Answer to Essential Question 11.9: If the two objects have the same kinetic energy and angular momentum, they must have the same rotational inertia. This allows us to solve for the radius of object C:

$$I_A = I_C\,; \qquad \frac{1}{2} M\,R_A^2 = M\,R_C^2\,; \qquad R_C = \frac{1}{\sqrt{2}} R_A\,.$$

Chapter Summary

Essential Idea

Concepts that we found to be powerful for analyzing motion in previous chapters, such as Newton's Second Law, Conservation of Momentum, and Conservation of Energy, are equally powerful for analyzing motion in a rotational setting.

A General Method for Solving a Problem Involving Newton's Second Law for Rotation

1. Draw a diagram of the situation.
2. Draw a free-body diagram showing all the forces acting on the object.
3. Choose a rotational coordinate system. Pick an appropriate axis to take torques about, and apply Newton's Second Law for Rotation ($\sum \vec{\tau} = I\vec{\alpha}$) to obtain a torque equation.
4. Choose an appropriate *x*-*y* coordinate system for forces. Apply Newton's Second Law ($\sum \vec{F} = m\vec{a}$) to obtain one or more force equations. The positive directions for the rotational and *x*-*y* coordinate systems should be consistent with one another.
5. Combine the resulting equations to solve the problem.

Rolling

It can be very helpful to look at rolling as a combination of purely translational motion and purely rotational motion.

Angular Momentum

Angular momentum is a vector, pointing in the direction of angular velocity. The angular momentum of a system can be changed by applying a net torque. If no net torque acts on a system its angular momentum is conserved.

Straight-line motion concept	Analogous rotational motion concept	Connection
Newton's Second Law, $\sum \vec{F} = m\vec{a}$	Second Law for Rotation, $\sum \vec{\tau} = I\vec{\alpha}$	Same form
Momentum: $\vec{p} = m\vec{v}$	Angular momentum: $\vec{L} = I\,\vec{\omega}$	$L = r\,p\sin\theta$
Translational kinetic energy: $K = \frac{1}{2}mv^2$	Rotational kinetic energy: $K = \frac{1}{2}I\omega^2$	Same form
Impulse: $\vec{F}\,\Delta t = \Delta\vec{p}$	Rotational impulse: $\vec{\tau}\,\Delta t = \Delta\vec{L}$	Same form
Work: $\Delta K = W_{net} = F_{net}\,\Delta r\cos\phi$	Work: $\Delta K = W_{net} = \tau_{net}\,\Delta\theta\cos\phi = \pm\tau_{net}\,\Delta\theta$	Same form

Table 11.1: The equations we use in rotational situations are completely analogous to those we use in analyzing motion in one, two, or three dimensions.