Problems set for Chapter 8

1. Express the following angles in radians: (*a*) 45.0°, (*b*) 60.0°, (*c*) 90.0°, (*d*) 360.0°, and (*e*) 445°. Give as numerical values and as fractions of π.

(*a*) $(45.0°)(2\pi \text{ rad}/360°) = \boxed{\pi/4 \text{ rad}} = \boxed{0.785 \text{ rad}}$

(*b*) $(60.0°)(2\pi \text{ rad}/360°) = \boxed{\pi/3 \text{ rad}} = \boxed{1.05 \text{ rad}}$

(*c*) $(90.0°)(2\pi \text{ rad}/360°) = \boxed{\pi/2 \text{ rad}} = \boxed{1.57 \text{ rad}}$

(*d*) $(360.0°)(2\pi \text{ rad}/360°) = \boxed{2\pi \text{ rad}} = \boxed{6.283 \text{ rad}}$

(*e*) $(445°)(2\pi \text{ rad}/360°) = \boxed{89\pi/36 \text{ rad}} = \boxed{7.77 \text{ rad}}$

2. The platter of the **hard drive** of a computer rotates at 7200 rpm,
rpm=revolutions per minute=rev/min.
(*a*) What is the angular velocity (rad/s) of the platter? (*b*) If the reading head of the drive is located 3.00 cm from the rotation axis, what is the linear speed of the point on the platter just below it? (*c*) If a single bit requires 0.50 μm of length along the direction of motion, how many bits per second can the writing head write when it is 3.00 cm from the axis?

(*a*) We convert rpm to rad/s.

$$\omega = \left(\frac{7200 \text{ rev}}{1 \text{ min}}\right)\left(\frac{2\pi \text{ rad}}{1 \text{ rev}}\right)\left(\frac{1 \text{ min}}{60 \text{ s}}\right) = 753.98 \text{ rad/s} \approx \boxed{750 \text{ rad/s}}$$

(*b*) To find the speed, we use the radius of the reading head location along with Eq. 8–4.

$$\upsilon = r\omega = (3.00\times10^{-2} \text{ m})(753.98 \text{ rad/s}) = 22.62 \text{ m/s} \approx \boxed{23 \text{ m/s}}$$

(*c*) We convert the speed of the point on the platter from m/s to bits/s, using the distance per bit.

$$(22.62 \text{ m/s})\left(\frac{1 \text{ bit}}{0.50\times10^{-6} \text{ m}}\right) = \boxed{4.5\times10^{7} \text{ bits/s}}$$

3. A 61-cm-diameter wheel accelerates uniformly about its center from 120 rpm to 280 rpm in 4.0 s. Determine (*a*) its angular acceleration, and (*b*) the radial and tangential components of the linear acceleration of a point on the edge of the wheel 2.0 s after it has started accelerating.

Convert the rpm values to angular velocities.

$$\omega_0 = \left(120\frac{\text{rev}}{\text{min}}\right)\left(\frac{2\pi \text{ rad}}{1 \text{ rev}}\right)\left(\frac{1 \text{ min}}{60 \text{ s}}\right) = 12.57 \text{ rad/s}$$

$$\omega = \left(280\frac{\text{rev}}{\text{min}}\right)\left(\frac{2\pi \text{ rad}}{1 \text{ rev}}\right)\left(\frac{1 \text{ min}}{60 \text{ s}}\right) = 29.32 \text{ rad/s}$$

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

$$\alpha = \frac{\omega - \omega_0}{t} = \frac{29.32 \text{ rad/s} - 12.57 \text{ rad/s}}{4.0 \text{ s}} = 4.188 \text{ rad/s}^2 \approx \boxed{4.2 \text{ rad/s}^2}$$

(*b*) To find the components of the acceleration, the instantaneous angular velocity is needed.

$$\omega = \omega_0 + \alpha t = 12.57 \text{ rad/s} + (4.188 \text{ rad/s}^2)(2.0 \text{ s}) = 20.95 \text{ rad/s}$$

