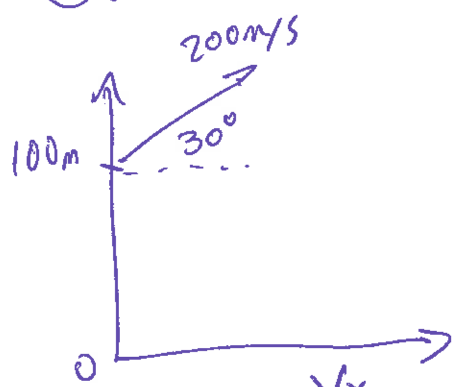
Practice Final Solutions

1. Godzilla vs. Hulk.



when $y=0$, $x=?$

$$x = \underbrace{V_0}_{=200\,m/s}\left(\underbrace{\cos 30^\circ}_{=0.866}\right)t \quad = (173\,m/s)\,t$$

just use $g = 10\,m/s^2$

$$y = y_0 + V_0 \sin 30^\circ\, t + \frac{1}{2} a_y t^2$$

$$y = 100m + (200\,m/s)(0.5)t + \frac{1}{2}(-10\,m/s^2)\,t^2$$

$$0 = y = 100m + (100\,m/s)t - 5\,m/s^2\; t^2$$

$a = -5 \quad b = 100 \quad c = 100$

$$t = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} = \frac{-100 \pm \sqrt{10000 + 2000}}{-10}$$

$t = +21$ sec.

$$\boxed{x = (173\,m/s) \cdot 21.0 = 3633m}$$

~ 3.6 km

w/ sig figs.

② Batman Revised

$$(m_R * g) - T = m_R a$$

$$m_B g \sin 45^\circ + T + (-)\mu_k g \cos 45^\circ = m_B a$$

$$a = g - \frac{T}{m_R}$$

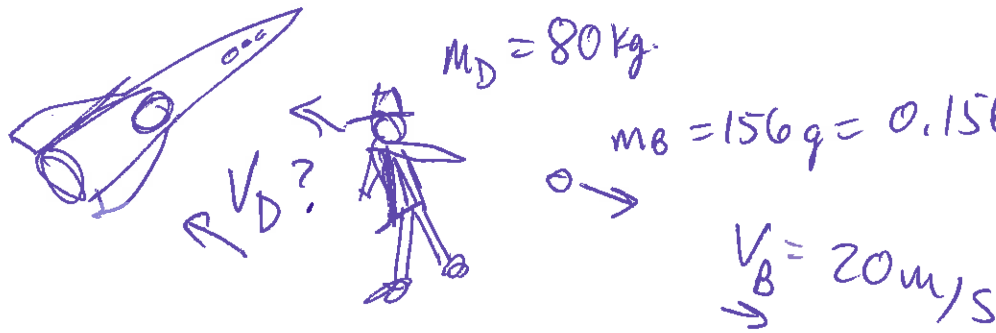
$$\underbrace{(1 - \underset{0.3}{\mu_k})}_{0.7} m_B g (0.707) + T = (m_B)\left(g - \frac{T}{m_R}\right)$$

$$0.49g + \frac{T}{m_B} = g - \frac{T}{m_R}$$

$$T\underbrace{\left(\frac{1}{m_B} + \frac{1}{m_R}\right)}_{0.03\ kg^{-1}} = 5.1\, \underset{\text{use } 10\ m/s^2}{g}$$

$$\boxed{T = 170\ N}$$

(3) DR. WHO in Space



Initially $V = 0$. conservation of momentum.

$$m_D V_D = m_B V_B$$

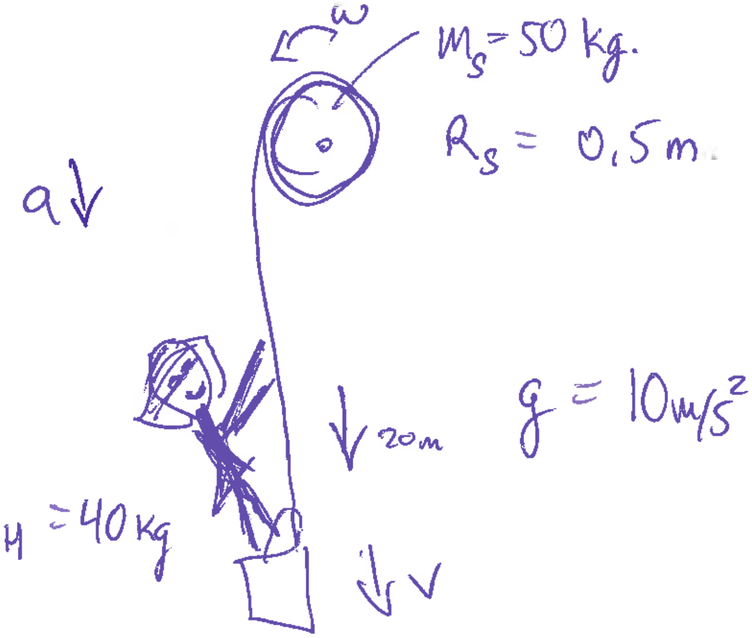
$m_D = 80\,kg$, $m_B = 0.156\,kg$, $V_B = 20\,m/s$

$$V_D = \frac{(0.156)}{(80)} (20\,m/s)$$

$$\boxed{V_D = 0.039\,m/s}$$

Slow! He'd better be close!

④ Hit Girl



$y_0 = 20m = h$

Use energy Conservation.

