Rotational Kinetic Energy

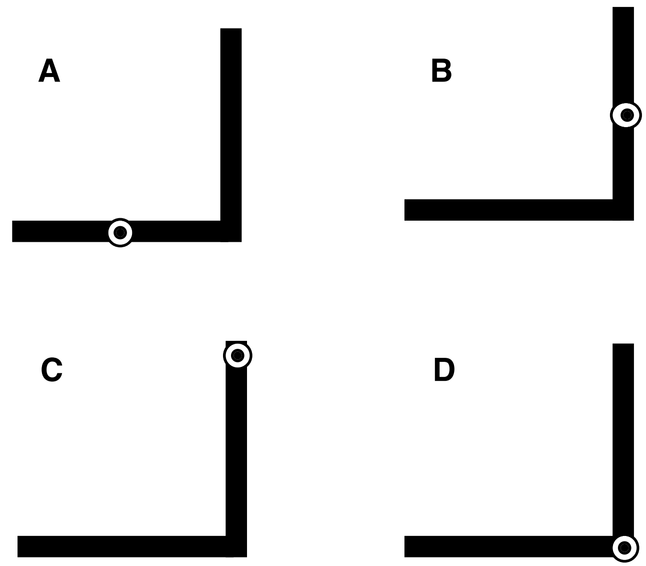
Pre-Class Questions

Problem Set (due next time)
Ch 9 - 31, 39, 42, 49

Lecture Outline

1. Rotational Inertia
2. Rotational Kinetic Energy
3. Rolling Motion

Below are four identical figure **L**'s, which are constructed from two rods of equal lengths and masses. For each figure, a different axis of rotation is indicated by the small circle with the dot inside, which indicates an axis that is perpendicular to the plane of the **L**'s. The axis of rotation is located either at the center or one end of a rod for each figure.



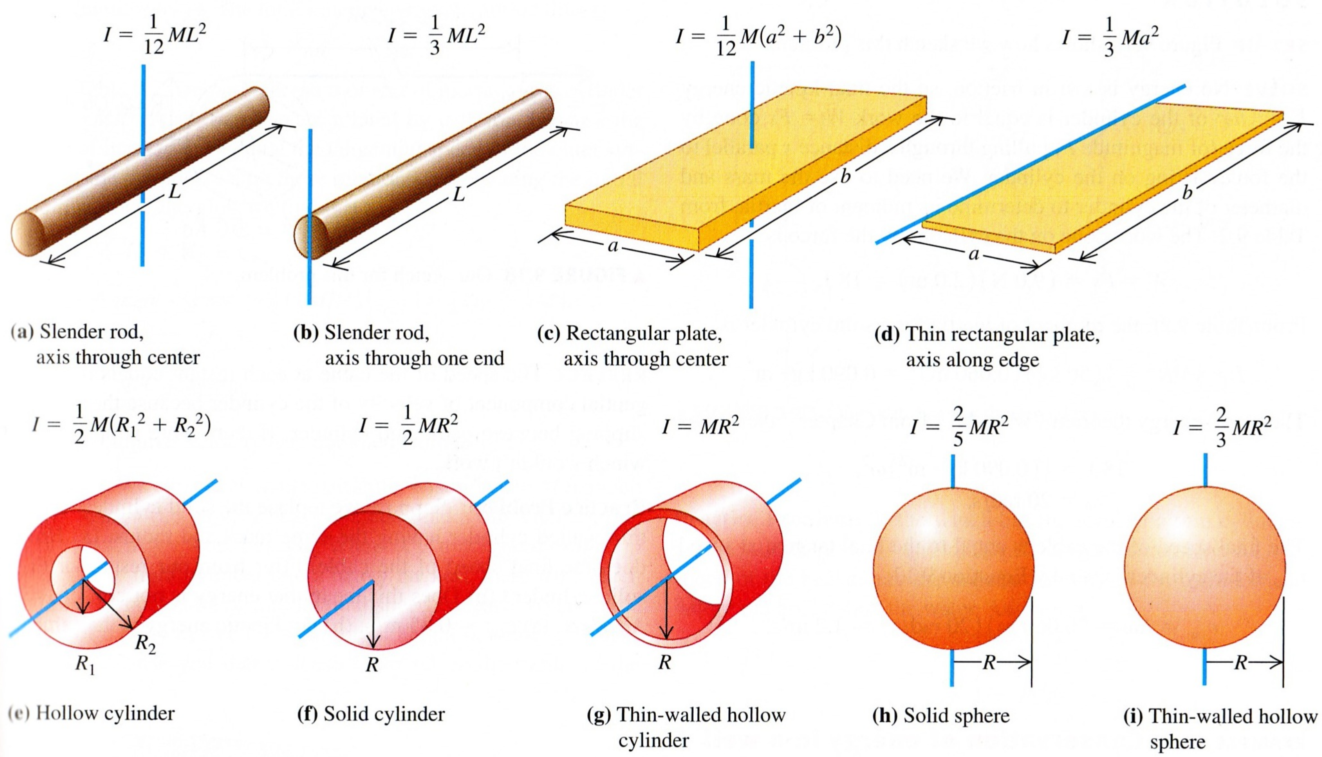
Rank these **L** figures according to their moments of inertia about the indicated axes, from largest to smallest. Ignore the width of each rod but not the length.

Largest 1 _____ 2 _____ 3 _____ 4 _____ Smallest

Or, all these **L** systems have the same moment of inertia. _____

Please carefully explain your reasoning.

TABLE 9.2 Moments of inertia for various bodies



(a) Slender rod, axis through center: $I = \frac{1}{12}ML^2$

(b) Slender rod, axis through one end: $I = \frac{1}{3}ML^2$

(c) Rectangular plate, axis through center: $I = \frac{1}{12}M(a^2 + b^2)$

(d) Thin rectangular plate, axis along edge: $I = \frac{1}{3}Ma^2$

(e) Hollow cylinder: $I = \frac{1}{2}M(R_1{}^2 + R_2{}^2)$

(f) Solid cylinder: $I = \frac{1}{2}MR^2$

(g) Thin-walled hollow cylinder: $I = MR^2$

(h) Solid sphere: $I = \frac{2}{5}MR^2$

(i) Thin-walled hollow sphere: $I = \frac{2}{3}MR^2$

Example 1: Calculate the rotational inertia of a curveball rotating at 2400rpm about the center. The mass of a baseball is 145g and it has a radius of 3.64cm.

Example 2: Calculate the rotational kinetic energy of a curveball rotating at 2400rpm about the center. The mass of a baseball is 145g and it has a radius of 3.64cm. Compare that to the translational kinetic energy if the ball is moving at 40.0m/s.

Example 3: An object with mass, m, radius, r, and rotational inertia, I, rolls down a hill of height, h. Find the speed at the bottom.

Lecture 23 - Summary

The Definition of Rotational Inertia $I \equiv m_1 r_1^2 + m_2 r_2^2 + m_3 r_3^2 + \cdots = \Sigma m_i r_i^2$

The rotational inertia of objects depends upon:

- mass
- shape
- axis

More mass further away from the axis the greater the rotational inertia.

The Rotational Kinetic Energy $K = \frac{1}{2} I\omega^2$

If an object rolls without slipping, $v = r\omega$