The instantaneous radial acceleration is given by $a_R = \omega^2 r$.

$$a_R = \omega^2 r = (20.95 \text{ rad/s})^2 \left(\frac{0.61 \text{ m}}{2}\right) = \boxed{130 \text{ m/s}^2}$$

The tangential acceleration is given by $a_{tan} = \alpha r$.

$$a_{tan} = \alpha r = (4.188 \text{ rad/s}^2)\left(\frac{0.61 \text{ m}}{2}\right) = \boxed{1.3 \text{ m/s}^2}$$

4. The tires of a car make 75 revolutions as the car reduces its speed uniformly from 95 km/h to 55 km/h. The tires have a diameter of 0.80 m. (*a*) What was the angular acceleration of the tires? If the car continues to decelerate at this rate, (*b*) how much more time is required for it to stop, and (*c*) how far does it go?

(*a*)The angular acceleration can be found from $\omega^2 = \omega_0^2 + 2\alpha\theta$, with the angular velocities being found from $\omega = \upsilon/r$.

$$\alpha = \frac{\omega^2 - \omega_0^2}{2\theta} = \frac{(\upsilon^2 - \upsilon_0^2)}{2r^2\theta} = \frac{\left[(55 \text{ km/h})^2 - (95 \text{ km/h})^2\right]\left(\frac{1 \text{ m/s}}{3.6 \text{ km/h}}\right)^2}{2(0.40 \text{ m})^2(75 \text{ rev})\left(\frac{2\pi \text{ rad}}{\text{rev}}\right)}$$

$$= -3.070 \text{ rad/s}^2 \approx \boxed{-3.1 \text{ rad/s}^2}$$

(*b*) The time to stop can be found from $\omega = \omega_0 + \alpha t$, with a final angular velocity of 0.

$$t = \frac{\omega - \omega_0}{\alpha} = \frac{\upsilon - \upsilon_0}{r\alpha} = \frac{-(55 \text{ km/h})\left(\frac{1 \text{ m/s}}{3.6 \text{ km/h}}\right)}{(0.40 \text{ m})(-3.070 \text{ rad/s}^2)} = 12.44 \text{ s} \approx \boxed{12 \text{ s}}$$

(*c*) We first find the total angular displacement of the tires as they slow from 55 km/h to rest, and then convert the angular displacement to a linear displacement, assuming that the tires are rolling without slipping.

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

$$\Delta\theta = \frac{\omega^2 - \omega_0^2}{2\alpha} = \frac{0 - \left(\frac{\upsilon_0}{r}\right)^2}{2\alpha} = -\frac{\left[\frac{(55 \text{ km/h})}{0.40 \text{ m}}\left(\frac{1 \text{ m/s}}{3.6 \text{ km/h}}\right)\right]^2}{2(-3.070 \text{ rad/s}^2)} = 237.6 \text{ rad}$$

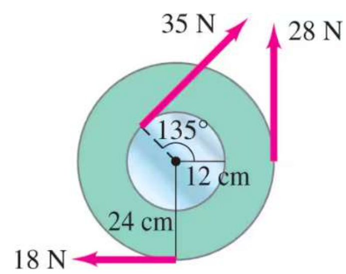
$$\Delta x = r\Delta\theta = (0.40 \text{ m})(237.6 \text{ rad}) = \boxed{95 \text{ m}}$$

For the total distance, add the distance moved during the time the car slows from 95 km/h to 55 km/h. The tires made 75 revolutions, so that distance is as follows:

$$\Delta x = r\Delta\theta = (0.40 \text{ m})(75 \text{ rev})\left(\frac{2\pi \text{ rad}}{\text{rev}}\right) = 188 \text{ m}$$

The total distance would be the sum of the two distances, 283 m.

5. Calculate the net torque about the axle of the wheel shown in the figure. Assume that a friction torque of 0.60 m·N opposes the motion.



