The Perfect Swing

What is this about?

You will get to understand more about the idea of rotational inertia, by learning how to measure a distance called the "center of oscillation (CO)". The "moment of inertia (MOI)" is a numerical measure of the rotational inertia and is directly related to the CO. You will learn to measure the CO of a baseball bat using a baseball pendulum and then calculate the MOI of the bat.

What do I need?

You will need a baseball bat, a wooden dowel about 1" in diameter and the same length as the bat, and 3 feet of string with a baseball tied to the end. A thumbtack in the ball can be helpful.

What will I be doing?

First you will find the correct length for the baseball pendulum so that it swings at the same rate as the dowel held at one end. Then you will repeat the same experiment with the bat in place of the dowel. The length of the pendulum with the same swing is equal to the CO.

What do I think will happen?

Take a minute and write down a description of what you think will happen and why you think it. Will the bat or the dowel need the longer baseball pendulum to swing at the same rate? Why?

What really happened?

1. Hold the dowel at one end and let it swing from one hand while letting the baseball pendulum swing from the other.
2. Adjust the length of the baseball pendulum until it swings at the same rate as the dowel. Measure the length for this pendulum from your fingertips to the center of the ball. Record the CO for the dowel. Did you get about two-thirds of the length of the dowel?
3. Repeat these steps using the baseball bat.

Write a description of your results. Compare the CO for the bat to the CO for the dowel.

What did I learn?

The CO for the bat is a bit bigger than the CO for the dowel because a greater fraction of the mass of the bat is further away from the rotation axis. In other words, the bat has a larger rotational inertia (per unit mass) than the dowel. As explained in the "Game in the Balance" activity, the batter needs to find a happy medium between a bat with a large rotational inertia or large CO that will hit the ball harder and a bat with a lower rotational inertia or lower CO that will be easier to swing.

What else should I think about?

You can think of the CM as the place where the mass of the bat acts when the bat is moving as a whole and you can think of the CO as the place where the mass of the bat acts when it is rotating about the end. Even though most ball players don't realize it, when they are given a new bat, they wiggle it around to get a sense of the CM and they swing it to get a sense of the CO.

If you know the CM of the bat and you just found the CO, you can actually calculate the "moment of inertia (MOI)" of the bat. First, you must know the bat's mass. Make sure you are using a consistent set of units. If you use kilograms for mass, be sure the CM and CO are in meters, if you use inches for the CM and CO use ounces for the bat mass.

Calculate the moment of inertia using,

$$\text{MOI} = (\text{mass})(\text{CO})(\text{CM}) = \_\_\_\_\_.$$

Typical numbers for a major league bat are 0.3 $kg \cdot m^2$ or 16,000 $oz \cdot in^2$. What did you get?

Catch it in the Web!

- Physics and Acoustics of Baseball & Softball Bats by Daniel A. Russell.
  (http://www.acs.psu.edu/drussell/bats/bat-moi.html)
  This site explains (in perhaps too much depth) the momentum of inertia of bats.

- Physics of Baseball by Rod Cross
  (http://www.physics.usyd.edu.au/~cross/baseball.html)
  Look down this page to number 6. There is a good explanation of "swing weight" which has to do with MOI. There are videos of a batter swinging different bats.