

## Holt Physics

**Problem 8C****NEWTON'S SECOND LAW FOR ROTATING OBJECTS****PROBLEM**

The giant sequoia General Sherman in California has a mass of about  $2.0 \times 10^6$  kg, making it the most massive tree in the world. Its height of 83 m is also impressive. Imagine a uniform bar with the same mass and length as the tree. If this bar is rotated about an axis that is perpendicular to and passes through the bar's midpoint, how large a torque would provide an angular acceleration of  $0.040$  rad/s<sup>2</sup>? (Note: Assume the bar is thin.)

**SOLUTION**

**Given:**  $M = 2.00 \times 10^6$  kg  
 $\ell = 83.0$  m  
 $\alpha = 0.040$  rad/s<sup>2</sup>

**Unknown:**  $\tau = ?$

Calculate the bar's moment of inertia using the formula for a thin rod with the axis of rotation at its center.

$$I = \frac{1}{12}M\ell^2 = \frac{1}{12}(2.00 \times 10^6 \text{ kg})(83.0 \text{ m})^2 = 1.15 \times 10^9 \text{ kg}\cdot\text{m}^2$$

Now use the equation for Newton's second law for rotating objects.

$$\tau = I\alpha = (1.15 \times 10^9 \text{ kg}\cdot\text{m}^2)(0.040 \text{ rad/s}^2) = \boxed{4.6 \times 10^7 \text{ N}\cdot\text{m}}$$

**ADDITIONAL PRACTICE**

- The largest Ferris wheel currently in existence is in Yokohama, Japan. The wheel has a radius of 50.0 m and a mass of  $1.200 \times 10^6$  kg. If a torque of  $1.0 \times 10^9$  N·m is needed to turn the wheel from a state of rest, what would be the wheel's angular speed in 3.0 s? Treat the wheel as a thin hoop.
- In 1992, Jacky Vranken, from Belgium, attained a speed of more than 250 km/h on just the back wheel of a motorcycle. Assume that all of the back wheel's mass is located at its outer edge. If the wheel has a mass of 22 kg and a radius of 0.36 m, what is the wheel's angular acceleration when a torque of 5.7 N·m is applied to the wheel?
- J. C. Payne, of Texas, amassed a ball of string that had a radius of 2.00 m. If the ball's moment of inertia is  $1.30 \times 10^4$  kg·m<sup>2</sup>, what force must be applied tangentially to the ball's surface in order to make the ball spin about its axis with an angular acceleration of  $3.20 \times 10^{-2}$  rad/s<sup>2</sup>?
- In 1990, a cherry pie with a radius of 3.0 m and a mass of  $17 \times 10^3$  kg was baked in Canada. Suppose the pie is placed on a light rotating platform attached to a motor. If this motor brings the angular speed of the pie from 0.00 rad/s to 3.46 rad/s in 12 s, what is the torque the motor must apply to the pie? Assume the mass of the platform is negligible and the pie is a uniformly solid disk.