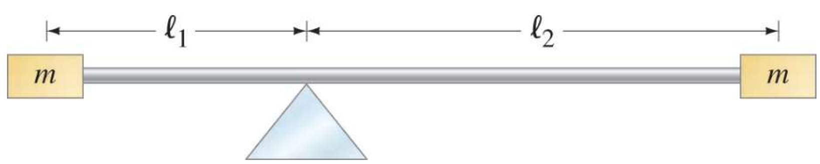
Each force is oriented so that it is perpendicular to its lever arm. Call counterclockwise torques positive. The torque due to the three applied forces is given by the following:

$$\tau_{\substack{\text{applied}\\\text{forces}}} = (28\text{ N})(0.24\text{ m}) - (18\text{ N})(0.24\text{ m}) - (35\text{ N})(0.12\text{ m}) = -1.8\text{ m}\cdot\text{N}$$

Since this torque is clockwise, we assume the wheel is rotating clockwise, so the frictional torque is counterclockwise. Thus the net torque is as follows:

$$\tau_{\text{net}} = (28\text{ N})(0.24\text{ m}) - (18\text{ N})(0.24\text{ m}) - (35\text{ N})(0.12\text{ m}) + 0.60\text{ m}\cdot\text{N} = -1.2\text{ m}\cdot\text{N}$$
$$= \boxed{1.2\text{ m}\cdot\text{N, clockwise}}$$

6. Two blocks, each of mass *m*, are attached to the ends of a massless rod which pivots as shown in the figure. Initially the rod is held in the horizontal position and then released. Calculate the magnitude and direction of the net torque on this system when it is first released.



There is a counterclockwise torque due to the force of gravity on the left block and a clockwise torque due to the force of gravity on the right block. Call clockwise the positive direction.

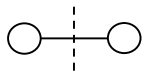
$$\sum \tau = mg\ell_2 - mg\ell_1 = \boxed{mg(\ell_2 - \ell_1)\text{, clockwise}}$$

7. Determine the moment of inertia of a 10.8-kg sphere of radius 0.648 m when the axis of rotation is through its center.

For a sphere rotating about an axis through its center, the moment of inertia is as follows:

$$I = \tfrac{2}{5}MR^2 = \tfrac{2}{5}(10.8\ \text{kg})(0.648\ \text{m})^2 = \boxed{1.81\ \text{kg}\cdot\text{m}^2}$$

8. An oxygen molecule consists of two oxygen atoms whose total mass is 5.3×10^{-26} kg and whose moment of inertia about an axis perpendicular to the line joining the two atoms, midway between them, is 1.9×10^{-46}kg·m^2. From these data, estimate the effective distance between the atoms.

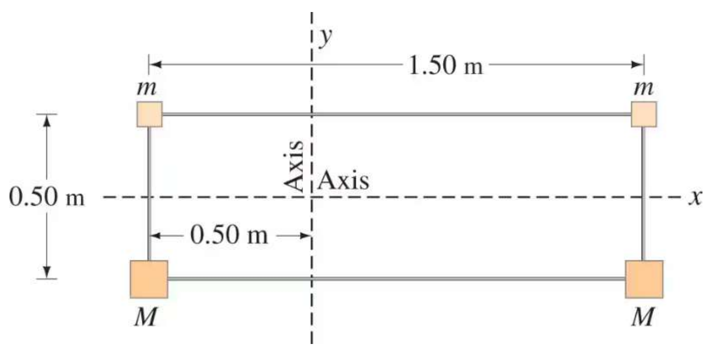


The oxygen molecule has a "dumbbell" geometry, as though it rotates about the dashed line shown in the diagram. If the total mass is *M*, then each atom has a mass of *M*/2. If the distance between them is *d*, then the distance from the axis of rotation to each atom is *d*/2. Treat each atom as a particle for calculating the moment of inertia.