No Net work.

$$K_1 = 0 \qquad U_1 = \overset{40kg}{m}g\overset{20m}{h} =$$

$$U_2 = 0$$

$$K_2 = \frac{1}{2}m_H V^2 + \frac{1}{2}\underbrace{I}_{=\frac{1}{2}M_S R_S^2}\omega^2 \qquad V_f = R\omega$$

$$K_1 + U_1 = K_2 + U_2$$

$$m_H g h = \frac{1}{2}m_H v^2 + \frac{1}{2}\left(\frac{1}{2}M_S \cancel{R_S^2}\right)\left(\frac{V_f}{\cancel{R_S}}\right)^2 + 0$$

$$- V_f = \sqrt{\frac{2gh}{1 + M_S/2m_H}} = \sqrt{\frac{400}{1 + 50/80}}$$

$$- V_f = 15.7 \text{ m/s} = \overset{=0}{V_0} + at$$

$$x = 0 = 20m + \underset{=0}{V_0 t} + \frac{1}{2}at^2$$

$at = -15.7$ m/s so :: $-20m = \left(\frac{1}{2}t\right)(15.7 \text{ m/s})$

$$\boxed{t = 2.55 \text{ sec.}}$$

④ Hit Girl Alternative

m_S 50kg

R_S 0.5m

$V_0 = 0$

$X_0 = 20$

$\Delta y = 20m$

$m_H = 40kg$

$$\Sigma F_y = m_H g + (-T) = m_H a_y$$

$$\Sigma \tau = TR = I\alpha = \frac{1}{2} m_S R_S^2 \alpha$$

$$a = R_S \alpha$$

$$T\cancel{R_S} = \frac{1}{2} m_S \cancel{R_S} a$$

$$T = m_H g - m_H a = (g - a) m_H$$

$$(g - a) m_H = \frac{1}{2} m_S a$$

$$g m_H = \frac{1}{2} m_S a + a m_H$$

$$g m_H = \left(\frac{1}{2} m_S + m_H\right) a$$

$$a = \Big(\frac{1}{2} \underset{50}{m_S} + \underset{40}{m_H}\Big)^{-1} \underset{10}{g} m_H$$

$$a = \left(\frac{10}{65} m/s^2\right) 40$$

$$a = 6.15 \, m/s^2$$

$$x = x_0 - \frac{1}{2} a t^2$$

$$0 = 20 - \frac{1}{2} a t^2 \Rightarrow \frac{40}{6.15} = t^2$$

$$t = (6.5 \, sec^2)^{1/2}$$

$$\boxed{t = 2.55 \, sec.}$$

(5). Geosynchronous JLA Watchtower

$$T = P = 1 \text{ day} = 86\,400 \text{ sec}$$

$$M_E = 5.97 \times 10^{24} \text{ kg}$$

Kepler $\quad T = 2\pi r^{3/2} / \sqrt{\underset{\overset{\shortparallel}{6.67\times10^{-11}\ N\cdot(m/kg)^2}}{G}\, M_E}$

$$r^{3/2} = \frac{T}{2\pi}\sqrt{G M_E}$$

$$r = \Bigg(\underbrace{\frac{86400\,s}{2\pi}}_{=\,13800} \underbrace{\sqrt{6.67\times10^{-11}\times 6\times10^{24}}}_{=\,39.8\times10^{13}} \Bigg)^{2/3}$$

1.99×10^{7}

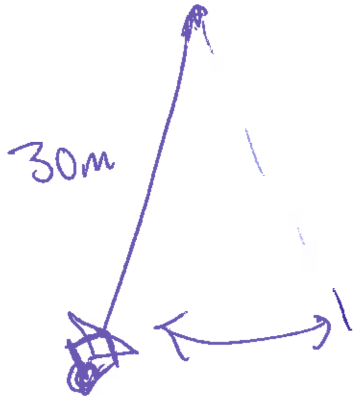
$$r = \left(2.75 \times 10^{12}\right)^{2/3}$$

$$\boxed{r = 4.27 \times 10^{6} \text{ m} = 42{,}700 \text{ km}}$$

(26 500 miles)

Note: often altitude is given above sea level, $R_E \approx 6400$ km.

(6) Spider-man on web



$g = 10\ m/s^2$

Asking for Period/2 Treat as simple pendulum.

$$\omega = \sqrt{g/L} = \sqrt{\frac{10}{30}} = 0.58\ s^{-1}$$

$$T = 2\pi/\omega$$

$$T = 10.8 \simeq \boxed{11\ sec.}\ /2$$

$$\Rightarrow 5.5\ sec.$$

7 Black Canary's Cry

$V_{sound} = 344\,m/s$

$f = 50\,kHz$

a) $\lambda = \frac{V_{sound}}{f} = \frac{344\,m/s}{50{,}000/s} = \boxed{0.00688\ m}$

$\approx 7\,mm$

$B_1 = 150\,dB$

b) $\cancel{\ }$ 150 dB but need to convert to W/m²

$\frac{d_1}{d_2} = \frac{1}{2}$

$150\,dB = 10\,dB \log\left(\frac{I_1}{10^{-12}\,W/m^2}\right)$

$15 = \log \frac{I_1}{10^{-12}\,W/m^2}$

$W/m^2\left(10^{15} \times 10^{-12}\right) = I_1$

$I_1 = 1000\,W/m^2$

I_2 is 2x distance, $\Rightarrow \frac{1}{4}$ the Intensity.

$\boxed{I_2 = 250\,W/m^2}$

$10\,dB \times \log\left(\frac{250\,W/m^2}{10^{-12}\,W/m^2}\right) = ?$ 144 dB