$$t=\frac{2\theta}{\omega_o+\omega}=\frac{2(993\text{ rev})}{10,300\text{ rev/min}}\left(\frac{60\text{ s}}{1\text{ min}}\right)=\boxed{10.9\text{ s}}$$

38. (*a*) The torque gives angular acceleration to the ball only, since the arm is considered massless. The angular acceleration of the ball is found from the given tangential acceleration.

$$\tau=I\alpha=MR^2\alpha=MR^2\frac{a_{\tan}}{R}=MRa_{\tan}=(3.6\text{ kg})(0.31\text{ m})(7.0\,\text{m/s}^2)$$
$$=7.812\,\text{m}\bullet\text{N}\approx\boxed{7.8\,\text{m}\bullet\text{N}}$$

(*b*) The triceps muscle must produce the torque required, but with a lever arm of only 2.5 cm, perpendicular to the triceps muscle force.

$$\tau=Fr_\perp\ \rightarrow\ F=\tau/r_\perp=7.812\,\text{m}\bullet\text{N}/(2.5\times10^{-2}\,\text{m})=\boxed{3.1\times10^2\,\text{N}}$$

39. (*a*) The angular acceleration can be found from

$$\alpha=\frac{\Delta\omega}{\Delta t}=\frac{\omega}{t}=\frac{v/r}{t}=\frac{(10.0\,\text{m/s})/(0.31\,\text{m})}{0.350\text{ s}}=92.17\,\text{rad/s}^2\approx\boxed{92\,\text{rad/s}^2}$$

(*b*) The force required can be found from the torque, since $\tau=Fr\sin\theta$. In this situation the force is perpendicular to the lever arm, and so $\theta=90^\circ$. The torque is also given by $\tau=I\alpha$, where I is the moment of inertia of the arm-ball combination. Equate the two expressions for the torque, and solve for the force.

$$Fr\sin\theta=I\alpha$$
$$F=\frac{I\alpha}{r\sin\theta}=\frac{m_{\text{ball}}d_{\text{ball}}^2+\frac{1}{3}m_{\text{arm}}L_{\text{arm}}^2}{r\sin90^\circ}\alpha$$
$$=\frac{(1.00\text{ kg})(0.31\text{ m})^2+\frac{1}{3}(3.70\text{ kg})(0.31\text{ m})^2}{(0.025\text{ m})}(92.17\,\text{rad/s}^2)=\boxed{7.9\times10^2\,\text{N}}$$

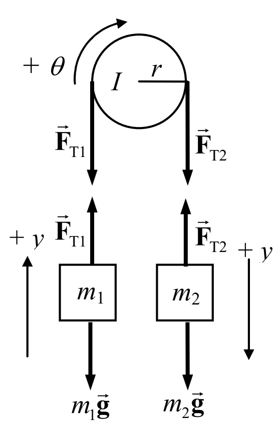
40. (*a*) The moment of inertia of a thin rod, rotating about its end, is given in Figure 8-21(g). There are three blades to add.

$$I_{\text{total}}=3\left(\tfrac{1}{3}ML^2\right)=ML^2=(160\text{ kg})(3.75\text{ m})^2=2250\,\text{kg}\bullet\text{m}^2\approx\boxed{2.3\times10^2\,\text{kg}\bullet\text{m}^2}$$

(*b*) The torque required is the rotational inertia times the angular acceleration, assumed constant.

$$\tau=I_{\text{total}}\alpha=I_{\text{total}}\frac{\omega-\omega_0}{t}=(2250\,\text{kg}\bullet\text{m}^2)\frac{(5.0\,\text{rev/sec})(2\pi\text{ rad/rev})}{8.0\text{ s}}=\boxed{8.8\times10^3\,\text{m}\bullet\text{N}}$$

41. We assume that $m_2>m_1$, and so m_2 will accelerate down, m_1 will accelerate up, and the pulley will accelerate clockwise. Call the direction of acceleration the positive direction for each object. The masses will have the same acceleration since they are connected by a cord. The rim of the pulley will have that same acceleration since the cord is making it rotate, and so $\alpha_{\text{pulley}}=a/r$. From the free-body diagrams for each object, we have the following.



$$\sum F_{y\,1}=F_{\text{T1}}-m_1g=m_1a\ \rightarrow\ F_{\text{T1}}=m_1g+m_1a$$
$$\sum F_{y\,2}=m_2g-F_{\text{T2}}=m_2a\ \rightarrow\ F_{\text{T2}}=m_2g-m_2a$$

