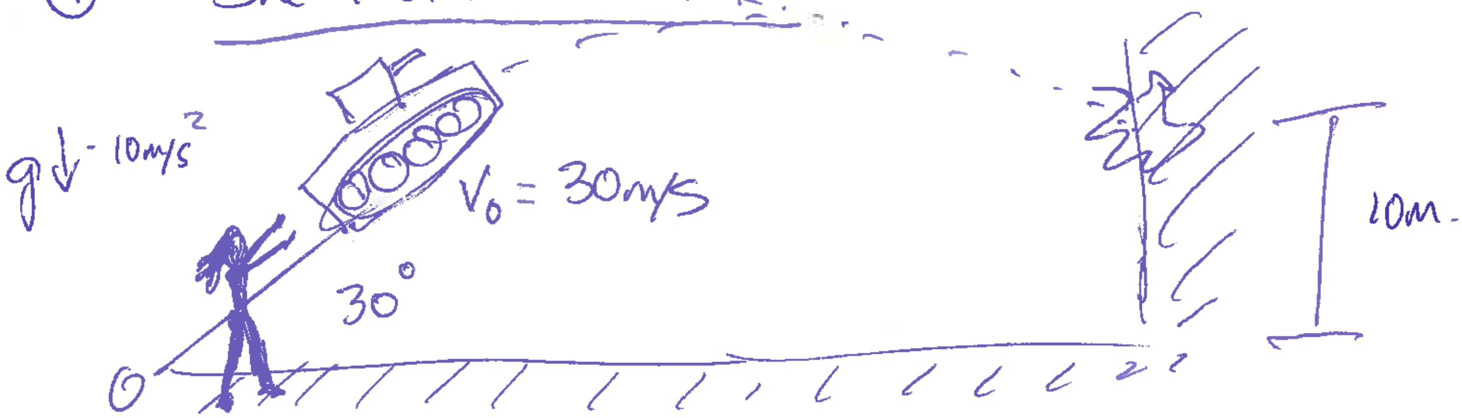
① She-Hulk vs. Tank



In projectile motion, $\Delta(K+U) = 0$.

$$K_1 + U_1 = K_2 + U_2$$

$$\frac{1}{2}mv_0^2 + mgh = \frac{1}{2}mv_f^2 + mgh$$

mass cancels out.

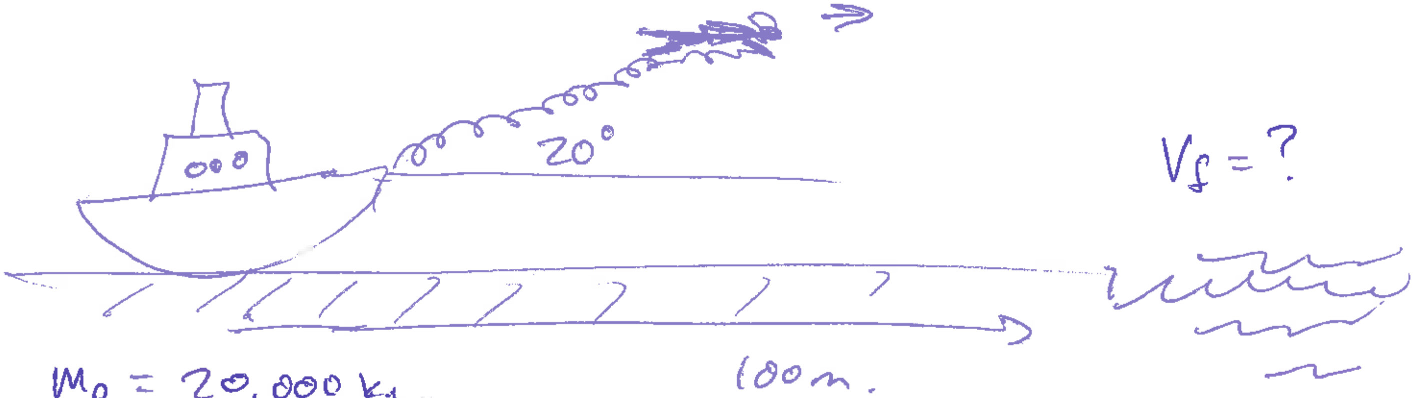
$v_0 = 30$ m/s, $h_1 = 0$, $g = 10\ m/s^2$, $h_2 = 10$ m

$$\frac{1}{2}(30\,m/s)^2 = \frac{1}{2}v_f^2 + 100\,m^2/s^2$$

$$v_f^2 = (450\,m^2/s^2 - 100\,m^2/s^2)\cdot 2 = 700\,m^2/s^2$$

$$\boxed{v_f = 26.5\,m/s}$$

(2)



