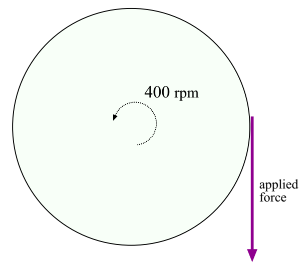
Name________________________

Apr. 9, 2010

Quiz #4 – Spring 2010

Phys 2110 – Sec 3

1. A wheel with moment of inertia $0.150\,\mathrm{kg}\cdot\mathrm{m}^2$ turns at a rate of 400 rpm; it has a torque of magnitude $6.30\,\mathrm{N}\cdot\mathrm{m}$ applied to slow it down and make it come to rest.



a) What is the angular acceleration of the the wheel?

The torque opposes the initial rotation, so with $\tau = -6.30\,\mathrm{N}\cdot\mathrm{m}$ and using $\tau = I\alpha$ we have

$$\alpha = \frac{\tau}{I} = \frac{-6.30\,\mathrm{N}\cdot\mathrm{m}}{0.150\,\mathrm{kg}\cdot\mathrm{m}^2} = -42.0\frac{\mathrm{rad}}{\mathrm{s}^2}$$

b) How long does it take to come to a halt?

Use $\omega = \omega_0 + \alpha t$. The initial angular velocity is

$$\omega_0 = 400\ \mathrm{rpm}\left(\frac{2\pi\ \mathrm{rad}}{1\ \mathrm{rev}}\right)\left(\frac{1\ \mathrm{min}}{60\ \mathrm{s}}\right) = 41.9\frac{\mathrm{rad}}{\mathrm{s}}$$

so that $\omega = 0$ gives

$$t = -\frac{\omega_0}{\alpha} = -\frac{41.9\frac{\mathrm{rad}}{\mathrm{s}}}{-42.0\frac{\mathrm{rad}}{\mathrm{s}^2}} = 0.998\ \mathrm{s}$$

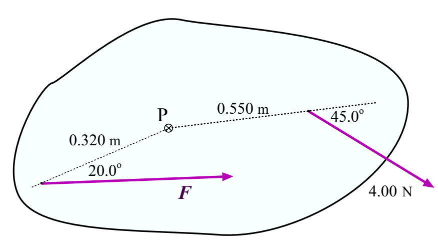
c) How many revolutions did the wheel make in coming to a halt?

As the angular acceleration was constant, we can use

$$\theta = \tfrac{1}{2}(\omega_0 + \omega)t = \tfrac{1}{2}(41.9\tfrac{\mathrm{rad}}{\mathrm{s}})(0.998\ \mathrm{s}) = 20.9\ \mathrm{rad}$$

Divide by 2π to get the number of revolutions, so $\theta =$ 3.33 revolutions.

2. Forces are applied to An irregular object rotates in a plane about the point P as shown at the right; with two forces applied as shown. If the net torque is to be zero, what is the magnitude of force **F**?



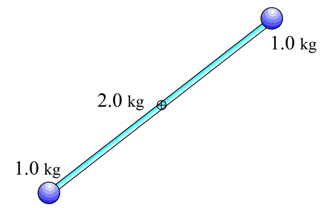
The forces give torques in opposite directions: their magnitudes must be equal and from that we get

$$(4.00\ \mathrm{N})(0.550\ \mathrm{m})\sin 45^\circ = F(0.320\ \mathrm{m})\sin 20^\circ$$

which gives

$$F = 14.2\ \mathrm{N}$$

3. A rotating object consists of a uniform rod of length 1.4 m and mass 2.0 kg with very small 1.0 kg masses attached to each end. The object rotates around an axis through the rod's center, perpendicular to the rod.



a) What is the moment of inertia of the object?

Moment of inertia is that of a stick rotating about its center and of two point masses, each of which contributes mr^2. We get:

$$I_{\text{total}} = \frac{1}{12}(2.0\text{ kg})(1.4\text{ m})^2 + 2(1.0\text{ kg})(0.7\text{ m})^2 = 1.31\,\text{kg}\cdot\text{m}^2$$

b) If the object is rotating with 1.5 J of kinetic energy, what is its angular velocity? Express the answer in units of revolutions per minute.

Use $K = \frac{1}{2}I\omega^2$ and the I found in (a) and get:

$$\omega^2 = \frac{2K}{I} = \frac{2(1.5\text{ J})}{(1.31\,\text{kg}\cdot\text{m}^2)} = 2.29\text{ s}^{-2} \qquad \Longrightarrow \qquad \omega = 1.51\frac{\text{rad}}{\text{s}}$$

This converts to

$$1.51\frac{\text{rad}}{\text{s}} = 14.5\text{ rpm}$$

You must show all your work and include the right units with your answers!

$$\omega = \omega_0 + \alpha t \qquad \theta = \theta_0 + \omega_0 t + \frac{1}{2}\alpha t^2 \qquad \omega^2 = \omega_0^2 + 2\alpha(\theta - \theta_0) \qquad \theta - \theta_0 = \frac{1}{2}(\omega_0 + \omega)t$$

$$\tau = rF\sin\theta \quad \tau = I\alpha \quad K_{\text{rot}} = \frac{1}{2}I\omega^2 \quad v_c = R\omega \quad a_c = R\alpha \quad K_{\text{roll}} = \frac{1}{2}mv_c^2 + \frac{1}{2}I\omega^2 \quad I = \sum_i m_i r_i^2$$

$$I_{\text{cyl}} = \frac{1}{2}MR^2 \qquad I_{\text{sph,sol}} = \frac{2}{5}MR^2 \qquad I_{\text{sph,hol}} = \frac{2}{3}MR^2 \qquad I_{\text{rod, ctr}} = \frac{1}{12}ML^2 \qquad I_{\text{rod, end}} = \frac{1}{3}ML^2$$