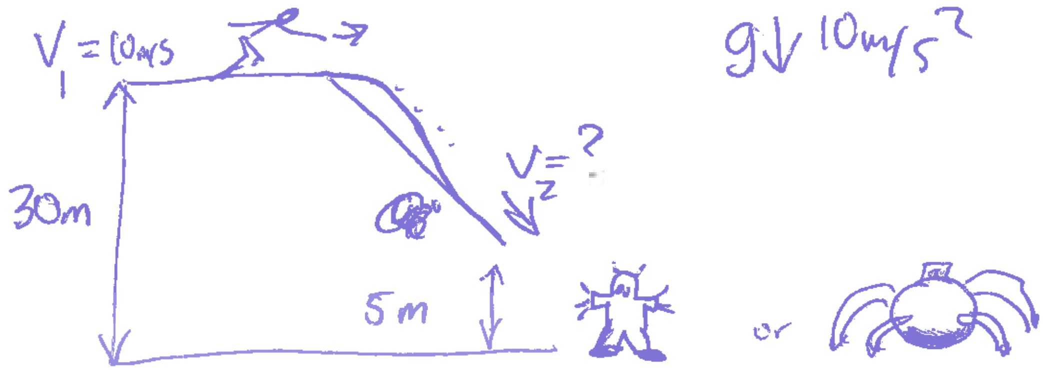
① Frozone



No friction or air resistance. Normal Force does no work ⇒ conservation of mechanical energy.

$$\overset{(10)}{K_1} + U_1 = K_2 + U_2$$

$$\frac{1}{2}\cancel{m}\underset{10\,m/s}{V_1^2} + \cancel{m}\underset{10\,m/s^2}{g}\underset{30m}{h_1} = \frac{1}{2}\cancel{m}\underset{?}{V_2^2} + \cancel{m}\underset{10\,m/s^2}{g}\underset{5m}{h_2}$$

$$\cancel{50\,m^2/s^2} + 300\,m^2/s^2 = \frac{1}{2}V_2^2 + \cancel{50\,m^2/s^2}$$

$$V_2 = \sqrt{600\,m^2/s^2}$$

$$\boxed{V_2 = \overset{24.5}{25.5}\,m/s}$$

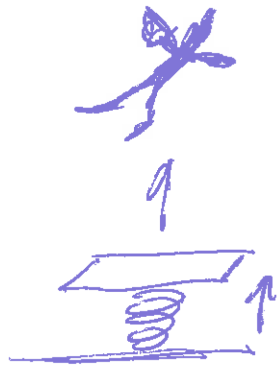
Rounding to 25 m/s ok.

5000
10000

② Storm

$g \downarrow$

$10\ m/s^2$



$m_s = 50$ kg

$K_{spring} = 10^6$ N/m $\quad \Delta S = 0.1$ m

$$U_1 = \tfrac{1}{2} k x^2 = 5000\,J$$

$k = 10^6$ N/m, $x = 0.1$ m

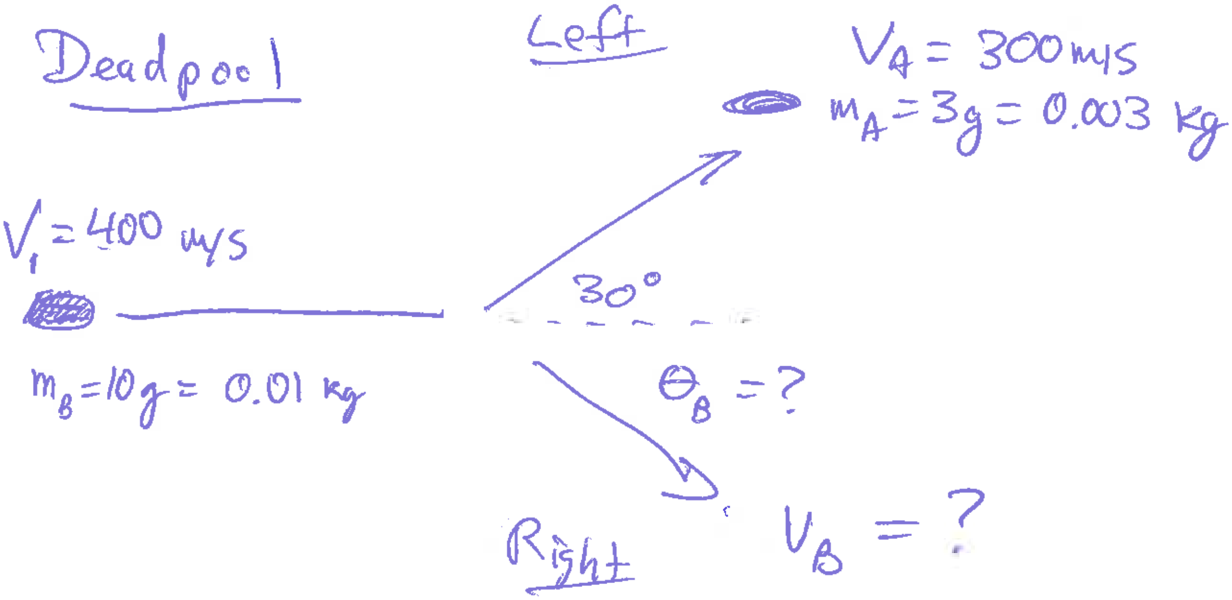
all converted to kinetic energy, which is the totally converted to potential energy mgh

