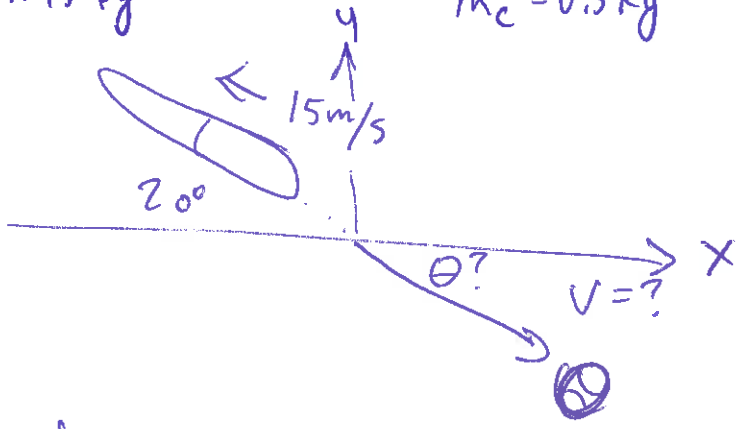
① Bullseye ; Dare devil

a.

$m_B = 0.145\ kg$ $\quad m_c = 0.5\ kg$

b.



Conservation of momentum:

$P_{ax} = m_B \vec{V}_B - m_c \vec{V}_c = (0.145\ kg \cdot 40\ m/s - 0.5\ kg \cdot 20\ m/s)$

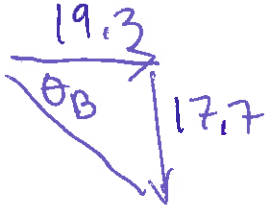
$P_{ay} = 0 \qquad = (5.8 - 10) = -4.2\ kg \cdot m/s$

$P_{by} = 0 = m_c V_{bc} \sin 20° + V_{bB} \sin\theta_B\, m_B$ ($0.5\ kg$, $-15\ m/s$, $\sin 20° = 0.34$, $m_B = 0.145\ kg$)

$\Rightarrow V_{bB} \sin\theta_B = -17.7\ m/s$

$P_{bx} = -4.2\ kg \cdot m/s = -m_c \cdot \cos 20° \cdot 15\ m/s + m_B \cos\theta_B V_{bB}$

$-7.0\ kg \cdot m/s$ $\quad m_B = 0.145\ kg$

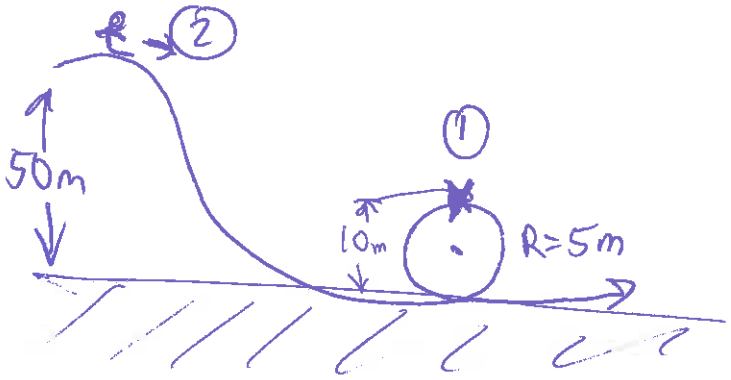


$\Rightarrow V_{Bb} \cos\theta_B = \frac{2.8\ kg \cdot m/s}{0.145\ kg} = 19.3\ m/s$

so $\frac{V_{bB} \sin\theta_B}{V_{Bb} \cos\theta_B} = \frac{17.7}{19.3} \Rightarrow \theta_B = \tan^{-1}(0.917) = 42.5°$

$V_{bB} \cos\theta_B = 19.3 \Rightarrow V_{Bb} = 26\ m/s$

ICY Slide Ride



$g = 10\,m/s^2$ ↓

$\mu_K = 0$

What is $\vec{a}$ at top of the loop?

direction is down toward center.

$|a| = \frac{v^2}{R}$ but what is v?

Conservation of Mech. Energy:

$mgh_1 + \frac{1}{2}mv_1^2 + W_{other} = \text{constant} = mgh_2$

$W_{other} = 0$ since $\mu_K = 0$

$g(10m) + \frac{1}{2}v^2 = g \cdot 50\,m$

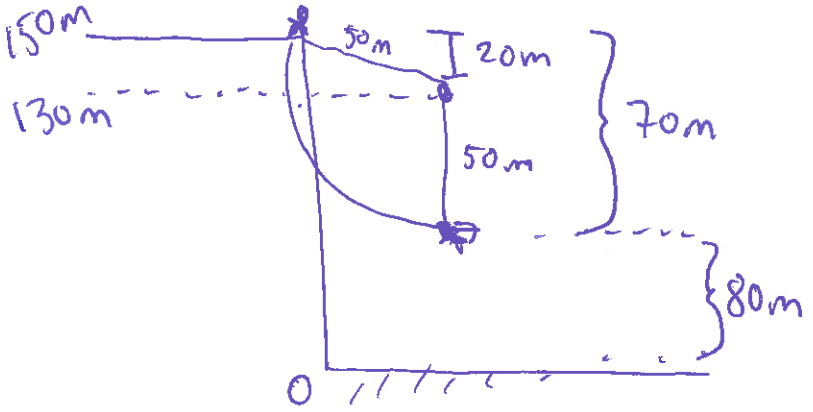
$\frac{1}{2}v^2 = 40m \cdot g = 400\,m^2/s^2$

$v^2 = 800\,m^2/s^2 \Rightarrow |v| = 28.3\,m/s$

$a = \frac{800\,m^2/s^2}{5m} =$ **160 m/s² ↓**

Spider-man Swings

How fast at bottom of swing?



