Pendulum Laboratory

Tuesday of week 1, 1st hour: Data collection. Tuesday 2nd hour: Group work on analysis. Wed: class self-assessment of analyzed data; modeling. Friday: Lab report due.

In this laboratory exercise you will measure properties of the pendulum motion and analyze them. The primary aspects of the lab are:

CALIBRATION:	Determine how the computer records the pendulum angle.
DATA COLLECTION:	Measure the motion of the pendulum as a function of time, including large and small oscillations. Measure the physical parameters of the pendulum to allow you to predict the period from the model.
DATA ANALYIS:	Examine the motion. Extract the period of the motion for several different amplitudes. Plot your results along with the values calculated from the models we have considered.
REPORT:	Report your experimental setup, calibration, data, and data analysis. Pay attention to organization, clarity, and presentation. Describe your results. In this lab report, you may keep your assessment very brief – a paragraph or two. We will focus on describing well the set up and data gathering, the data, and the data analysis.
MODELING:	In a group mode exercise that you'll start in class and finish for homework, we will examine a model for the motion of the pendulum and predict (numerically) the outcome of the period measurements. You'll need the result of this prediction in your report.

CALIBRATION: The measurement apparatus must be calibrated so that you know how the recorded resistance data correspond to the pendulum's angular position. This is easily done by holding the pendulum at some fixed angles (e.g. 0˚, ±90˚, ±150˚, etc.) and recording the corresponding signal.

DATA COLLECTION & ANALYSIS: Record the motion of the pendulum. Make sure you measure the motion for many angles, from small angles up to angles close to 180˚. If the pendulum goes over the top, you **must** bring it back to the original position to record data. The axle can rotate ONLY 3 times – forcing the system beyond this will destroy it. Equilibrium has been set to the middle. The period of the pendulum can be measured on the computer screen using the cursors. The amplitude can be similarly obtained (in voltage units, though). You should also export the angle *vs*. time data to Excel or another program, so that you can access it for presentation purposes and for any further analysis.

• Complete the *Pendulum Period Worksheet* to predict theoretical expectations for the amplitude dependence of the period, and compare to the data.

TECHNICAL DETAILS: The pendulum swings on an axle that is connected to a potentiometer or variable resistor. As the angle changes, the resistance between two output leads changes, and the resistance is recorded by LabPro, a data acquisition system made by Vernier. Pendulum $\theta(t)$ data is recorded with a program called Logger-Pro, which you'll find on the computer desktop in the short-cuts folder. Pushing the `collect` button will start data-taking; a screen display results. You can set the data acquisition rate and the total time under the `Experiment->Data Collection` pull-down menu. The graphics cursor allows quick and easy analysis.

REPORT: For this first lab report, you will focus on reporting the experimental set up and procedure (including calibration), and presenting the experimental data and the analysis of those data. (We will not focus in detail on reporting the model we use to understand the motion, but we cannot ignore it entirely in the report!) Part of the assignment is to think about how to report your experiment in a clear and logical fashion as possible. Most writing in physics conforms to the general form of abstract, introduction/motivation, experimental setup, results, analysis/discussion, and conclusion. A template of sorts is provided for this first lab (it a .doc document that you can download from the class webpage). Its purpose is to save you time and to give you an idea about expectations, but it is not a "fill-in-the-blank" template, and you should feel free to alter it. The template is about 8 pages (including a title page and acknowledgement/bibliography page; your report should not be much longer than this. You must record and report sufficient information for you or another person to repeat and hence verify your experiment. This means recording critical aspects of the experimental setup, organizing the data in tables and/or graphs where appropriate, and discussing how the data is analyzed. You should pay careful attention to graphs – are the data presented in the clearest possible way? Are axes labeled sensibly and informatively? Is your graph easy to read? Do you give units? You should also pay careful attention to tables – are the data organized sensibly? Have you used the correct number of significant figures? Acknowledge sources specifically.

MODELING: Comparison of your data with a model, and confronting discrepancies is very important. Discrepancies may point to errors in technique, or to limitations of the model, which in turn causes us to be cautious about the model's predictive power. For this lab, you will (in

class groups) calculate the period numerically based on the model we develop in lecture. For your lab write-up, you can keep your description and assessment of the model very brief.

INDEPENDENT WORK:

Your data will be collected in groups, so each group member has identical data. The analysis and write up of the experiment **must be independent**. You are encouraged to consult with one another, but be responsible for your own learning. Healthy collaboration has independent analyses going simultaneously with checks and brainstorming at stumbling points. You do yourself (and science) no good by leaning too heavily on the talents of others, and likewise you do your colleagues a disservice by supplying answers too readily. Science makes progress because different people bring fresh perspectives. Have confidence in yourself, and have the confidence to question others and yourself. Develop a healthy skepticism, and at the same time develop a sense of what constitutes evidence and proof. ALWAYS QUESTION!!!

TIMELINESS AND PROFESSIONALISM:

Professional integrity demands that you learn as much as possible from the exercise, and that you acknowledge assistance from all sources. Be specific - rather than a blanket list at the end, cite sources for specific reasons. Professional courtesy requires that you complete work on time. This means starting early and working diligently at all times. Should circumstances arise that preclude timely completion, consult with the instructor in advance of the deadline. Under no circumstances should you allow a deadline to pass without consulting the instructor.

REVISING YOUR DRAFT: I encourage you to seek feedback from me and from the TA on your presentation. If you consult me IN PERSON (no email) on Wednesday or Thursday (I will stay after class Thursday) with a written draft, I will provide verbal feedback, and I will give extra credit for having sought feedback.