When the little hand is on the 3 and the big hand is on the 12 . . . . (Problem 21)

22. •• **BIO** A centrifuge is a common laboratory instrument that separates components of differing densities in solution. This is accomplished by spinning a sample around in a circle with a large angular speed. Suppose that after a centrifuge in a medical laboratory is turned off, it continues to rotate with a constant angular deceleration for 10.2 s before coming to rest. **(a)** If its initial angular speed was 3850 rpm, what is the magnitude of its angular deceleration? **(b)** How many revolutions did the centrifuge complete after being turned off?

23. •• **The Slowing Earth** The Earth's rate of rotation is constantly decreasing, causing the day to increase in duration. In the year 2006 the Earth took about 0.840 s longer to complete 365 revolutions than it did in the year 1906. What was the average angular acceleration of the Earth during this time? Give your answer in rad/s^2.

24. •• **IP** A compact disk (CD) speeds up uniformly from rest to 310 rpm in 3.3 s. **(a)** Describe a strategy that allows you to calculate the number of revolutions the CD makes in this time. **(b)** Use your strategy to find the number of revolutions.

25. •• When a carpenter shuts off his circular saw, the 10.0-inch-diameter blade slows from 4440 rpm to 0.00 rpm in 2.50 s. **(a)** What is the angular acceleration of the blade? **(b)** What is the distance traveled by a point on the rim of the blade during the deceleration? **(c)** What is the magnitude of the net displacement of a point on the rim of the blade during the deceleration?

26. •• **The World's Fastest Turbine** The drill used by most dentists today is powered by a small air turbine that can operate at angular speeds of 350,000 rpm. These drills, along with ultrasonic dental drills, are the fastest turbines in the world—far exceeding the angular speeds of jet engines. Suppose a drill starts at rest and comes up to operating speed in 2.1 s. **(a)** Find the angular acceler-

Walker 10.22 (Centrifuge)

$f_i = 3850\ rpm \times \frac{1\ min}{60\ s} = 64.17\ rev/s$

$\omega_i = 2\pi f_i = 403.2\ rad/s$

$f_f = \omega_f = 0$

$\Delta t = 10.2\ s$

(a) $\alpha = \frac{\omega_f - \omega_i}{\Delta t} = -39.53\ rad/s^2$

(b) $\Delta\theta = \omega_i t + \frac{1}{2}\alpha t^2$

$= \left(403.2\ \frac{rad}{s}\right)(10.2\ s) + \frac{1}{2}\left(-39.5\ \frac{rad}{s^2}\right)(10.2\ s)^2$

$\Delta\theta = 2056$ radians

$revs = \frac{\Delta\theta\ rad}{2\pi\ rad/rev} = 327.3$ revolutions

$\approx$ **327 revolutions**

OR

$\omega^2 = \omega_0^2 + 2\alpha(\Delta\theta)$

$\Delta\theta = \frac{\omega^2 - \omega_0^2}{2\alpha} = \frac{0 - (403.2\ rad/s)^2}{2(-39.5\ rad/s^2)}$

$\Delta\theta = 2056$ radians