LAB 6 ROLLING BALLS

EXPERIMENTAL GOALS

In this experiment, you will let a small plastic ball move a fixed distance D down a grooved track and measure the ball's final speed v_f as a function of the height H of its initial position above its final position. You will then compare your results to those predicted by various possible physical models of the situation: (1) a simplistic model where the ball slides without friction down the track, (2) a more sophisticated model where the ball *rolls* without slipping down the incline (see section C9.7 of the textbook), and (if necessary) more sophisticated models of the situation. (It turns out that in this situation, friction does *not* channel a significant amout of energy to thermal energy, so keeping track of thermal energy is *not* the way to make your model more sophisticated.)

LABORATORY SKILLS you will be developing

The uncertainty analysis for this lab will involve estimating the uncertainties of calculated quantities using the techniques discussed in chapter 9 of the *Lab Reference Manual* as well as calculating the uncertainty of the mean of a set of repeated measurements using the results discussed in the previous lab. You will also continue to practice linearizing non-linear relationships, interpreting graphs, and general uncertainty analysis skills. Finally, you will learn in this lab how to use a vernier caliper to measure small distances precisely.

SOME PROCEDURAL SUGGESTIONS AND NOTES

Each lab setup consists of a length of steel track, a mount that allows you to vary the height of one end of the track, a small plastic ball, a stopwatch, a meter stick, and a pair of vernier calipers. These calipers can be used to measure the ball's diameter d and the track's interior width w accurately to about ±0.1 mm. Your lab instructor or helper will show you how to use the calipers to perform these measurements.

It is not easy to measure directly the ball's final speed v_f at the end of the track, but in fact you can take advantage of the fact that the ball's acceleration is constant to express the v_f in terms of the magnitude of the ball's *average velocity* as it rolls down the track. If the ball rolls a distance D down the track during time T, then the latter is simply D/T, and you can easily measure both D and T. Make sure that you can explain to your grader very clearly how v_f is related to D/T and why.

Make sure that you roll the ball down the *same* distance D along the track each time. You should vary the ball's initial height by increasing the angle of the track, not by starting it further up the track. This reduces possible systematic effects that might depend on the distance rolled. Also choose H values so that the very end of the track is less than 40 cm above the table.

Think about how v_f *ought* to vary with H according to the two models discussed in the goals section above. The answer for both cases can be found on page 148 of unit *C*, but you should be able to *derive* these results if asked. How can you plot your v_f and H data so that the resulting graph is linear in each case? How can you tell from this graph which model your data best fits?

You may use the program *RepDat* to calculate means and uncertainties of the mean for any sets of repeated measurements you make, but everyone should practice doing a hand calculation of the uncertainty of the mean at least once so that you can show your grader that you know how to do this. Also practice using the weakest-link rule whenever it applies (you can *check* your work using *PropUnc*). However, there may be some uncertainty calculations during the lab where you *must* use *PropUnc*: make sure that you can explain why the weakest link rule *won't* work.

If neither of the basic models work, try to identify the approximations made in those models that aren't true in this situation. When you think that you qualitatively understand which approximations are valid and which are not, develop an improved model and describe it to your helper. Your helper will then help you refine and test your new model.