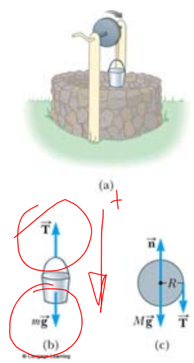


A solid frictionless cylindrical reel of mass M=3.00 kg and radius R=0.400 m is used to draw water from a well. A bucket of mass m=2.00 kg is attached to a cord that is wrapped around the cylinder.

(a) Find the tension T in the cord and acceleration a of the bucket.
(b) If the bucket starts from rest at the top of the well and falls for 3.00 s before hitting the water, how far does it fall?

$\Sigma F_y = ma_y$

$mg - T = ma_y$

$mg - T = ma_T$

$\Sigma\tau = I\alpha$

$\Sigma\tau = \frac{1}{2}MR^2\alpha$

$TR = \frac{1}{2}MR^2\alpha$ Remove 1 unknown

$$\boxed{a_T = \alpha R \qquad \alpha = \frac{a_T}{R}}$$

$v_i = 0$

$a = 5.60\ m/s^2$

$t = 3.00\ s$

$\boxed{\Delta y = -25.2\ m}$

$mg - \frac{1}{2}Ma_T = ma_T$

$mg = \frac{1}{2}Ma_T + ma_T$

$mg = a_T\left(\frac{1}{2}M + m\right)$

$a_T = \dfrac{mg}{\frac{1}{2}M + m}$

$a_T = \dfrac{2(9.80)}{\frac{1}{2}(3) + 2}$

$\boxed{a_T = 5.60\ m/s^2}$

$TR = \frac{1}{2}MR^2\dfrac{a_T}{R}$

$T = \frac{1}{2}Ma_T$

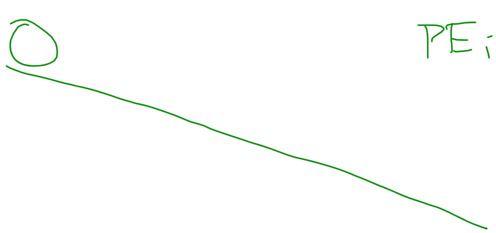
$T = \frac{1}{2}(3)(5.60)$

$\boxed{T = 8.40\ N}$

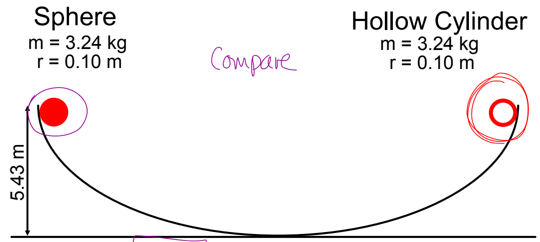
Rotational Kinetic Energy

$$KE = \frac{1}{2}mv^2$$

$$\boxed{KE_r = \frac{1}{2}I\omega^2}$$



$PE_i = KE + KE_r$



$E_i = E_f$ $\boxed{\text{Sphere}}$

$$\boxed{PE_i + \cancel{KE_i} + \cancel{KE_{ri}} = \cancel{PE_f} + KE_f + KE_{rf}}$$

$r\omega = v \qquad \omega = \frac{v_t}{r}$

Sphere:

$mgh_i = \frac{1}{2} m v_f^2 + \frac{1}{2} I \omega_f^2$

$\cancel{m}gh_i = \frac{1}{2} \cancel{m} v_f^2 + \frac{1}{2}\frac{2}{5} \cancel{M} r^2 \omega^2$

$2gh_i = v_f^2 + \frac{2}{5} r^2 \omega^2$

$10gh_i = 5v_f^2 + 2r^2\omega^2$

$10gh_i = 5v_f^2 + 2\cancel{r^2} \frac{v_t^2}{\cancel{r^2}}$

$10gh_i = 5v_f^2 + 2v_t^2$

$10gh_i = 7v_f^2$

$\frac{10}{7} gh_i = v_f^2$

$\sqrt{\frac{10}{7}(9.80)(5.43)} = v_f$

$\boxed{v_f = 8.72 \text{ m/s}}$

Hollow Cylinder:

$mgh_i = \frac{1}{2} m v_f^2 + \frac{1}{2} I \omega_f^2$

$\cancel{m}gh_i = \frac{1}{2} \cancel{m} v_f^2 + \frac{1}{2} \cancel{M} R^2 \omega_f^2$