$$I = (M/2)(d/2)^2 + (M/2)(d/2)^2 = 2(M/2)(d/2)^2 = \tfrac{1}{4}Md^2 \quad \rightarrow$$

$$d = \sqrt{4I/M} = \sqrt{4(1.9\times10^{-46}\ \text{kg}\cdot\text{m}^2)/(5.3\times10^{-26}\ \text{kg})} = \boxed{1.2\times10^{-10}\ \text{m}}$$

9. Calculate the moment of inertia of the array of point objects shown in the figure about (*a*) the *y* axis, and (*b*) the *x* axis. Assume m=2.2 kg, M=3.4 kg, and the objects are wired together by very light, rigid pieces of wire. The array is rectangular and is split through the middle by the *x* axis. (*c*) About which axis would it be harder to accelerate this array?



(*a*)To calculate the moment of inertia about the *y* axis (vertical), use the following:

$$I = \sum M_i R_{ix}^2 = m(0.50\ \text{m})^2 + M(0.50\ \text{m})^2 + m(1.00\ \text{m})^2 + M(1.00\ \text{m})^2$$
$$= (m+M)\left[(0.50\ \text{m})^2 + (1.00\ \text{m})^2\right] = (5.6\ \text{kg})\left[(0.50\ \text{m})^2 + (1.00\ \text{m})^2\right] = \boxed{7.0\ \text{kg}\cdot\text{m}^2}$$

(*b*)To calculate the moment of inertia about the *x* axis (horizontal), use the following:

$$I = \sum M_i R_{iy}^2 = (2m + 2M)(0.25\ \text{m})^2 = 2(5.6\ \text{kg})(0.25\ \text{m})^2 = \boxed{0.70\ \text{kg}\cdot\text{m}^2}$$

(*c*)Because of the larger *I* value, it is ten times harder to accelerate the array about the $\boxed{\text{vertical axis}}$.

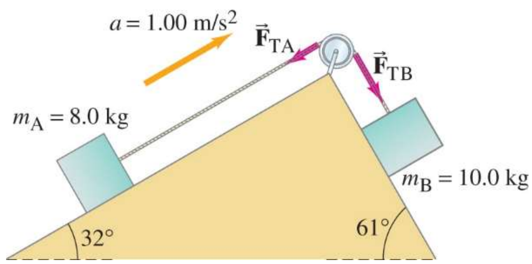
10. A 0.72-m-diameter solid sphere can be rotated about an axis through its center by a torque of 10.8 m·N which accelerates it uniformly from rest through a total of 160 revolutions in 15.0 s. What is the mass of the sphere?

The torque supplied is equal to the angular acceleration times the moment of inertia. The angular acceleration is found by using Eq. 8–9b, with $\omega_0 = 0$. Use the moment of inertia of a sphere.

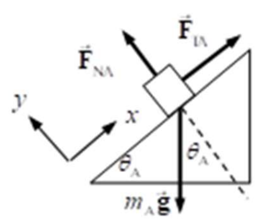
$$\theta = \omega_0 + \tfrac{1}{2}\alpha t^2 \quad \rightarrow \quad \alpha = \frac{2\theta}{t^2}; \quad \tau = I\alpha = \left(\tfrac{2}{5}Mr_0^2\right)\left(\frac{2\theta}{t^2}\right) \quad \rightarrow$$

$$M = \frac{5\tau t^2}{4r_0^2\theta} = \frac{5(10.8\ \text{m}\cdot\text{N})(15.0\ \text{s})^2}{4(0.36\ \text{m})^2(320\pi\ \text{rad})} = 23.31\ \text{kg} \approx \boxed{23\ \text{kg}}$$

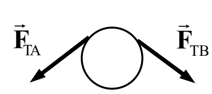
11. Two blocks are connected by a light string passing over a pulley of radius 0.15 m and moment of inertia *I*. The blocks move (towards the right) with an acceleration of 1.00 m/s² along their frictionless inclines (see the figure). (*a*) Draw free-body diagrams for each of the two blocks and the pulley. (*b*) Determine FTA and FTB, the tensions in the two parts of the string. (*c*) Find the net torque acting on the pulley, and determine its moment of inertia, *I*.