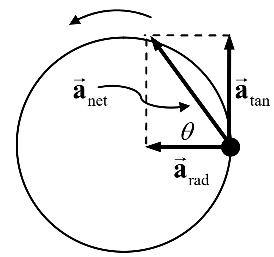
$$\sum \tau = F_{T2}r - F_{T1}r = I\alpha = I\frac{a}{r}$$

Substitute the expressions for the tensions into the torque equation, and solve for the acceleration.

$$F_{T2}r - F_{T1}r = I\frac{a}{r} \rightarrow (m_2 g - m_2 a)r - (m_1 g + m_1 a)r = I\frac{a}{r} \rightarrow \boxed{a = \frac{(m_2 - m_1)}{(m_1 + m_2 + I/r^2)} g}$$

If the moment of inertia is ignored, then from the torque equation we see that $F_{T2} = F_{T1}$, and the acceleration will be $\boxed{a_{I=0} = \frac{(m_2 - m_1)}{(m_1 + m_2)} g}$. We see that the acceleration with the moment of inertia included will be smaller than if the moment of inertia is ignored.

42. A top view diagram of the hammer is shown, just at the instant of release, along with the acceleration vectors.



(*a*) The angular acceleration is found from Eq. 8-9c.

$$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta \rightarrow$$

$$\alpha = \frac{\omega^2 - \omega_0^2}{2\Delta\theta} = \frac{(v/r)^2 - 0}{2\Delta\theta} = \frac{[(28.0\,\text{m/s})/(1.20\text{ m})]^2}{2(8\pi\text{ rad})} = \boxed{10.8\,\text{rad/s}^2}$$

(*b*) The tangential acceleration is found from the angular acceleration and the radius.

$$a_{tan} = \alpha r = (10.8\,\text{rad/s}^2)(1.20\text{ m}) = \boxed{13.0\,\text{m/s}^2}$$

(*c*) The centripetal acceleration is found from the speed and the radius.

$$a_{rad} = v^2/r = (28.0\,\text{m/s})^2/(1.20\text{ m}) = \boxed{653\,\text{m/s}^2}$$

(*d*) The net force is the mass times the net acceleration. It is in the same direction as the net acceleration, also.

$$F_{net} = ma_{net} = m\sqrt{a_{tan}^2 + a_{rad}^2} = (7.30\text{ kg})\sqrt{(13.0\,\text{m/s}^2)^2 + (653\,\text{m/s}^2)^2} = \boxed{4.77\times10^3\,\text{N}}$$

(*e*) Find the angle from the two acceleration vectors.

$$\theta = \tan^{-1}\frac{a_{tan}}{a_{rad}} = \tan^{-1}\frac{13.0\,\text{m/s}^2}{653\,\text{m/s}^2} = \boxed{1.14^\circ}$$

43. The energy required to bring the rotor up to speed from rest is equal to the final rotational KE of the rotor.

$$KE_{rot} = \tfrac{1}{2}I\omega^2 = \tfrac{1}{2}(3.75\times10^{-2}\,\text{kg}\bullet\text{m}^2)\left[8250\frac{\text{rev}}{\text{min}}\left(\frac{2\pi\text{ rad}}{1\text{ rev}}\right)\left(\frac{1\text{ min}}{60\text{ s}}\right)\right]^2 = \boxed{1.40\times10^4\,\text{J}}$$

44. Work can be expressed in rotational quantities as $W = \tau\,\Delta\theta$, and so power can be expressed in rotational quantities as $P = \frac{W}{\Delta t} = \tau\frac{\Delta\theta}{\Delta t} = \tau\omega$.

$$P = \tau\omega = (280\,\text{m}\bullet\text{N})\left(3800\frac{\text{rev}}{\text{min}}\right)\left(\frac{2\pi\text{ rad}}{1\text{ rev}}\right)\left(\frac{1\text{ min}}{60\text{ s}}\right) = 1.114\times10^5\,\text{W} \approx \boxed{1.1\times10^5\,\text{W}}$$

$$1.114\times10^5\,\text{W}\left(\frac{1\text{ hp}}{746\text{ W}}\right) = \boxed{1.5\times10^2\,\text{hp}}$$