LAB 12 THE MASS-DEPENDENCE OF THE SIMPLE PENDULUM

EXPERIMENTAL QUESTION

Equation N11.28 in the Unit *N* text (N12.32 in the printed version) implies that the equation of motion for an ideal simple pendulum is completely *independent* of the mass of the bob, even if we *don't* make the small angle approximation. This is actually a direct consequence of the equivalence of inertial and gravitational mass, the primary prediction of General Relativity we checked during the term's first lab. So, if this model is correct, the period of the pendulum should also be strictly independent of the mass of its bob. Your task in this lab is to check this assertion.

You will have at your disposal a set of pendulum bobs of the same (symmetrical) shape and size but differing densities (and thus masses). You will also use a photogate timing system that will enable you to make extremely precise period measurements. You should design and execute an experiment to check for any mass-dependence of the period while holding other variables constant.

EDUCATIONAL PURPOSE

The primary educational goals of this lab are (1) to give you a chance to work with a more modern approach to measuring time intervals, and (2) to expose you to some of the subtleties often encountered by scientists doing experimental work, including issues regarding the source of systematic errors and whether a correlation between variables necessarily implies a direct causal link. (This last issue is important in the context of the the PAC 4 credit that you will earn.)

PROCEDURAL COMMENTS

At the beginning of lab, your helper will show you how to use the photogate timing system. Using this device makes it very easy to make very precise measurements of the pendulum period.

You should by now be able to design an appropriate experiment to measure the mass-dependence of the pendulum period while carefully controlling for the other variables we know the pendulum's period depends on. As usual, you should think about how you might determine the uncertainties of quantities that you measure. Here are other some procedural issues to ponder:

1. In order to do this experiment, we have to make some choices about the pendulum's length and swing amplitude. How should we choose appropriate values for these quantities, and what if anything did you do to control for these variables?
2. How should we compute experimental uncertainties of our time measurements?
3. How will we know whether our data consistent with no mass dependence (within your experimental uncertainties)? How did you arrive at your conclusions?

Before you ask your grader for the checkout interview, carefully consider the results that you got. If you found that there was no mass-dependence, is the evidence weak or is it inassailable in supporting that claim? On the other hand, if your data indicate a mass-dependence, can you find and correct a systematic experimental error that skews your results? As you consider possible explanations for systematic problems, be sure to check that a proposed explanation would skew the data in the right direction. For example, would air friction lengthen the period of light bobs more than heavy bobs or vice versa? Is that consistent with what you observe?

If it is possible to fix or otherwise correct for a possible systematic problem, do so *before* you ask for a checkout interview. Also, no matter how your data comes out, MAKE SURE that you think about the following general issue before your interview: Does an observed correlation of two variables in an experiment necessarily imply that a theory that predicts no correlation is false? Conversely, does an observed *lack* of correlation necessarily imply that a theory that also predicts no correlation is true?