Where'd the Energy Go?

Name: ____ Date: _____________________

This investigation will introduce you to the concept of rotational inertia and rotational kinetic energy.

Part 1: Theoretical Calculations

Using energy and theoretical considerations, determine the distance that a ball bearing launched horizontally off a ramp which is on a table will land. You may measure the ramp height (table to top) and vertical distance from the ramp to the floor. Use projectile motion equations to find the horizontal distance that the ball bearing will land. Include a very well labelled diagram with your measurements.

Theoretical Distance: _________________________ [generalized equation and work attached]

Part 2: Experimental Calculations

Roll a steel ball bearing down the ramp and measure how far from the table it lands. Compare this distance to the distance you calculated in part 1. You will then compare this distance to the theoretical calculation in the analysis section below.

Experimental Distance: _________________________

Initial Analysis

Discuss the differences between the theoretical distance that you calculated and the experimental distance. How can you account for this difference (see information below)?

Percent difference between theoretical and experimental range: ____________________________

Rotational Inertia and Rotational Kinetic Energy

In describing the motion of rolling objects, it must be kept in mind that the kinetic energy is divided between **translational kinetic energy** and **rotational kinetic energy**. Another key is that for rolling without slipping, the linear velocity of the center of mass is equal to the angular velocity times the radius.

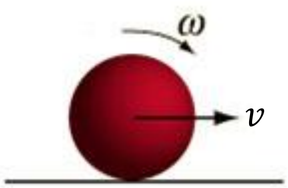

Figure 1: Total Kinetic Energy

If not slipping the angular speed is given by: $\omega = \frac{v}{R}$

The total energy of rolling is given by:

$$KE_{rolling} = \frac{mv^2}{2} + \frac{I\omega^2}{2}$$

Determining the total kinetic energy of rolling involves first determining the **angular velocity, ω** and also the **moment of inertia, *I*.**

The moment of inertia used must be the moment of inertia about the center of mass. A list of moments of inertia for various uniformly distributed objects can be found in *figure 2*.

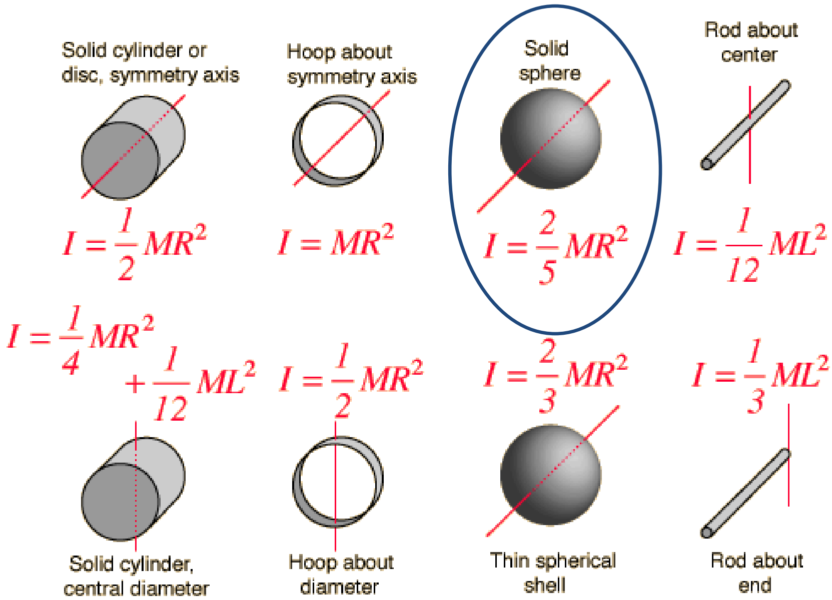

Figure 2: Moments of Inertia for some common uniformly distributed objects.

Analysis

Measure the **radius, R**, of the steel ball bearing and measure the **mass, M**, of the steel ball bearing. Knowing that the gravitational energy is converted into both translational and rotational kinetic energy, write a general equation solving for v_0 **(muzzle velocity in this case)** as the ball leaves the end of the ramp.

Using this adjustment for the better approximation of the muzzle velocity, recalculate the theoretical distance where the ball will land and compare it to the experimental value.

New Theoretical Distance: ___________________________ [generalized equation and work attached]

Percent difference between new theoretical and experimental range: ______________________________

Questions

1. Describe the difference between translational and rotational kinetic energy
2. Up until today we have only ever used translational kinetic energy explain why this is just a simplification for rolling objects. Do flat objects that are sliding and not rotating have rotational kinetic energy?
3. What other factors were not accounted for?