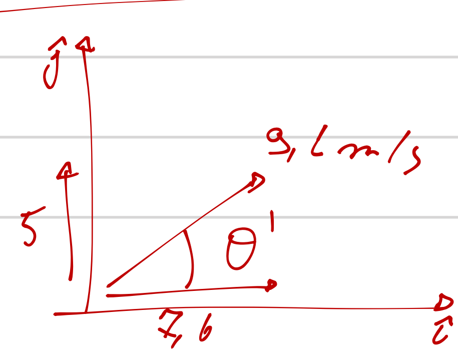
p/ saltar longe eu preciso

$$\frac{d\Delta X}{d\theta} = 0 \qquad \theta \Rightarrow q\ \text{dá}\ \Delta X\ \text{máx}$$

Solução $\boxed{\theta = 18°}$

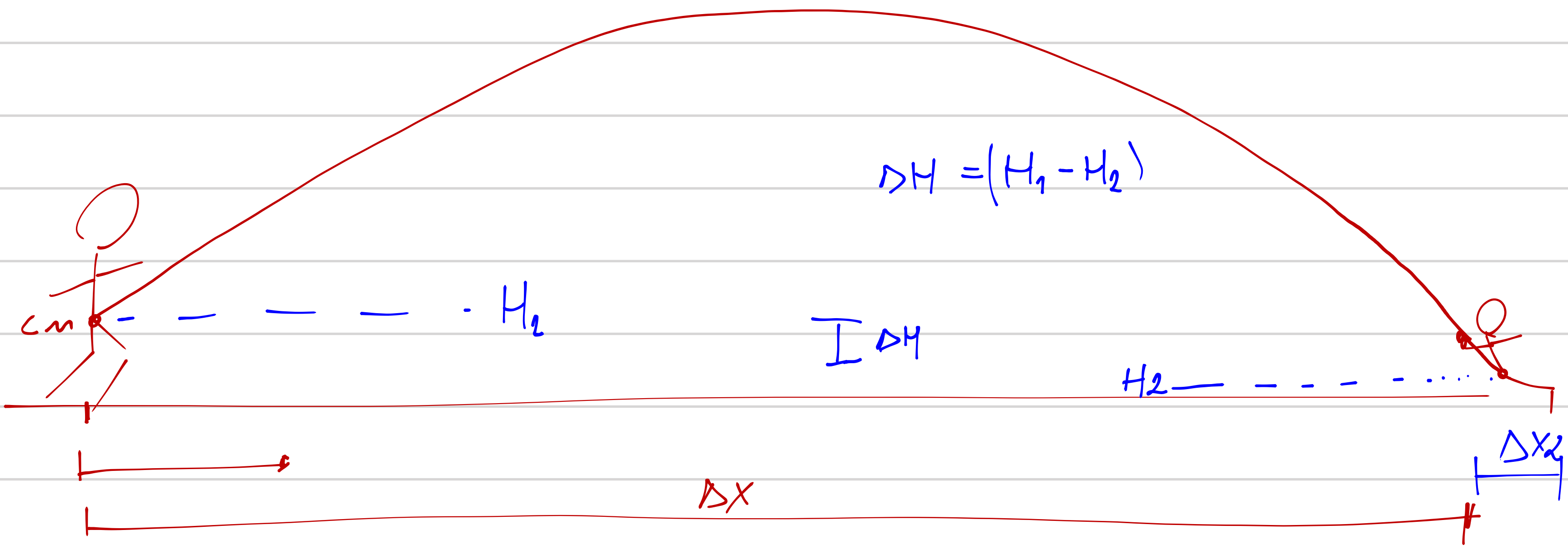
$V_x = 7{,}6\ m/s$

$V_y = 5\ m/s$



$\boxed{\theta' = 33°}$

$\boxed{\text{atleta salta a } 20°}$



ref. "Kinematics of the long jump"
author A. Tan
J. Zumerchik