$$mgh = 5000\,J$$

$m = 50$ kg, $g = 10\ m/s^2$

$$\boxed{h = 10\ m}$$

③ Deadpool



Momentum Conservation:

$\vec{P}_1 = m_B \vec{V}_1 = 4 \frac{m}{s}\cdot kg$ in +x direction.

(5) $\vec{P}_1 = \vec{P}_A + \vec{P}_B$

(5) X: $4 \, m/s \cdot kg = \underset{3g}{m_A} \underset{300 m/s}{V_A} \underset{0.866}{\cos 30^\circ} + \underset{7g}{m_B} V_B \cos\theta_B$

① $V_B \cos\theta_B = \dfrac{4 \frac{m}{s} \cancel{kg} - 0.78 \frac{m}{s} \cancel{kg}}{0.007 \cancel{kg}} = 460$ m/s

(5) y: $0 = \underbrace{m_A V_A}_{0.9} \underbrace{\sin\theta}_{\substack{30^\circ \\ 0.5}} - m_B V_B \sin\theta_B$

$= (0.007 \text{ kg}) \, V_B \sin\theta_B$

② $V_B \sin\theta_B = 64$ m/s

→ Combine

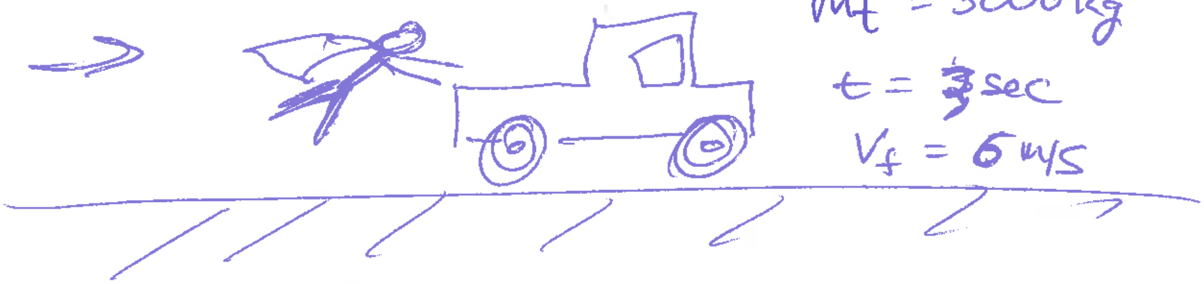
(5) $\dfrac{\cancel{V_B} \cos\theta_B}{\cancel{V_B} \sin\theta_B} = \dfrac{460}{64} = 7.1875 \approx 7.2$

$\tan\theta_B = \frac{1}{7.2} \Rightarrow \boxed{\theta_B \approx 7.9^\circ}$

sub → $V_B \cos\theta_B = 460$ m/s

$V_B = \dfrac{460 \text{ m/s}}{0.99} = \boxed{464 \text{ m/s}}$

④ Powergirl



$m_t = 3000\,kg$

$t = 3\,sec$

$V_f = 6\,m/s$

Ave Power =? $= \dfrac{\Delta W}{\Delta t}$, $\Delta t = 3\,sec.$

Work = Force · distance

$\Delta V = 6\,m/s$ Ave. Velocity $= 3\,m/s$

Ave. Acc $= \dfrac{6\,m/s}{3\,sec} = 2\,m/s^2$

$F_{net} = m \cdot a_{Ave} = (3000\,kg)(2\,m/s^2)$

$F_{net} = 6000\,N$

$P_{Ave} = F_{net} \cdot V_{Ave} = \boxed{18000\,W}$

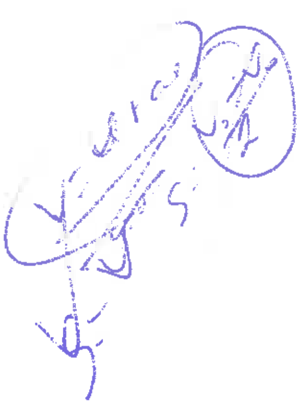
Or using Work-energy!

