7.2: Activities

Equipment

- swing protractor
- pendulum support assembly
- pendulum (iron weight with string)
- magnet
- triple-beam balance

The General Idea

As described in the Background Material, we will be looking at a physical process where mass swinging on a string picks up a stationary mass. We can measure the starting height of the swinging mass and the final height of the combined mass (both indirectly with the help of a protractor). We will use those measurements for the following specific task: You will measure the mass of the swinging weight (it is ostensibly a 20 gram weight, but you may want to check that with the balance provided), and will use your measurements to compute the mass of the magnet.

A single swing will give an answer to this question, but as everyone knows, such an approach is fraught with danger regarding uncertainties. So instead, you will do many runs (at least 6, but more is better) and make a plot of y_f (the final height) vs. y_o (the starting height). If you have worked out the mathematical relationship between these heights and the masses of the two objects involved, then it should be clear how this plot will be useful for attaining your goal.

Some Things to Think About

Here are several suggestions and warnings to help you on your way:

- As usual, you should use video recording to make your measurements of the moving object as accurate as possible.
- Something we have not encountered yet in laboratory procedure turns out to be very important in this lab. It is called *calibration of the equipment*. In this lab, it comes up in two places. First, the orientation of protractor is adjustable, and you should make sure that it is positioned correctly before taking data. And second, you may find that there is a measurable friction effect between the string and the rod that supports it. You can measure this approximate amount of this effect by doing one or more runs of the pendulum drop *without* it grabbing the magnet. If there was negligible friction, then the starting and final angles of the swing would be equal. If these are not equal, then you can account for the role of friction in your actual data runs by adjusting the angle measurements according to what you learned in these calibration runs.
- Something we encountered in previous labs also comes up here. We are mapping the motion of the pendulum with the protractor behind it, so we need to minimize the effect of parallax in our view. This is accomplished in the usual ways – keep the pendulum as close to the protractor as possible, and the camera as far away as possible (while still being able to see the result).
- While the protractor is helpful (and easier to use than measuring the heights directly), it can be misused. The act of grabbing the magnet causes the iron weight to not move so "smoothly" on the string as the swing continues. This causes the string's shape to fluctuate rapidly, and it may not be reliable to use it as a way of measuring the angle. But no matter how much the *string* jitters about, the angle made by the center of mass st the end of the string is what matters here. Keep this in mind when logging data from your video recordings.
- As with previous labs that involve extracting an answer from graphical methods, we will not be determining the uncertainty range for the final answer. If you are not getting an answer within 5% of the actual mass of the magnet (you can measure this on the scale only *after* you have computed it!), then you have likely made one or more fixable mistakes.
- As usual, for your plots you should use the usual online graphing calculator to plot your data points. Now that you have done a few of these "by hand," it's time to unleash the power of our computers. Here is how to get the best-fit line (a process called *linear regression*) on Desmos: Create the data table by clicking on the "+" in the upper-left corner, and selecting "table." You will see that the variables "x_1" and "y_1" are used in the table. In the next box, put in the equation for a line with these two variables, but instead of using an equal sign, use "~". So it should look like "$y_1 \sim mx_1+b$". A best-fit line will be drawn for you, and the values of m and b for this line will be displayed. The r^2 value is an indication of the quality of the fit, with a value of 1.0 being "perfect" (all the points lie on the line).

Lab Report

Craft a lab report for these activities and analysis, making sure to include every contributing group member's name on the front page. You are ***strongly encouraged*** to refer back to the Read Me as you do this, to make sure that you are not leaving out anything important. You should also feel free to get feedback from your lab TA whenever you find that your group requires clarification or is at an impasse.

Every member of the group must upload a separate digital copy of the report to their lab assignment in Canvas *prior to leaving the lab classroom*. These reports are not to be written outside the lab setting.
