3. (a) The time for one revolution is the circumference of the orbit divided by the speed v of the Sun: $T = 2\pi R/v$, where R is the radius of the orbit. We convert the radius:

$$R = \left(2.3 \times 10^4 \,\text{ly}\right)\left(9.46 \times 10^{12} \,\text{km/ly}\right) = 2.18 \times 10^{17} \text{ km}$$

where the ly $\leftrightarrow$ km conversion can be found in Appendix D or figured "from basics" (knowing the speed of light). Therefore, we obtain

$$T = \frac{2\pi\left(2.18 \times 10^{17} \,\text{km}\right)}{250 \,\text{km/s}} = 5.5 \times 10^{15} \text{ s} .$$

(b) The number of revolutions N is the total time t divided by the time T for one revolution; that is, $N = t/T$. We convert the total time from years to seconds and obtain

$$N = \frac{\left(4.5 \times 10^9 \,\text{y}\right)\left(3.16 \times 10^7 \,\text{s/y}\right)}{5.5 \times 10^{15} \text{ s}} = 26 .$$

24. (a) Converting from hours to seconds, we find the angular velocity (assuming it is positive) from Eq. 11-18:

$$\omega = \frac{v}{r} = \frac{\left(2.90 \times 10^4 \,\mathrm{km/h}\right)\left(\frac{1.00\,\mathrm{h}}{3600\,\mathrm{s}}\right)}{3.22 \times 10^3 \,\mathrm{km}} = 2.50 \times 10^{-3} \,\mathrm{rad/s} \ .$$

(b) The radial (or centripetal) acceleration is computed according to Eq. 11-23:

$$a_r = \omega^2 r = \left(2.50 \times 10^{-3} \,\mathrm{rad/s}\right)^2 \left(3.22 \times 10^6 \,\mathrm{m}\right) = 20.2 \ \mathrm{m/s}^2 \ .$$

(c) Assuming the angular velocity is constant, then the angular acceleration and the tangential acceleration vanish, since

$$\alpha = \frac{d\omega}{dt} = 0 \quad \text{and} \quad a_t = r\alpha = 0 \ .$$

41. We use the parallel-axis theorem. According to Table 11-2(i), the rotational inertia of a uniform slab about an axis through the center and perpendicular to the large faces is given by

$$I_{\text{com}} = \frac{M}{12}(a^2 + b^2) \ .$$

A parallel axis through the corner is a distance $h = \sqrt{(a/2)^2 + (b/2)^2}$ from the center. Therefore,

$$I = I_{\text{com}} + Mh^2 = \frac{M}{12}\left(a^2 + b^2\right) + \frac{M}{4}\left(a^2 + b^2\right) = \frac{M}{3}\left(a^2 + b^2\right) \ .$$

53. We use $\tau = Fr = I\alpha$, where α satisfies $\theta = \frac{1}{2}\alpha t^2$ (Eq. 11-13). Here $\theta = 90° = \frac{\pi}{2}$ rad and $t = 30\,\text{s}$. The force needed is consequently

$$F = \frac{I\alpha}{r} = \frac{I\left(2\theta/t^2\right)}{r} = \frac{(8.7 \times 10^4)\left(2(\pi/2)/30^2\right)}{2.4} = 1.3 \times 10^2\ \text{N}\ .$$

76. We choose positive coordinate directions (different choices for each item) so that each is accelerating positively, which will allow us to set $a_1 = a_2 = R\alpha$ (for simplicity, we denote this as a). Thus, we choose upward positive for m_1, downward positive for m_2 and (somewhat unconventionally) clockwise for positive sense of disk rotation. Applying Newton's second law to m_1, m_2 and (in the form of Eq. 11-37) to M, respectively, we arrive at the following three equations.

$$\begin{aligned} T_1 - m_1 g &= m_1 a_1 \\ m_2 g - T_2 &= m_2 a_2 \\ T_2 R - T_1 R &= I\alpha \end{aligned}$$

(a) The rotational inertia of the disk is $I = \frac{1}{2}MR^2$ (Table 11-2(c)), so we divide the third equation (above) by R, add them all, and use the earlier equality among accelerations – to obtain:

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

which yields $a = \frac{4}{25}\, g = 1.6\ \mathrm{m/s^2}$.

(b) Plugging back in to the first equation, we find $T_1 = \frac{29}{24} m_1 g = 4.6$ N (where it is important in this step to have the mass in SI units: $m_1 = 0.40$ kg).

(c) Similarly, with $m_2 = 0.60$ kg, we find $T_2 = \frac{5}{6} m_2 g = 4.9$ N.

86. Using Eq. 11-12, we have

$$\omega = \omega_0 + \alpha t \quad \Longrightarrow \quad \alpha = \frac{2.6 - 8.0}{3.0}$$

which yields $\alpha = -1.8 \text{ rad/s}^2$. Using this value in Eq. 11-14 leads to

$$\omega^2 = \omega_0^2 + 2\alpha\theta \quad \Longrightarrow \quad \theta = \frac{0^2 - 8.0^2}{2\,(-1.8)} = 18 \text{ rad} .$$