Period of a Pendulum (Part 1)

Post-Lab Assignment

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Conclusions

The conclusion is your *interpretation* and *discussion* of your data.

- What do your data tell you?
- How do your data match the model (or models) you were comparing against, or to your expectations in general? (Sometimes this means using the t' test, but other times it means making qualitative comparisons.)
- Were you able to estimate uncertainties well, or do you see room to make changes or improvements in the technique?
- Do your results lead to new questions?
- Can you think of other ways to extend or improve the experiment?

In about one or two paragraphs, draw conclusions from the pendulum data you collected today. Address both the qualitative and quantitative aspects of the experiment and feel free to use plots, tables or anything else from your notebook to support your words. Don't include throw-away statements like "Looks good" or "Agrees pretty well"; instead, try to be precise.

Remember… your goal is not to discover some "correct" answer. In fact, approaching any experiment with that mind set is the wrong thing to do. You must always strive to reach conclusions which are supported by your data, regardless of what you think the "right" answer should be. Never should you state a conclusion which is contradicted by the data. Stating that the results of your experiment are inconclusive, or do not agree with theoretical predictions is completely acceptable if that is what your data indicate. Trying to shoehorn your data into agreement with some preconceived expectation when you cannot support that claim is fraudulent.

The outcome of our lab was inconclusive due to the various errors present in the experiment process that made it difficult to obtain accurate values and draw accurate conclusions. Based on the predicted period as calculated, our experimental periods were practically always faster than the estimated period, which implied that there was some systematic error impacting the accuracy of the experiment and preventing us from accurately matching our experimental results with the predicted outcome. Despite the lack of accuracy in the experiment, there was some level of precision in obtaining our experimental values of the period.

The uncertainties for our experiment were determined solely by the precision of our measurement devices (e.g., stopwatch, meter stick) but did not account for potential uncertainties arising from human error, such as the mistiming of the stopwatch, even with video playback. At the same time, some systematic errors were also challenging to control, such as how to release the pendulum without introducing additional force. In future experiments, I will consider setting a greater uncertainty, accounting for the fact of human reaction time, and attempt to improve the experiment design to accommodate sources of error as control variables. I also question if the limitation of 10 degrees is removed, then perhaps the component of force from releasing the pendulum will be less significant than the acceleration provided by the horizontal component of gravity.

Questions

Next, we want you to think a bit about the learning objectives for this lab course. These were listed on the lab homepage, but as a reminder we provide them again here.

> For the introductory physics laboratories here at the University of Chicago, we have adopted a set of learning objectives. By the end of this course, you should be able to do the following:
>
> - collect data and revise an experimental procedure iteratively and reflectively;
> - evaluate the process and outcomes of an experiment quantitatively and qualitatively;
> - extend the scope of an investigation whether or not results come out as expected;
> - communicate the process and outcomes of an experiment; and
> - conduct an experiment collaboratively and ethically.
>
> **Put succinctly, the goal is to understand how we know, not what we know.***
>
> ** These goals were first outlined by the Physics Education Research Lab at Cornell University for labs at all levels, but especially for introductory labs. You can read more about the philosophy behind these learning goals here.)*

Consider the following questions:

- The objectives of the lab course are intended to benefit students regardless of their future careers.
    - Choose at least two of the objectives from the five above. How do these objectives apply to your current career interests?
    - Do you have any *personal* goals for this lab course… something that you hope to learn or get better at by the end of the year?
- The overarching principle of these labs is to understand **how we know, not what we know**. Reflecting back on today's experiment, identify at least one thing that your group did that helped you understand *how* instead of *what*.
- In the next lab, we will return to the pendulum to take more measurements. What is one improvement you could make – to your apparatus, to your measurement technique, to your data collection strategy, etc. – that will help you reduce your *statistical uncertainties*? What is one improvement you could make to help you study (or eliminate) *systematic uncertainties*?

I feel that communicating processes and extending the scope of investigation are essential skills for me to have, as I believe that data collection would be very important for my potential interests. Within experimental and applied economics, there is a high expectation of rigor for building upon past conclusions, even if it is not in agreement (to prevent confirmation bias) and communication is necessary to share experimental results in the field as well as to document and evidence made conclusions.

Personally, I'd like to improve my array of skills and apply them in different situations, such as in physics experiments. While I have some knowledge in Python programming, design documentation and math, I would want to work on applying my skills in a variety of situations that will allow me to become more familiar with the knowledge I already know. Since the treatment of knowledge is pretty theoretical at this university, I feel that having more opportunities to apply my knowledge would help me reinforce what I learned in CS or Calculus.

In the process of designing and conducting the experiment, we were concerned about whether the accuracy of the initial angle/position would impact the outcome of the experiment, as it seemed theoretically that the angle was not a component for the period length, but it seemed like something that could influence the result of the experiment. After a few trials, we realized that regardless of the angle, the period timing is the same, answering our concern and demonstrating the theoretical equation.

One improvement that I would make is to extend the string length to make it easier to ascertain the period of the pendulum (it is hard to tell with a short string length) as well as to reduce the

component of applied force when the pendulum is dropped by increasing the acceleration of the bob as a result of gravitational acceleration.