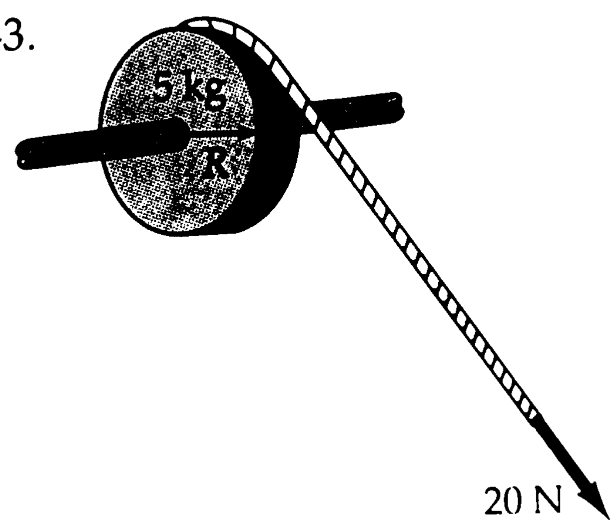
Level II

42. A flywheel is a uniform disk of mass 100 kg and radius of 1.2 m. It rotates with an angular velocity of 1200 rev/min. (*a*) A constant tangential force is applied at a radial distance of 0.5 m. What work must this force do to stop the wheel? (*b*) If the wheel is brought to rest in 2 min, what torque does the force produce? What is the magnitude of the force? (*c*) How many revolutions does the wheel make in these 2 min?

43. A uniform disk of radius 0.12 m and mass 5 kg is pivoted such that it rotates freely about its axis. A string wrapped around the disk is pulled with a force of 20 N (Figure 8-55). (*a*) What is the torque exerted on the disk? (*b*) What is the angular acceleration of the disk? (*c*) If the disk starts from rest, what is its angular velocity after 3 s? (*d*) What is its kinetic energy after 3 s? (*e*) What is its angular momentum after 3 s? (*f*) Find the total angle θ the disk turns through in 3 s, and (*g*) show that the work done by the torque $\tau\theta$ equals the kinetic energy.

Figure 8-55 Problem 43.



Physics 131: Physics I—Mechanics
Torque and Angular Acceleration

43. The disk has radius $R = 0.120\,\text{m}$ and mass $M = 5.00\,\text{kg}$. The string pulls with a force $F = 20.0\,\text{N}$

a. What is the torque?

Torque $\tau = FR$, since the angle between the force and radius vector is 90 degrees. (That is, the string is tangent to the rim of the disk.) $\tau = (20.0\,\text{N}) \times (0.120\,\text{m}) = \boxed{2.40\,\text{Nm}}$.

b. What is the angular acceleration?

$$\begin{aligned}\tau &= I\alpha \\ I &= \frac{1}{2}MR^2 = \boxed{0.036\,\text{kgm}^2} \\ \alpha &= \frac{\tau}{I} = \frac{2.40\,\text{Nm}}{0.036\,\text{kgm}^2} \\ \alpha &= \boxed{66.7\,\text{rad/s}^2}\end{aligned}$$

c. At t = 3.00 s:

$$\begin{aligned}\omega_0 &= 0 \\ \omega &= \omega_0 + \alpha t = 0 + (66.7\,\text{rad/s}^2) \times (3.00\,\text{s}) \\ \omega &= \boxed{200\,\text{rad/s}}\end{aligned}$$

d. Kinetic energy:

$$\begin{aligned}K &= \frac{1}{2}I\omega^2 = \frac{1}{2} \times (0.036\,\text{kgm}^2) \times (200\,\text{rad/s})^2 \\ K &= \boxed{720\,\text{J}}\end{aligned}$$

e. Angular momentum:

$$L = I\omega = 0.036\,\text{kgm}^2 \times 200\,\text{rad/s} = \boxed{7.20\,\text{kgm}^2/\text{s}}$$

f. Total angle:

$$\begin{aligned}\theta &= \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2 \\ \theta &= 0 + 0 + \frac{1}{2} \times (66.7\,\text{rad/s}^2) \times (3.00\,\text{s})^2 \\ &= \boxed{300\,\text{radians}}\end{aligned}$$

g. Work:

$$\begin{aligned}W &= \tau\theta = 2.40\,\text{Nm} \times 300\,\text{radians} \\ W &= \boxed{720\,\text{J}}\end{aligned}$$