Tension $\perp$ to motion

$\Rightarrow$ No work

So $K_1 + U_1 + \overset{0}{W_{other}} = K_2 + U_2$

$K_1 = U_1 = 0 = \frac{1}{2}mv^2 + mgh$

mgh : $g = 10\,m/s^2$

pick starting point as $y = 0$ to make math easier.

$\Rightarrow h = -70\,m.$

$0 = \frac{1}{2}mv^2 + mgh$; $g = 10\,m/s^2$, $h = -70\,m$.

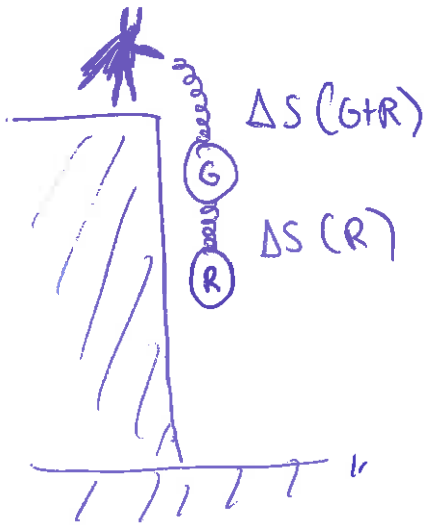
$\frac{1}{2}v^2 = 700\,m^2/s^2$

$v^2 = 1400\,m^2/s^2$

$\boxed{v \simeq 37\,m/s}$

(About 82 mph!)

Bat family



Convert to mks:

$K = 5\ N/mm = 5000\ N/m$

ΔS in each Spring?

$|F| = k \cdot s$

Robin: $m_R = 50kg$

Static

$g = 10\ m/s^2$

$\Rightarrow |F| = T = mg = k \cdot \Delta S(R)$

$\Delta S(R) = \frac{mg}{k} = \frac{50 \times 10}{5000} m = 0.1m$

$m_{BG} = 60kg$

Robin + Batgirl: $\omega = (m_R + m_{BG})\, g$

$110\ kg \quad 10\ m/s^2$

$\Delta S(R+G) = \frac{110\ kg \cdot 10\ m/s^2}{5000\ N/m}$

$\Delta S(R+BG) = 0.22\ m$

Black Widow's Glock 22s

Apply conservation of momentum (No external impulses).

$$P_1 = P_2 = 0$$

$$P_2 = m_G V_G + m_B V_B = 0$$

m_G: 615g, V_G: Recoil Velocity, m_B: 7.5g, V_B: 370 m/s

Velocities in opposite directions.

$$|V_G| = \frac{m_B |V_B|}{m_G} = \frac{7.5g\ (370 m/s)}{615g}$$

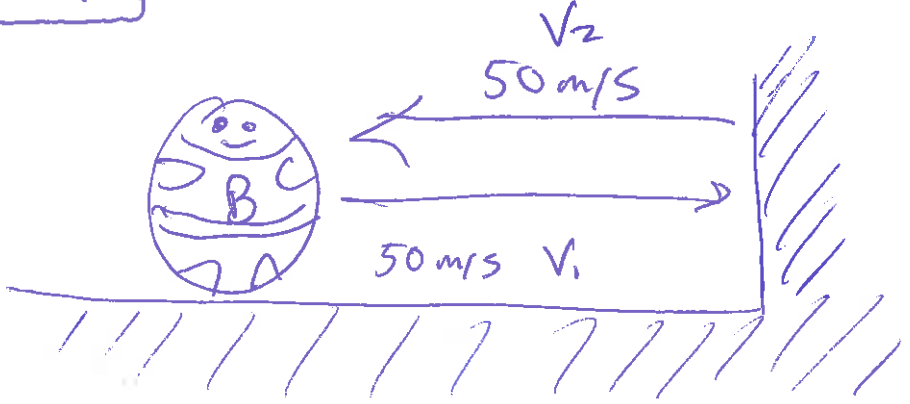
$$\boxed{V_G = 4.5\ m/s}$$

Kinetic Energy Ratio:

$$\frac{K_B}{K_G} = \frac{\frac{1}{2} m_B V_B^2}{\frac{1}{2} m_G V_G^2} = \frac{7.5\ (370)^2}{615\ (4.5)^2}$$

$$\boxed{\frac{K_B}{K_G} \approx 82}$$

Bouncing Boy



$m_B = 100\ kg$

$\vec{J}$ = Impulse $= \vec{p}_2 - \vec{p}_1$

$= -m_B V_2 - m_B V_1$

$= -100\ kg\ (50\ m/s + 50\ m/s)$

$= \boxed{-10{,}000\ kg\ m/s}$

direction is toward where he came from.

$|F_{Ave}| \cdot \Delta t = |J|$ (0.1 sec.)

$|F_{Ave}| = \dfrac{10{,}000\ kg \cdot m/s}{\Delta t} = \dfrac{10{,}000\ N \cdot s}{\Delta t = 0.1 s}$

$= \boxed{100{,}000\ N}$

Ouch!