LAB 8 SIMPLE PENDULUM

EXPERIMENTAL QUESTION

A *simple pendulum* consists of point mass (the pendulum *bob*) suspended from a fixed point by an inextensible, massless string. Under the conditions described in section N11.6 in the text, the period T of one complete cycle of the pendulum's oscillation is given by $T = 2\pi\sqrt{L/g}$, where L is the length of the pendulum, measured from the fixed point to the point mass. The pendulum's period is defined to be the time that it takes to travel from an extreme point (where the bob is instantaneously at rest) back to the *same* extreme point, or more generally, the time between the instant that pendulum bob passes any given point on its swing (such as the very bottom) and the next instant when it passes the *same* point *and is traveling in the same direction*.

Your job in this experiment is to check two predictions that this equation makes:

1. that the pendulum's period increases as the square root of its length,
2. that the period does *not* depend on the swing's *amplitude angle*, which defined to be the angle the string makes with the vertical at the extreme points of its swing.

EDUCATIONAL PURPOSE

This experiment draws on virtually all of the skills you have developed during the semester. You will develop an appropriate procedure, do a graphical analysis of your experimental data using *LinReg*, create a linearized graph of non-linear data, and determine uncertainties using propagation of uncertainties. Finally, and most importantly, you will write a complete lab report for this lab.

SOME PROCEDURAL ISSUES TO PONDER

You should be sure to check your procedure with your helper before taking lots of measurements. As you flesh out your procedure, you might think about the following questions (this is *not* meant to be an all-inclusive list of things to think about, though):

1. How can we minimize the uncertainty of T, balancing accuracy against the need to complete the lab on time? What are the advantages and disadvantages of measuring the period by watching the bob as it passes a mark near the bottom of the swing compared to watching the bob approach an extreme point? What are the advantages and disadvantages of measuring the time required of 5 or 10 complete swings and dividing by the number of swings to get the period, as opposed to measuring the duration of a single complete oscillation?
2. How many times should we repeat a given period measurement to get a reliable estimate of its uncertainty (again considering time constraints)? Is this measurement genuinely repeatable?
3. How should we choose the range and number of swing amplitude angles θ_0 to examine when testing whether the period is independent of θ_0? What might be an appropriate (fixed) length for the pendulum for this part of the experiment and why?
4. If we choose to measure the time for 5 or 10 swings of the pendulum and divide by the number of swings to get a more accurate period measurement, we may note that the swing amplitude θ_0 decreases with time during the time in question. What is the best way to handle this?
5. How should we choose the range and number of pendulum lengths L to measure to test the first prediction? Exactly how should these lengths be measured (from where to where)?
6. What (fixed) amplitude angle θ_0 would be best for this part of the experiment and why?
7. How should we graph the T versus L data to best display consistency or inconsistency with the equation $T = 2\pi\sqrt{L/g}$? How can we use this graph to verify the numerical value of the other quantities appearing in this equation?

By the end of the first week, you should have completed the amplitude-dependence measurements. By the end of the second week, you should be ready to write your report. Be *SURE* to check with your helper before you leave lab each week so that he or she can verify that you have made good progress and you are ready for the next step.

WRITING FIRST AND FINAL EDITIONS OF THE LAB REPORT

As the lab syllabus shows, your work on this lab is spread out over almost four weeks (with another lab intervening). During the week of October 31, you will take your amplitude-dependence data. During the week of November 7, you will take your length dependence data and begin your analysis. **The first edition of your lab report is due at the beginning of your lab session during the week of November 14.** At the beginning of that session, you should choose a half-hour appointment during the week of November 28 for reviewing the first edition of your lab report with a lab staffer. Reviewing first editions will be the *only* thing you do during that week.

The grader assigned to do your report will read and grade your first edition before your appointment and come prepared to discuss ways you can improve it. The reader will give you *two* grades, one the grade this first edition would receive if it were submitted as a final edition, and one (the one that actually counts) based primarily on your *effort* and avoidance of obvious errors. It is to your advantage if your first edition is as complete and finished as possible: not only will this earn you a good effort grade on the first edition but it will make it much easier for your interviewer to offer good and detailed suggestions for improvement. Therefore, consider this to be a genuine *first edition* of your report (rather than a rough draft), and hope that you will only have to make only minor revisions to produce a final edition. Be sure to take careful notes on the suggestions that your reader offers: he or she may not have time to write many comments on your paper.

You should *not* count on the grader to find all the weaknesses in your first edition, particularly if your first edition has substantial weaknesses (as these will overshadow any fine details that you should also know about). We also expect you to think carefully about the *general* implications of *specific* suggestions your grader makes. For example, if your grader points out that three data points are insufficient to make the length dependence clear, you might appropriately conclude that three amplitude data points are also insufficient, even if your grader doesn't mention that.

Your *first* edition, as mentioned above, will be based primarily on the level of *effort* the reader sees; if you made a significant effort to describe the procedure and carry out the analysis in detail, you will probably get a fairly good grade even if you made some mistakes or omitted some details. In contrast, your *final* edition will be graded primarily on its content; that is, the evidence it provides about your ability to carry out the experiment carefully, analyze data correctly, and write a clear and informative lab report. In particular, we expect that in your second edition you will have repaired any mistakes or omissions in your first edition, whether identified by the lab staff or not.

In writing your first edition, you may find yourself pressed for time and wondering how to use your time to best advantage. The *Analysis* section is the most crucial part to see worked out in detail in your first edition. Among other things, we use this section to check that you haven't omitted crucial steps in the analysis and that you haven't made some basic error in taking your data or analyzing your uncertainty. Then work on your *Procedure*, then your *Theory*, and lastly on the *Introduction*, *Abstract*, and *Conclusion* sections.

The final edition of your lab report will be due at the beginning of your lab session during the week of December 5 (the session where you do the *Mass Dependence of the Pendulum* lab). **Be sure to resubmit your first edition with your final edition,** so that your reader will be able to compare them. Note carefully the rules in the Lab Information sheet (handed out during the first week of class) about late papers. If you miss your appointment time without a valid excuse, you may get bumped to the end of the schedule. If you miss your appointment entirely (without a valid excuse), your first edition score will be reduced by half and you will not be able to benefit from the comments of your reader.

Your first edition counts 20 points and the second 60 points. These editions together count for about 25% of your lab grade, so it is wise to take your data carefully, analyze it thoughtfully, and take the time to write good first and second editions. **Use the checklist on the inside front cover of the *Lab Reference Manual* to make sure that each of your editions is complete.**