① $0 = m_G v_G + m_p v_p$ $\Rightarrow$ $45 v_G + 165 v_p = 0$ $\rightarrow$ ①

Also:

$$\cancel{v_p - v_G = 2.5}$$

$v_G - v_p = 1.51$ $\Rightarrow$ $165 v_G - 165 v_p = 165 \times 1.51 \rightarrow$ ②

① & ② $\Rightarrow$ $210 v_G = 165 \times 1.51$

                 $\Rightarrow v_G = 1.19$ m/s

           $\& \ v_p = -0.32$ m/s

②

$m_1 v_{1i} + m_2 v_{2i} = (m_1 + m_2) v_f$

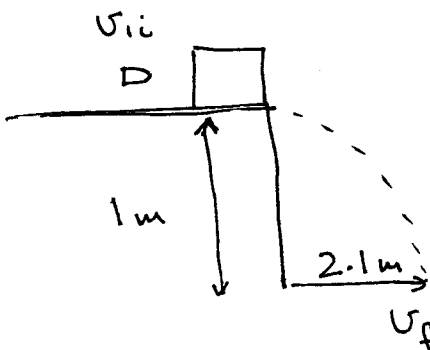$0.008 v_{1i} = 0.288 v_f$

$\Rightarrow v_f = 0.028 v_{1i}$

$v_{fx} = v_f \quad , \quad v_{fy} = 0$
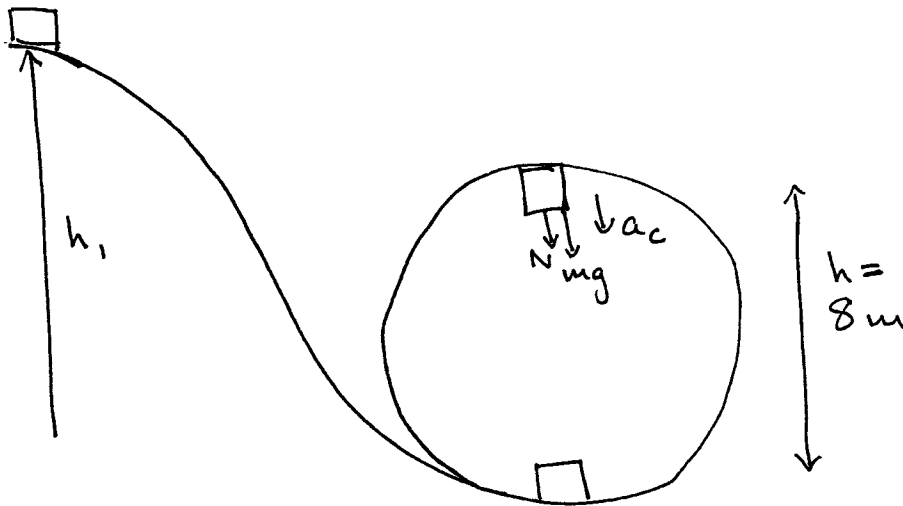
$\Delta x = v_o t + \frac{1}{2} a t^2$

$\Rightarrow -1 = 0 + \frac{1}{2}(-9.8) t^2$ $\Rightarrow t = 0.452$ s

$v_f t = 2.1$ m $\Rightarrow$ $v_f = 4.65$ m/s

$\Rightarrow v_{1i} = 166$ m/s

③

$$\Rightarrow \quad -N - mg = -ma_c$$

for safety $\quad N = mg$

$$\Rightarrow \quad 2mg = m\frac{v^2}{R} \quad \Rightarrow \quad v = \sqrt{2gR} \quad = 8.85 \, m/s$$
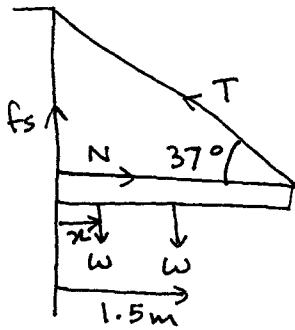
Total energy at $h_1 = mgh_1$

Total energy at top of loop $= \frac{1}{2}mv^2 + mgh$

$$\Rightarrow \quad mgh_1 = \frac{1}{2}mv^2 + mgh$$

$$\Rightarrow \quad h_1 = \frac{v^2}{2g} + h = 12 \, m$$

④

$\sum F_x = N - T\cos 37° = 0 \qquad \longrightarrow \quad ①$

$\sum F_y = f_s + T\sin 37° - 2\omega = 0 \qquad \longrightarrow \quad ②$

$\sum \tau = -\omega x - 1.5\omega + 3T\sin 37° = 0 \rightarrow \quad ③$

$① \Rightarrow N = T\cos 37°$

$f_s = \mu_s N = 0.3 T\cos 37°$

from $② \Rightarrow 0.3 T\cos 37° + T\sin 37° = 2\omega$

$\Rightarrow T = \dfrac{2\omega}{0.3\cos 37° + \sin 37°}$

Using in $③ \Rightarrow$

$-\omega x - 1.5\omega + \dfrac{6\omega\sin 37°}{0.3\cos 37° + \sin 37°} =$

$-\phi x - 1.5\phi + \dfrac{6\phi \sin 37°}{0.3\cos 37° + \sin 37°} = 0$

$\Rightarrow x = 2.79 \text{ m}$