$m_B = 20{,}000 \text{ kg}$

$|F_{PG}| = 10{,}000 \text{ N}$ @ $20°$ from horizontal

No friction

$$K_1 + U_1 + W_{other} = K_2 + U_2$$

($K_1 = 0$, $U_1 = 0$, $K_2 = \frac{1}{2}mv^2$, $U_2 = 0$)

$$W_{other} = \vec{F} \cdot \vec{s} = |F| \cos 20° \cdot 100 \text{ m}$$

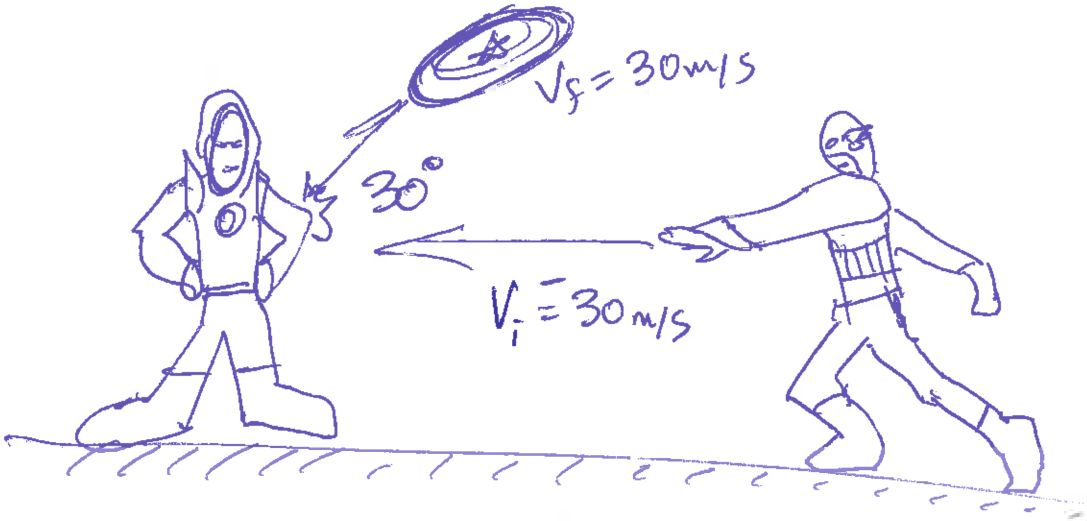
$$= 10{,}000 \cdot 100 \cdot (0.94) \cdot \text{J}$$

$$= 939692 \text{ J} = \frac{1}{2} m_B V_B^2$$

$$V_B^2 = 94 \text{ m}^2/\text{s}^2$$

$$\boxed{V_B = 9.7 \text{ m/s}}$$

(3)



$m_s = 5 kg.$

Impulse - momentum

$\vec{J} = \Delta \vec{p} = \vec{p}_f - \vec{p}_i \qquad \vec{p} = m_s \vec{v}$

x: $J_x = P_{fx} - P_{ix} = m_s(V_f \cdot \cos 30° - -30 m/s)$

$= 5 kg (30 m/s (0.866) + 30 m/s)$

$= 5 kg \cdot (56 m/s) = 280 \; kg \cdot m/s$

y: $J_y = P_{fy} - P_{iy} = m_s (V_f \cdot \sin 30° - 0)$

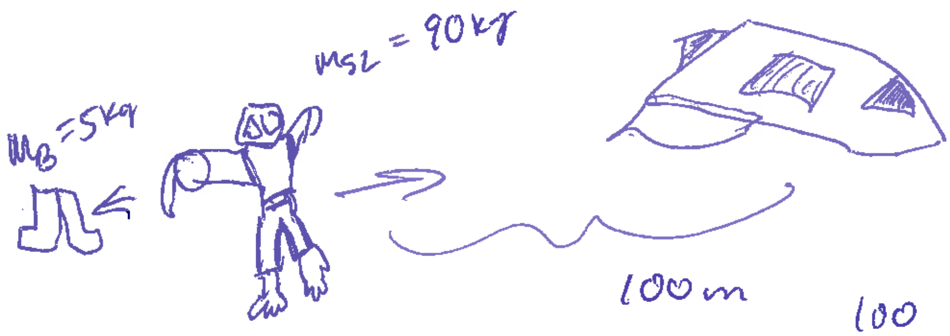
$= 5 kg (30 m/s \cdot (0.5))$

$= 75 \; kg \cdot m/s$

$|J| = \sqrt{75^2 + 280^2} = \boxed{290 \; kg \cdot m/s}$

$\theta = \arctan\left(\frac{J_y}{J_x}\right) = \tan^{-1}\left(\frac{75}{280}\right) = \boxed{15°}$