(*a*) The free-body diagrams are shown. Note that only the forces producing torque are shown on the pulley. There would also be a gravity force on the pulley (since it has mass) and a normal force from the pulley's suspension, but they are not shown since they do not enter into the solution.



(*b*) Write Newton's second law for the two blocks, taking the positive *x* direction as shown in the free-body diagrams.

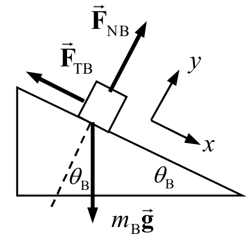


$$m_A: \ \sum F_x = F_{TA} - m_A g \sin\theta_A = m_A a \ \rightarrow$$

$$F_{TA} = m_A(g \sin\theta_A + a)$$

$$= (8.0 \text{ kg})\left[(9.80 \text{ m/s}^2)\sin 32° + 1.00 \text{ m/s}^2\right] = 49.55 \text{ N}$$

$$\approx \boxed{50 \text{ N}} \text{ (2 significant figures)}$$



$$m_B: \ \sum F_x = m_B g \sin\theta_B - F_{TB} = m_B a \ \rightarrow$$

$$F_{TB} = m_B(g \sin\theta_B - a)$$

$$= (10.0 \text{ kg})\left[(9.80 \text{ m/s}^2)\sin 61° - 1.00 \text{ m/s}^2\right] = 75.71 \text{ N}$$

$$\approx \boxed{76 \text{ N}}$$

(*c*) The net torque on the pulley is caused by the two tensions. We take clockwise torques as positive.

$$\sum\tau = (F_{TB} - F_{TA})R = (75.71 \text{ N} - 49.55 \text{ N})(0.15 \text{ m}) = 3.924 \text{ m}\cdot\text{N} \approx \boxed{3.9 \text{ m}\cdot\text{N}}$$

Use Newton's second law to find the rotational inertia of the pulley. The tangential acceleration of the pulley's rim is the same as the linear acceleration of the blocks, assuming that the string doesn't slip.

$$\sum\tau = I\alpha = I\frac{a}{R} = (F_{TB} - F_{TA})R \ \rightarrow$$

$$I = \frac{(F_{TB} - F_{TA})R^2}{a} = \frac{(75.71 \text{ N} - 49.55 \text{ N})(0.15 \text{ m})^2}{1.00 \text{ m/s}^2} = \boxed{0.59 \text{ kg}\cdot\text{m}^2}$$

12. Estimate the kinetic energy of the Earth with respect to the Sun as the sum of two terms, (*a*) that due to its daily rotation about its axis, and (*b*) that due to its yearly revolution about the Sun. [Assume the Earth is a uniform sphere with mass=6.0×10^{24} kg, radius=6.4×10^6 m, and is 1.5×10^8 km from the Sun.]

(*a*) For the daily rotation about its axis, treat the Earth as a uniform sphere, with an angular frequency of one revolution per day.

$$\text{KE}_{\text{daily}} = \tfrac{1}{2}I\omega_{\text{daily}}^2 = \tfrac{1}{2}\left(\tfrac{2}{5}MR_{\text{Earth}}^2\right)\omega_{\text{daily}}^2$$

$$= \tfrac{1}{5}(6.0\times10^{24} \text{ kg})(6.4\times10^6 \text{ m})^2\left[\left(\frac{2\pi \text{ rad}}{1 \text{ day}}\right)\left(\frac{1 \text{ day}}{86{,}400 \text{ s}}\right)\right]^2 = \boxed{2.6\times10^{29} \text{ J}}$$

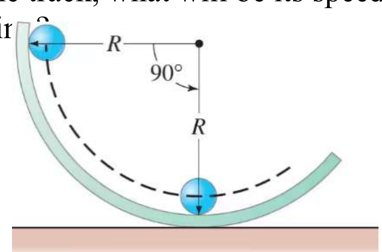
(*b*) For the yearly revolution about the Sun, treat the Earth as a particle, with an angular frequency of one revolution per year.

