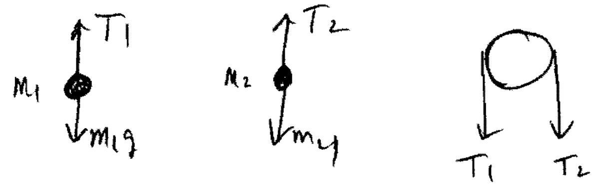
(1)



$$T_1 - m_1 g = m_1 \frac{\Delta v}{\Delta t} \qquad m_2 g - T_2 = m_2 \frac{\Delta v}{\Delta t} \qquad R(T_2 - T_1) = I \frac{\Delta \omega}{\Delta t} = I \frac{(\Delta v)/R}{\Delta t}$$

$$T_1 = m_1\left(g + \frac{\Delta v}{\Delta t}\right) \qquad T_2 = m_2\left(g - \frac{\Delta v}{\Delta t}\right)$$

$$T_2 - T_1 = m_2\left(g - \frac{\Delta v}{\Delta t}\right) - m_1\left(g + \frac{\Delta v}{\Delta t}\right) = \left(\frac{1}{2}M\cancel{R^2}\right)\frac{\Delta v}{\cancel{R^2}\Delta t}$$

$$m_2 g - m_1 g = \frac{\Delta v}{\Delta t}\left(\frac{1}{2}M + m_1 + m_2\right)$$

$$\Delta v = \frac{(m_2 - m_1)g\ \Delta t}{m_1 + m_2 + \frac{1}{2}M} = \frac{(3.5\,\text{kg} - 1.2\,\text{kg})(9.8\,\frac{\text{m}}{\text{s}^2})(3.0\,\text{s})}{1.2\,\text{kg} + 3.5\,\text{kg} + \frac{1}{2}(2.6\,\text{kg})}$$

$$= 11.3\ \text{m/s}$$

(2) Initial: $K_i = 0 \qquad U_i = 0$

Final: $U_f = mgh = (2.5\,\text{kg})(9.8\,\text{m/s}^2)(-0.45\,\text{m}) = -11.0\ \text{J}$

$$K_f = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

as cord unwraps, v_{tang} of sphere $= v$ of cord

$$v = \omega R$$

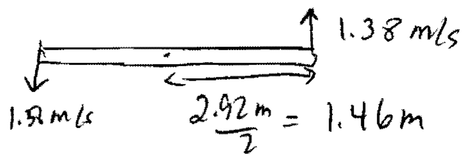
$$K_f = \frac{1}{2}mv^2 + \frac{1}{2}I\left(\frac{v}{R}\right)^2 \qquad I = \frac{2}{5}MR^2 \text{ for sphere}$$

$$K_f = \frac{1}{2}mv^2 + \frac{1}{2}\left(\frac{2}{5}MR^2\right)\frac{v^2}{R^2} = \frac{1}{2}mv^2 + \frac{1}{5}Mv^2$$

$$E_f = E_i \Rightarrow \frac{1}{2}mv^2 + \frac{1}{5}Mv^2 - mgh = 0$$

$$v = \sqrt{\frac{mgh}{\frac{1}{2}m + \frac{1}{5}M}} = 2.37\ \text{m/s}$$

③ (a)



The skaters rotate about their center of mass (midpoint of pole) with angular speed

$$\omega = \frac{v}{r} = \frac{1.36\,m/s}{1.46\,m} = 0.945\,rad/s$$

(b) Treat each skater as a "particle" with $I = mr^2$

$$L_i = I_1 \omega_i + I_2 \omega_i = 2 m r_i^2 \omega_i$$

$$L_f = 2 m r_f^2 \omega_f$$

$$L_i = L_f \Rightarrow \quad 2 m r_i^2 \omega_i = 2 m r_f^2 \omega_f$$

$$\omega_f = \omega_i \frac{r_i^2}{r_f^2} = \left(0.945\,\frac{rad}{s}\right)\left(\frac{1.46\,m}{0.47\,m}\right) = 9.12\,\frac{rad}{s}$$