(4) Starlord in Space



$V_0 \leftarrow 0.1 m/s$

0

$$100m = X_0 + V_f t \quad (X_0 = 0,\ t = 5 min = 300 sec.) \Rightarrow V_f = 0.33 m/s$$

$$V_f = V_{SL} + V_0$$

$V_{SL} = ?$, $V_0 = 0.1 m/s$

$$V_{SL} = 0.43 m/s$$

$$\Delta P = 0 \Rightarrow m_B V_B = m_{SL} V_{SL}$$

$$5kg \cdot V_B = 90 kg \cdot 0.43 m/s$$

$$\boxed{V_B = 7.74 \ m/s}$$

Not easy, but he can do it!

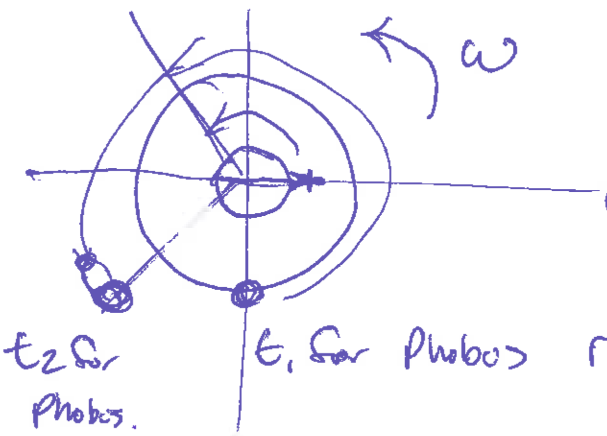
5 Moons of Mars: Phobos

Period Phobos = 0.319 days

Mars Revolution = 24 hrs + 40 minutes.

$$\Rightarrow \omega_p = \frac{2\pi \text{ rad}}{0.319 \text{ days}} = \frac{2\pi \text{ rad}}{7.656 \text{ hrs}} = 0.820 \text{ rad/hr.}$$

$$\omega_M = \frac{2\pi \text{ rad}}{24.67 \text{ hrs}} = 0.255 \text{ rad/hr.}$$



Rising: $\Theta_{p,1} = -\frac{\pi}{2}$ rad.

Setting $\Theta_{p,2} = \Theta_m + \frac{\pi}{2}$

$$\Theta_m = \omega_m \cdot t$$

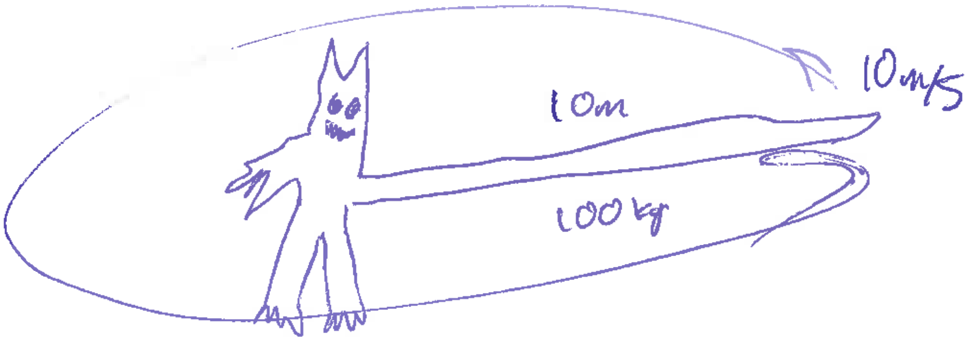
$$\Theta_p = -\frac{\pi}{2} + \omega_p t$$

$$\Rightarrow -\frac{\pi}{2} + \omega_p t = \omega_m \cdot t + \frac{\pi}{2}$$

$$(\omega_p - \omega_m)t = \pi$$

$$t = \frac{\pi}{(0.820 - 0.255 \text{ rad/hr})} = \boxed{5.56 \text{ hrs.}}$$

⑥ I am Groot!



$\omega_G = ?$

$K = ?$

$$\omega_G = \frac{v}{r} = \frac{10\ m/s}{10\ m} = \boxed{1\ rad/sec.} \quad \text{or} \quad 1\ s^{-1}$$

$$K = \frac{1}{2} I \omega^2$$

$$I = \frac{1}{3} m L^2 \quad (\text{Table 9.1, b})$$

$$K = \left(\frac{1}{2}\right)\left(\frac{1}{3} m L^2\right)\left(1\ rad/s\right)^2$$

$$K = \frac{1}{6} \cdot 100\ kg\ (10\ m)^2 \cdot (1\ s^{-1})^2$$

$$\boxed{K = 1667\ J}$$