Chapter 10

1. The problem asks us to assume v_{com} and ω are constant. For consistency of units, we write

$$v_{com} = (85\,\text{mi/h})\left(\frac{5280\,\text{ft/mi}}{60\,\text{min/h}}\right) = 7480\,\text{ft/min}\,.$$

Thus, with $\Delta x = 60\,\text{ft}$, the time of flight is

$$t = \Delta x / v_{com} = (60\ \text{ft})/(7480\ \text{ft/min}) = 0.00802\,\text{min}\,.$$

During that time, the angular displacement of a point on the ball's surface is

$$\theta = \omega t = (1800\,\text{rev/min})(0.00802\,\text{min}) \approx 14\,\text{rev}\,.$$

5. Applying Eq. 2-15 to the vertical axis (with $+y$ downward) we obtain the free-fall time:

$$\Delta y = v_{0y}t + \frac{1}{2}gt^2 \Rightarrow t = \sqrt{\frac{2(10\ \text{m})}{9.8\ \text{m/s}^2}} = 1.4\ \text{s}.$$

Thus, by Eq. 10-5, the magnitude of the average angular velocity is

$$\omega_{avg} = \frac{(2.5\ \text{rev})(2\pi\ \text{rad/rev})}{1.4\ \text{s}} = 11\ \text{rad/s}.$$

12. (a) We assume the sense of rotation is positive. Applying Eq. 10-12, we obtain

$$\omega = \omega_0 + \alpha t \quad \Rightarrow \quad \alpha = \frac{(3000-1200)\ \text{rev/min}}{(12/60)\ \text{min}} = 9.0\times10^3\ \text{rev/min}^2.$$

(b) And Eq. 10-15 gives

$$\theta = \frac{1}{2}(\omega_0 + \omega)t = \frac{1}{2}(1200\ \text{rev/min} + 3000\ \text{rev/min})\left(\frac{12}{60}\ \text{min}\right) = 4.2\times10^2\ \text{rev}.$$

35. Since the rotational inertia of a cylinder is $I = \frac{1}{2}MR^2$ (Table 10-2(c)), its rotational kinetic energy is

$$K = \frac{1}{2}I\omega^2 = \frac{1}{4}MR^2\omega^2.$$

(a) For the smaller cylinder, we have

$$K_1 = \frac{1}{4}(1.25\text{ kg})(0.25\text{ m})^2(235\text{ rad/s})^2 = 1.08\times10^3\text{ J} \approx 1.1\times10^3\text{ J}.$$

(b) For the larger cylinder, we obtain

$$K_2 = \frac{1}{4}(1.25\text{ kg})(0.75\text{ m})^2(235\text{ rad/s})^2 = 9.71\times10^3\text{ J} \approx 9.7\times10^3\text{ J}.$$

45. We take a torque that tends to cause a counterclockwise rotation from rest to be positive and a torque tending to cause a clockwise rotation to be negative. Thus, a positive torque of magnitude $r_1 F_1 \sin\theta_1$ is associated with $\vec{F}_1$ and a negative torque of magnitude $r_2F_2 \sin\theta_2$ is associated with $\vec{F}_2$. The net torque is consequently

$$\tau = r_1F_1\sin\theta_1 - r_2F_2\sin\theta_2.$$

Substituting the given values, we obtain

$$\tau = (1.30\text{ m})(4.20\text{ N})\sin 75° - (2.15\text{ m})(4.90\text{ N})\sin 60° = -3.85\text{ N}\cdot\text{m}.$$

63. We use ℓ to denote the length of the stick. Since its center of mass is $\ell/2$ from either end, its initial potential energy is $\frac{1}{2}mg\ell$, where m is its mass. Its initial kinetic energy is zero. 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 just before it hits the floor. 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)

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

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

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