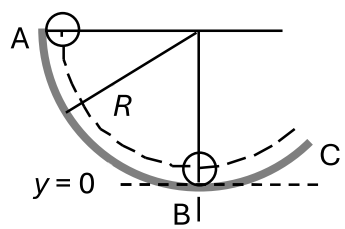
$$\text{KE}_{\text{yearly}} = \tfrac{1}{2}I\omega_{\text{yearly}}^2 = \tfrac{1}{2}\left(MR_{\text{Sun-Earth}}^2\right)\omega_{\text{yearly}}^2$$

$$= \tfrac{1}{2}(6.0\times10^{24} \text{ kg})(1.5\times10^{11} \text{ m})^2\left[\left(\frac{2\pi \text{ rad}}{365 \text{ day}}\right)\left(\frac{1 \text{ day}}{86{,}400 \text{ s}}\right)\right]^2 = \boxed{2.7\times10^{33} \text{ J}}$$

Thus the total kinetic energy is $\text{KE}_{\text{daily}} + \text{KE}_{\text{yearly}} = 2.6\times10^{29} \text{ J} + 2.7\times10^{33} \text{ J} = \boxed{2.7\times10^{33} \text{ J}}$. The kinetic energy due to the daily motion is about 10,000 times smaller than that due to the yearly motion.

13. A ball of radius *r* rolls on the inside of a track of radius *R* (see the figure). If the ball starts from rest at the vertical edge of the track, what will be its speed when it reaches the lowest point of the track, rolling without slipping?





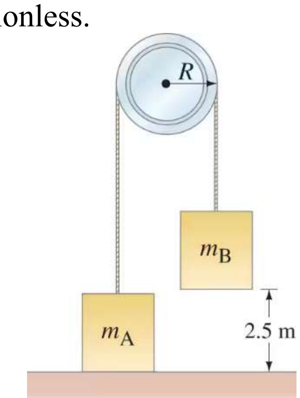
Use conservation of mechanical energy to equate the energy at points A and B. Call the zero level for gravitational potential energy the lowest point on which the ball rolls. Since the ball rolls without slipping, $\omega = \upsilon/r$.

$$E_A = E_B \quad \rightarrow \quad \mathrm{PE_A} = \mathrm{PE_B} + \mathrm{KE_B} = \mathrm{PE_B} + \mathrm{KE_{B\,CM}} + \mathrm{KE_{B\,rot}} \quad \rightarrow$$

$$mgR = mgr + \tfrac{1}{2}m\upsilon_B^2 + \tfrac{1}{2}I\omega_B^2$$

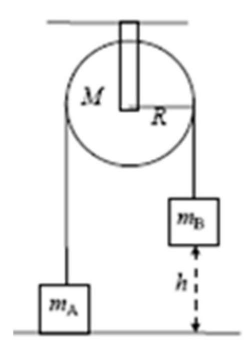
$$= mgr + \tfrac{1}{2}m\upsilon_B^2 + \tfrac{1}{2}\left(\tfrac{2}{5}mr^2\right)\left(\frac{\upsilon_B}{r}\right)^2 \quad \rightarrow \quad \upsilon_B = \boxed{\sqrt{\tfrac{10}{7}g(R-r)}}$$

14. Two masses, mA=32.0 kg and mB=38.0 kg, are connected by a rope that hangs over a pulley (as in the figure). The pulley is a uniform cylinder of radius R=0.311m and mass 3.1 kg. Initially mA is on the ground and mB rests 2.5 m above the ground. If the system is released, use conservation of energy to determine the speed of mB just before it strikes the ground. Assume the pulley bearing is frictionless.



