52. According to the sign conventions used in the book, the magnitude of the net torque exerted on the cylinder of mass m and radius R is

$$\tau_{\text{net}} = F_1R - F_2R - F_3r = (6.0\text{ N})(0.12\text{ m}) - (4.0\text{ N})(0.12\text{ m}) - (2.0\text{ N})(0.050\text{ m}) = 71\text{N}\cdot\text{m}.$$

(a) The resulting angular acceleration of the cylinder (with $I = \frac{1}{2}MR^2$ according to Table 10-2(c)) is

$$\alpha = \frac{\tau_{\text{net}}}{I} = \frac{71\text{N}\cdot\text{m}}{\frac{1}{2}(2.0\text{kg})(0.12\text{ m})^2} = 9.7\,\text{rad/s}^2.$$

(b) The direction is counterclockwise (which is the positive sense of rotation).

53. Combining Eq. 10-45 ($\tau_{\text{net}} = I\alpha$) with Eq. 10-38 gives $RF_2 - RF_1 = I\alpha$, where $\alpha = \omega/t$ by Eq. 10-12 (with $\omega_o = 0$). Using item (c) in Table 10-2 and solving for F_2 we find

$$F_2 = \frac{MR\omega}{2t} + F_1 = \frac{(0.02)(0.02)(250)}{2(1.25)} + 0.1 = 0.140\text{ N}.$$

56. With counterclockwise positive, the angular acceleration α for both masses satisfies

$$\tau = mgL_1 - mgL_2 = I\alpha = \left(mL_1^2 + mL_2^2\right)\alpha,$$

by combining Eq. 10-45 with Eq. 10-39 and Eq. 10-33. Therefore, using SI units,

$$\alpha = \frac{g\left(L_1 - L_2\right)}{L_1^2 + L_2^2} = \frac{\left(9.8\text{ m/s}^2\right)\left(0.20\text{ m} - 0.80\text{ m}\right)}{(0.20\text{ m})^2 + (0.80\text{ m})^2} = -8.65\text{ rad/s}^2$$

where the negative sign indicates the system starts turning in the clockwise sense. The magnitude of the acceleration vector involves no radial component (yet) since it is evaluated at $t = 0$ when the instantaneous velocity is zero. Thus, for the two masses, we apply Eq. 10-22:

(a) $\left|\vec{a}_1\right| = |\alpha|L_1 = \left(8.65\text{ rad/s}^2\right)\left(0.20\text{ m}\right) = 1.7\text{ m/s}.$

(b) $\left|\vec{a}_2\right| = |\alpha|L_2 = \left(8.65\text{ rad/s}^2\right)\left(0.80\text{ m}\right) = 6.9\text{ m/s}^2.$

63. **THINK** As the meter stick falls by rotating about the axis passing through one end of the stick, its potential energy is converted into rotational kinetic energy.

EXPRESS We use ℓ to denote the length of the stick. The meter stick is initially at rest so its initial kinetic energy is zero. Since its center of mass is $\ell/2$ from either end, its initial potential energy is $U_g = \frac{1}{2}mg\ell$, where m is its mass. Just before the stick hits the floor, its final potential energy is zero, and its final kinetic energy is $\frac{1}{2}I\omega^2$, where I is its rotational inertia about an axis passing through one end of the stick and ω is the angular velocity. Conservation of energy yields

$$\frac{1}{2}mg\ell = \frac{1}{2}I\omega^2 \Rightarrow \omega = \sqrt{\frac{mg\ell}{I}}.$$

The free end of the stick is a distance ℓ from the rotation axis, so its speed as it hits the floor is (from Eq. 10-18)

$$v = \omega\ell = \sqrt{\frac{mg\ell^3}{I}}.$$

ANALYZE Using Table 10-2 and the parallel-axis theorem, the rotational inertial is $I = \frac{1}{3}m\ell^2$, so

$$v = \sqrt{3g\ell} = \sqrt{3\left(9.8\ \text{m/s}^2\right)\left(1.00\ \text{m}\right)} = 5.42\ \text{m/s}.$$

LEARN The linear speed of a point on the meter stick depends on its distance from the axis of rotation. One may show that the speed of the center of mass is

$$v_{\text{cm}} = \omega(\ell/2) = \frac{1}{2}\sqrt{3g\ell}.$$

64. (a) We use the parallel-axis theorem to find the rotational inertia:

$$I = I_{\text{com}} + Mh^2 = \frac{1}{2}MR^2 + Mh^2 = \frac{1}{2}\left(20\ \text{kg}\right)\left(0.10\ \text{m}\right)^2 + \left(20\ \text{kg}\right)\left(0.50\ \text{m}\right)^2 = 0.15\ \text{kg}\cdot\text{m}^2.$$

(b) Conservation of energy requires that $Mgh = \frac{1}{2}I\omega^2$, where ω is the angular speed of the cylinder as it passes through the lowest position. Therefore,

$$\omega = \sqrt{\frac{2Mgh}{I}} = \sqrt{\frac{2(20\ \text{kg})(9.8\ \text{m/s}^2)(0.050\ \text{m})}{0.15\ \text{kg}\cdot\text{m}^2}} = 11\ \text{rad/s}.$$