$2gh_i = v_f^2 + R^2 \omega_f^2$

$2gh_i = v_f^2 + \cancel{R^2} \frac{v_t^2}{\cancel{R^2}}$

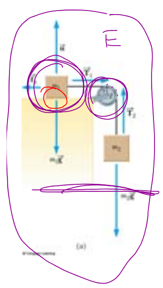
$2gh_i = v_f^2 + v_f^2$

$2gh_i = 2v_f^2$

$gh_i = v_f^2$

$v_f = \sqrt{9.80(5.43)}$

$\boxed{v_f = 7.29 \text{ m/s}}$



Two blocks with masses m_1 = 5.00 kg and m_2 = 7.00 kg are attached by a string as in Figure (a) over a pulley with mass M = 2.00 kg. The pulley, which turns on a frictionless axle, is a hollow cylinder with radius 0.0500 m over which the string moves without slipping. The horizontal surface has a coefficient of kinetic friction of 0.350. Find the speed of the system when the block of mass m_2 has dropped 2.00 m.

$E_i = E_f + W_{nc}$

$PE_i + KE_i + KE_{ri} = PE_f + KE_f + KE_{rf} + W_{nc}$

$PE_{2i} = KE_{1f} + KE_r + KE_2 + W_{nc}$

$m_2 g h_i = \frac{1}{2} m_1 v_{1f}^2 + \frac{1}{2} I \omega^2 + \frac{1}{2} m_2 v_{2f}^2 + \underbrace{\mu F_{N1}}_{F}(h)$

ω^2

$\omega r = v_t$

$\omega^2 = \frac{v_t^2}{R^2}$

$2m_2 g h_i = m_1 v_{1f}^2 + I\omega^2 + m_2 v_{2f}^2 + 2\mu F_N h$

$2m_2 g h_i = m_1 v_{1f}^2 + m_3 \cancel{R^2} \frac{v_t^2}{\cancel{R^2}} + m_2 v_{2f}^2 + 2\mu m g h$

$2m_2 g h_i = m_1 v_{1f}^2 + m_3 v_t^2 + m_2 v_{2f}^2 + 2\mu m g h$

$2m_2 g h_i - 2\mu m_1 g h = v^2 (m_1 + m_2 + m_3)$

$v = \sqrt{\frac{2m_2 g h_i - 2\mu m_1 g h}{m_1 + m_2 + m_3}}$

$v = \sqrt{\frac{2gh(m - \mu m_1)}{m_1 + m_2 + m_3}}$

$\boxed{v = 3.83 \text{ m/s}}$

Angular Momentum

$$P=mv$$

$$\boxed{L=I\omega}$$

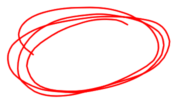
Impulse

$$\Delta p=F\Delta t$$

$$F=\frac{\Delta p}{\Delta t}$$

$$\boxed{\tau=\frac{\Delta L}{\Delta t}}$$

Conservation of Angular Momentum



$$L_i = L_f$$

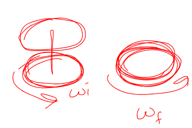
$$I_i \omega_i = I_f \omega_f$$

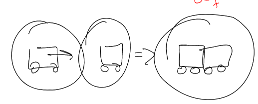
$$M r_i^2 \omega_i = M r_f^2 \omega_f$$

4 A horizontal disk with moment of inertia I_i rotates with angular speed w_i about a vertical frictionless axle. A second horizontal disk having moment of inertia I_2 drops on the first, initially not rotating but sharing the same axis as the first disk. Because their surfaces are rough the two disks eventually reach the same angular speed ω. The ratio ω/ω_1 is equal to

A I_1/I_2
B I_2/I_1
C $I_1/(I_1+I_2)$
D $I_2/(I_1+I_2)$

$$\frac{\omega_f}{\omega_1}$$





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

$$\frac{I_1}{(I_1+I_2)} \qquad \frac{m_1}{m_1+m_2} = \frac{v_f}{v_i} \qquad \frac{\omega_f}{\omega_i}$$

$$I_1 \omega_{1i} + \boxed{\cancel{I_2 \omega_{2i}}} = (I_1 + I_2)\omega_f$$

$$I_1 \omega_{1i} = (I_1 + I_2)\omega_f$$

$$\frac{I_1 = \cancel{(I_1+I_2)} \frac{\omega_f}{\omega_i}}{(I_1+I_2) \qquad \cancel{(I_1+I_2)}}$$