Physics 233 **Lab 1**
September 2011 **The Rolling Sphere & Systematic Error**

Goals:

- To investigate the motion of a sphere rolling down an inclined plane
- To practice calculating standard deviations of measurements
- To analyze the systematic errors associated with the experimental measurements and the calculated results

Reading:

- Chapter 1 (How to Keep a Lab Notebook), Chapters 4 (Standard Deviation) and 5 (Experimental Uncertainty) of the lab reference manual.

Pre-Lab Problems: (Done in WebAssign.)

1. Exercise 4.1.
2. Exercise 5.4
3. What is the difference between accuracy and precision? (You'll need to look these up.)
4. What is the difference between random and systematic errors?
5. Derive an equation for the theoretical time t_{theory} that you expect a sphere to take to roll a distance d, starting from rest down a plane inclined at an angle θ with respect to the horizontal. You may have to refer to your textbook and notes from Physics 231 for help with this derivation.

Lab Procedure:

- Using the board, beams and clamps provided, set up an inclined plane.
- Measure and record the height H and length L *along* the ramp for the inclined plane. Assume that the uncertainty in each measurement is 3 mm. These measurements will be used to calculate sin θ.
- Measure the distance d between two marks on your incline about a meter apart. Assume the same uncertainty as above.
- Let your sphere roll, starting from rest at the upper mark, down the incline. Measure the time required for the sphere to roll from the first mark to the second.
- In the first part of this experiment, we are concentrating on the systematic errors. Determine what parts of this measurement are error-prone. Determine three to five different methods for taking this data, which may have more or less systematic error. Describe each method clearly in your notebook.
- Make 20 measurements of the time for each of the different methods, using a stopwatch with a resolution of 0.01 seconds.

Post-Lab Assignment:

1. Using the derivation for the time that you did before lab, calculate the theoretical time t_{theory}. Assume the acceleration due to gravity is $g = 9.81$ m/s^2.
2. Calculate the mean and standard deviation for each set of 20 measurements made using a different technique.
3. For each set of measurements, calculate the difference between the mean and the expected value (a measure of the accuracy) and the uncertainty of any single measurement (a measure of the precision).
4. Pick a "best" measurement technique. Write a paragraph justifying your decision by referring to the data you collected (this can be written in your lab notebook or typed up separately). Which is more important for deciding the best method, accuracy or precision?