Chapter 10 Problem 32 †

Given

$m = 108\ g = 0.108\ kg$
$D = 24\ cm = 0.24\ m$
$\Delta\theta = 1/4\ turn = \pi/2\ rad$
$\Delta\omega = 550\ rpm = \left(\frac{550\ rev}{min}\right)\left(\frac{2\pi\ rad}{rev}\right)\left(\frac{1\ min}{60\ s}\right) = 57.6\ rad/s$

Solution

a) Find the moment of inertia of the Frisbee.

Half of the mass is distributed as a ring with a moment of inertia of $I = MR^2$ and half of the mass is distributed as a disk with a moment of inertia of $I = \frac{1}{2}MR^2$. Therefore, $M = m/2 = 0.054\ kg$. Also notice that the diameter of the Frisbee is given and we need the radius. The total moment of inertia is then

$$I_{tot} = MR^2 + \frac{1}{2}MR^2 = \tfrac{3}{2}MR^2 = \tfrac{3}{2}(0.054\ kg)(0.12\ m)^2$$

$$I_{tot} = 1.17 \times 10^{-3}\ kg \cdot m^2$$

b) Find the torque exerted on the Frisbee.

Torque generates an angular acceleration with a magnitude given by the formula

$$\tau = I\alpha \tag{1}$$

The angular acceleration can be derived from the kinematic formula

$$\omega_f^2 - \omega_0^2 = 2\alpha\Delta\theta$$

Solving for α and substituting into equation 1 gives

$$\tau = \frac{I(\omega_f^2 - \omega_0^2)}{2\Delta\theta} = \frac{(1.17 \times 10^{-3}\ kg \cdot m^2)((57.6\ rad/s)^2 - (0)^2)}{2(\pi/2)}$$

$$\tau = 1.24\ N \cdot m$$

†Problem from Essential University Physics, Wolfson