$W = K_2 - K_1 = \frac{1}{2}(3000\,kg)(6\,m/s)^2$

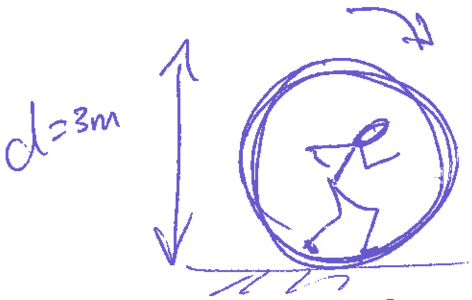
$= 54000\,J$

$\Delta t = 3\,sec.$

$P_{ave} = \dfrac{54000\,J}{3\,sec} = \boxed{\cancel{27000}\,W \quad 18000\,W}$



⑤ Quicksilver



$r_{Ball} = 3\,m/2 = 1.5\,m$

$m_{Ball} = 30\,kg$

$m_Q = 70\,kg$

linear $a = 10t\ m/s^3$

@ t=5sec?

a) $V_Q = \int_0^{5s} 10t\ m/s^3\, dt = \frac{10}{2} t^2\ m/s^3 \Big|_0^{t} = \boxed{125\,m/s}$

b) distance rolled?

$d = \int_0^{5sec} 5t^2\ m/s^3\, dt = \frac{5}{3} t^3\ m/s^3 \Big|_0^{5s} = \boxed{208\,m}$

c) How many rotations?

$N = \frac{\text{distance}}{\text{circumference}} = \frac{208\,m}{2\pi \underbrace{r}_{=1.5m}} \approx \boxed{22.1}$

d) Kinetic Energy @ 5 sec? In kJ?

$K = \frac{1}{2} m_Q V_Q^2 + \frac{1}{2} m_{Ball} \underbrace{V_{Ball}^2}_{= V_Q} + \frac{1}{2} I_{\substack{Hollow\\ sphere}} \omega^2 \qquad \omega = \frac{V}{r}$

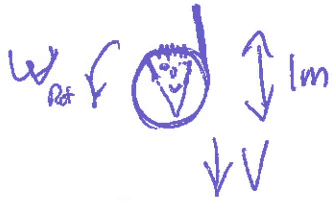
$K = \frac{1}{2}(100\,kg)(125\,m/s)^2 + \cancel{\frac{1}{2}}\, \cancel{\frac{2}{3}}\, \underbrace{M_{Ball}}_{30kg} \underbrace{R^2}_{1.5m} \omega^2 \qquad \omega = 83\,rad/s$

$K = 781250\,J + (10)(1.5)^2(83)^2\,J$

$K = 781250\,J + 155002.5\,J = \boxed{936\,kJ}$

⑥ Joker's Yo-Yo

$g \downarrow$



$r_{yy} = 1m$

$M_{yy} = 100kg$

$I_{\text{solid cyl.}} = \frac{1}{2} MR^2$

$V = \omega R$

$V_1 = 0$, $K_1 = 0$, $U_1 = mgh$

Energy

$$mgh_1 = \frac{1}{2} mV^2 + \frac{1}{2} I\omega^2 + mgh_2$$

$$\cancel{m}g(\underbrace{h_1 - h_2}_{10m}) = \frac{1}{2}\cancel{m}V^2 + \frac{1}{2}\cdot\frac{1}{2}\cancel{M}\cancel{R^2}\cdot\frac{V^2}{\cancel{R^2}}$$

$$g \cdot 10m = \frac{1}{2}V^2 + \frac{1}{4}V^2 = \frac{3}{4}V^2$$

$g \approx 10 m/s^2$

$$100\, m^2/s^2 = \frac{3}{4}V^2$$

$$V = \sqrt{\frac{400}{3}\frac{m^2}{s^2}} = \boxed{11.5\, m/s \text{ down}}$$