Objective: To determine experimentally the moments of inertia of various objects, and to compare these measurements with theoretical calculations.

Equipment:

Sketches:

Background: Define in words and equations:
Average velocity:

Final velocity if acceleration is constant:

Gravitational potential energy:

Kinetic energy:

Moment of inertia:

Kinetic energy of rotation:

Torque:

Conservation of energy:

I_{\text{experimental}} =

Theoretical Calculations of the moment of inertia I:

Disk, radius R, mass M, axis in the center, \( I = \)

Thin ring, radius R, mass M, axis in the center, \( I = \)

Thin bar, length L, mass M, axis in the center, \( I = \)

Solid sphere, radius R, mass M, \( I = \)
**Procedure:**

1. Measure the dimensions and the masses of the various objects. Record these in your team spreadsheet.

   Since there are two different methods for measuring moment of inertia, each lab team will divide in half and do half the objects with each method. Then the people will switch to the other apparatus and measure the objects with that equipment.

**Method A (spinning cross apparatus):**

2. Use a vernier caliper to measure the diameter of the drum. \(\text{cm} = \text{m}\)  
Radius = \(r = \text{m}\)

3. Set up the equipment such that the total fall is at least one meter. Level the spinning cross apparatus carefully.

4. Use small masses (paper clips without a mass hanger) on the string to overcome friction so that the spinning cross apparatus rotates at a constant speed once started. These paper clip masses will be used (but not counted) in the mass causing acceleration. (_________ paper clips)

5. Add mass (50 grams) to the paper clips and measure the time of fall 3 times. As soon as the mass hanger hits the floor, gently stop the cross apparatus from spinning. Then you can wind the string up without having to do the whole string. Be careful to wind it on the drum and not on the axle. Calculate the moment of inertia of the apparatus itself.

6. Place one of the regularly shaped objects on the apparatus. Put paper clips on the string to overcome friction so that the cross apparatus plus object rotates at a constant speed once started. These masses will be used, but not figured in the mass causing acceleration. Add mass (100 grams) to the string and measure the time of fall 3 times. Calculate the moment of inertia of the cross apparatus plus object, then subtract the moment of inertia of the cross apparatus to get the moment of inertia of the object alone. Repeat for 200 grams.

7. Repeat for one other regularly shaped object.

**Method B (inclined plane):**

2. Set up the board as an inclined plane with a shallow slope.

3. Aim the motion sensor down the plank at the object. Turn on the motion sensor, then open Vernier software, Logger Pro, motion sensor, motion sensor.

4. Release the object at the top of the ramp and record the time and displacement till it reaches the bottom. Do all measurements three times.
**Analysis:**
1. Calculate the theoretical moment of inertia of the objects from their dimensions.

2. Compare the experimental values for the same object with different accelerating masses with each other and find the percent spread. Compare these with the theoretical values and find the percent error. Can the error be totally explained by the experimental spread?

3. Estimate the error in your measurement of m, h, and t. Which one would have the largest effect on the experimental value for the moment of inertia?

**Report:** Write a team report of your experience. Include a list of equipment, a sketch of the setup, Excel spreadsheet with appropriate graphs, a sample of each calculation, experimental errors, estimate of errors at each step, and application of these methods to other situations.