The only force doing work in this system is gravity, so mechanical energy is conserved. The initial state of the system is the configuration with m_A on the ground and all objects at rest. The final state of the system has m_B just reaching the ground and all objects in motion. Call the zero level of gravitational potential energy the ground level. Both masses will have the same speed since they are connected by the rope. Assuming that the rope does not slip on the pulley, the angular speed of the pulley is related to the speed of the masses by $\omega = \upsilon/r$. All objects have an initial speed of 0.

$$E_i = E_f \quad \rightarrow$$



$$\tfrac{1}{2}m_A\upsilon_i^2+\tfrac{1}{2}m_B\upsilon_i^2+\tfrac{1}{2}I\omega_i^2+m_Ag\,y_{1i}+m_Bg\,y_{2i}=\tfrac{1}{2}m_A\upsilon_f^2+\tfrac{1}{2}m_B\upsilon_f^2+\tfrac{1}{2}I\omega_f^2$$
$$+m_Ag\,y_{1f}+m_Bg\,y_{2f}$$

$$m_Bgh=\tfrac{1}{2}m_A\upsilon_f^2+\tfrac{1}{2}m_B\upsilon_f^2+\tfrac{1}{2}\left(\tfrac{1}{2}MR^2\right)\left(\frac{\upsilon_f^2}{R^2}\right)+m_Agh$$

$$\upsilon_f=\sqrt{\frac{2(m_B-m_A)gh}{\left(m_A+m_B+\tfrac{1}{2}M\right)}}=\sqrt{\frac{2(38.0\text{ kg}-32.0\text{ kg})(9.80\text{ m/s}^2)(2.5\text{ m})}{\left(38.0\text{ kg}+32.0\text{ kg}+\left(\tfrac{1}{2}\right)3.1\text{ kg}\right)}}=\boxed{2.0\text{ m/s}}$$

15. (*a*) What is the angular momentum of a 2.8-kg uniform cylindrical grinding wheel of radius 28 cm when rotating at 1300 rpm? (*b*) How much torque is required to stop it in 6.0 s?

(*a*)The angular momentum is given by Eq. 8–18.

$$L=I\omega=\tfrac{1}{2}MR^2\omega=\tfrac{1}{2}(2.8\text{ kg})(0.28\text{ m})^2\left[\left(\frac{1300\text{ rev}}{1\text{ min}}\right)\left(\frac{2\pi\text{ rad}}{1\text{ rev}}\right)\left(\frac{1\text{ min}}{60\text{ s}}\right)\right]$$
$$=14.94\text{ kg}\cdot\text{m}^2/\text{s}\approx\boxed{15\text{ kg}\cdot\text{m}^2/\text{s}}$$

(*b*) The torque required is the change in angular momentum per unit time. The final angular momentum is zero.

$$\tau=\frac{L-L_0}{\Delta t}=\frac{0-14.94\text{ kg}\cdot\text{m}^2/\text{s}}{6.0\text{ s}}=\boxed{-2.5\text{ m}\cdot\text{N}}$$

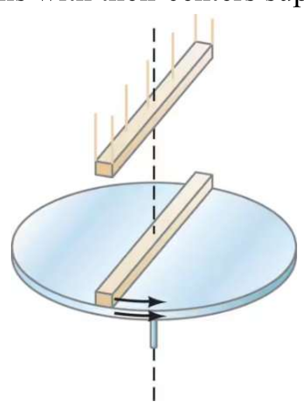
The negative sign indicates that the torque is used to oppose the initial angular momentum.

16. A person stands, hands at his side, on a platform that is rotating at a rate of 0.90 rev/s. If he raises his arms to a horizontal position, the figure, the speed of rotation decreases to 0.60 rev/s. (*a*) Why? (*b*) By what factor has his moment of inertia changed?

