ACTIVITY: Twin Baton Paradox

PURPOSE: To experience rotational inertia "first hand" by observing the connection between the distribution of mass and resistance to rotational acceleration.

APPARATUS: 1 pair of rotational batons, meterstick, scale

PROCEDURE

Step 1: Measure and record the length of each baton.
Length of Baton A: _____ Length of Baton B: _____

Is one baton **significantly** longer than the other or are the batons about the same length?

Step 2: Use the scale to measure and record the mass of each baton.
Mass of Baton A: _____ Mass of Baton B: _____

Is one baton **significantly** more massive than the other or are the batons essential equal in mass?

Step 3: Stand up and hold one baton in each hand. Make sure to grab the middle of each. While keeping each baton vertical, shake them left and right (inward and outward) as rapidly as you can by bringing them close together and then quickly pulling them apart as shown in **Figure 1** below.

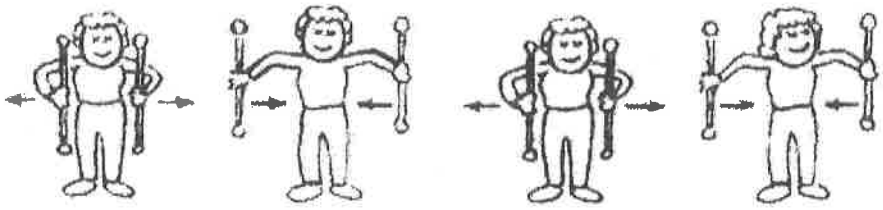

Figure 1. Shaking the Batons Back and Forth

The extent to which the batons resist the back and forth motion is an indication of the "linear inertia" (regular inertia). Try it once, then switch the batons so that the hand holding Baton A is now holding Baton B.

Does one baton resist being shaken **significantly** more than the other, or do the batons have essentially the same linear inertia? Describe your experience.

Step 4: Now hold the batons vertically with your arms extended. Instead of shaking the batons back and forth, twist the batons at least 90 degrees left and right as rapidly as you can. See **Figure 2**.

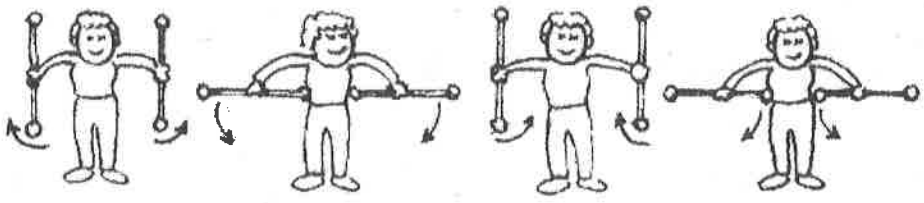

Figure 2. Twisting the Batons Back and Forth

Does one baton resist being twisted **significantly** more than the other, or do the batons have essentially the same rotational inertia/resistance to angular motion? Describe your experience.

WHAT'S GOING ON??!?!?!? READ THIS!

The extent to which an object maintains its state of motion is its inertia. Mass is a measure of linear inertia. More massive objects require more force to undergo a given acceleration. However, the laws of linear motion apply to rotational movement as well. The extent to which an object maintains its state of rotational (angular) motion is based on something called rotational inertia. Objects with more rotational inertia require more torque to undergo a given angular acceleration.

SUMMING UP QUESTIONS

1. One baton has a significant amount of mass located near its center. The other has mass located at the ends. Correctly label the illustrations in **Figure 3**, "Baton A," and "Baton B." or 1 or 2, or whatever numbers/letters you see on your batons.

Figure 3

2. Which one of the two dumbbells in **Figure 4** would have more rotational inertia (resistance to twisting)? Why is that?

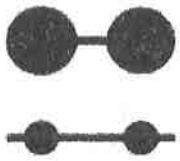

Figure 4

3. Which one of the two dumbbells in **Figure 5** would have more rotational inertia? Why is that?

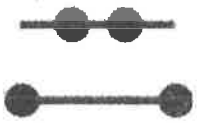

Figure 5

4. **Figure 6 is not drawn to scale.** Dumbbell G has two 4-kilogram masses 2 meters apart; Dumbbell H has two 1-kilogram masses 4 meters apart. Dumbbells G and H have equal rotational inertias. Dumbbells J and K also have equal rotational inertias.

How much masses must each ball on Dumbbell L have so that its rotational inertia is equal to that of Dumbbell M? Dumbbell M has two 1-kilogram masses 8 meters apart.

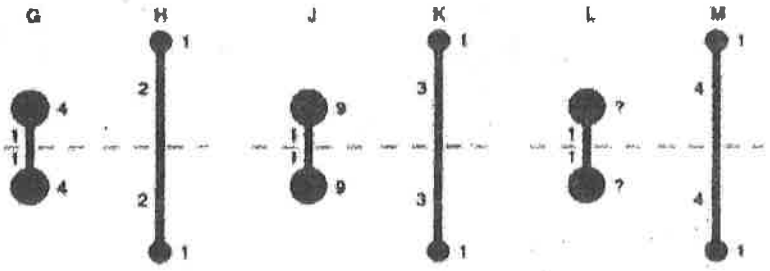

Figure 6