(*a*) Consider the person and platform a system for angular momentum analysis. Since the force and torque to raise and/or lower the arms are internal to the system, the raising or lowering of the arms will cause no change in the total angular momentum of the system. However, the rotational inertia increases when the arms are raised. $\boxed{\text{Since angular momentum is conserved, an increase in rotational inertia must be accompanied by a decrease in angular velocity.}}$

(*b*) $L_i = L_f \quad \rightarrow \quad I_i\omega_i = I_f\omega_f \quad \rightarrow \quad I_f = I_i\dfrac{\omega_i}{\omega_f} = I_i\dfrac{0.90 \text{ rev/s}}{0.60 \text{ rev/s}} = 1.5\, I_i$ The rotational inertia has increased by a factor of $\boxed{1.5}$.

17. A uniform disk turns at 3.3 rev/s around a frictionless central axis. A nonrotating rod, of the same mass as the disk and length equal to the disk's diameter, is dropped onto the freely spinning disk, the figure. They then turn together around the axis with their centers superposed. What is the angular frequency in rev/s of the combination?



The angular momentum of the disk–rod combination will be conserved, because there are no external torques on the combination. This situation is a totally inelastic collision, in which the final angular velocity is the same for both the disk and the rod. Subscript 1 represents before the collision, and subscript 2 represents after the collision. The rod has no initial angular momentum.

$$L_1 = L_2 \quad \rightarrow \quad I_1\omega_1 = I_2\omega_2 \quad \rightarrow$$

$$\omega_2 = \omega_1\frac{I_1}{I_2} = \omega_1\frac{I_{\text{disk}}}{I_{\text{disk}} + I_{\text{rod}}} = \omega_1\left[\frac{\frac{1}{2}MR^2}{\frac{1}{2}MR^2 + \frac{1}{12}M(2R)^2}\right] = (3.3 \text{ rev/s})\left(\frac{3}{5}\right) = \boxed{2.0 \text{ rev/s}}$$

18. Suppose a 65-kg person stands at the edge of a 5.5-m diameter merry-go-round turntable that is mounted on frictionless bearings and has a moment of inertia of 1850 kg·m2. The turntable is at rest initially, but when the person begins running at a speed of 4.0 m/s (with respect to the turntable) around its edge, the turntable begins to rotate in the opposite direction. Calculate the angular velocity of the turntable.

The angular momentum of the person–turntable system will be conserved. Call the direction of the person's motion the positive rotation direction. Relative to the ground, the person's speed will be $\upsilon + \upsilon_T$, where υ is the person's speed relative to the turntable, and υ_{T} is the speed of the rim of the turntable with respect to the ground. The turntable's angular speed is $\omega_{\mathrm{T}} = \upsilon_{\mathrm{T}}/R,$ and the person's angular speed relative to the ground is $\omega_{\mathrm{P}} = \dfrac{\upsilon + \upsilon_{\mathrm{T}}}{R} = \dfrac{\upsilon}{R} + \omega_{\mathrm{T}}.$ The person is treated as a point particle for calculation of the moment of inertia.

$$L_{\mathrm{i}} = L_{\mathrm{f}} \quad \rightarrow \quad 0 = I_{\mathrm{T}}\omega_{\mathrm{T}} + I_{\mathrm{P}}\omega_{\mathrm{P}} = I_{\mathrm{T}}\omega_{\mathrm{T}} + mR^2\left(\omega_{\mathrm{T}} + \frac{\upsilon}{R}\right) \quad \rightarrow$$

$$\omega_{\mathrm{T}} = -\frac{mR\upsilon}{I_{\mathrm{T}} + mR^2} = -\frac{(65\ \mathrm{kg})(2.75\ \mathrm{m})(4.0\ \mathrm{m/s})}{1850\ \mathrm{kg}\cdot\mathrm{m}^2 + (65\ \mathrm{kg})(2.75\ \mathrm{m})^2} = -0.3054\ \mathrm{rad/s} \approx \boxed{-0.31\ \mathrm{rad/s}}$$