ANALYSIS AND DISCUSSION

Since this is your first experiment in this course, more detailed instructions are given below to assist you with the analysis and discussion of your results. Feel free to use alternative analysis procedures provided they are correct, rigorous and address the three statements in the proposed theory.

Statement 1: The oscillation period of a simple pendulum is independent of the oscillation amplitude.

A quick glance at your first data table may give you a feel of how much your data supports this statement. However, scientifically speaking this cannot be accepted as an appropriate analysis of your results and more rigorous analysis procedures should be followed. In particular, do the values predicted by the theory agree with the measured values within the estimated uncertainties in your measurements? This is the question that you need to answer in any testing experiment.

In the first part of the lab, you measured the oscillation time of a simple pendulum for different oscillation angles (or amplitudes) while keeping the mass and the length of the pendulum fixed. To begin analyzing your data, you need to calculate the periods of oscillation for the different oscillation amplitudes. Since you measured the time for ten oscillations, you need to divide by 10 to find the period. For example, if the measured time for ten oscillations is 14.28 s, then the period is calculated to be 1.428 s. However, does this value really have four significant figures?

To answer this question you need to know the uncertainty of your timing measurement. One way to do that is to make ten measurements (using the stopwatch) of the time it takes the Seconds Hand on a wall clock to make 5 moves. Of course, we know that this corresponds to an exact time of 5.00 s. However, you may get (for example) the following values:

5.07 s, 4.87 s, 5.17 s, 5.10 s, 5.03 s, 4.98 s, 4.77 s, 5.07 s, 5.13 s and 4.78 s

In these measurements we see that 4.77 s deviates the most from the correct time. The difference (0.23 s) is called the maximum deviation time and can be used as an estimate of the error in your timing. Note that your timing may have higher or lower uncertainty depending on the devise used and on your personal reaction time.

Returning back to the time measurement for 10 oscillations (of 14.28 s) we now see that the first digit after the decimal is uncertain. Therefore, this measurement has three significant figures only and should be written as

$$t = 14.3 \pm 0.2 \text{ s}$$

The period also has three significant figures and it is equal to

$$T = 1.43 \pm 0.02 \text{ s}$$

Similar calculations can be made for the other oscillation amplitudes with the results entered into the appropriate column in Table 1. In the lab report, it is important to include sample calculations and show how the different numbers in the table were obtained.

To proceed with the analysis enter your data into the Graphical Analysis Program where each measurement is represented by a single data point (period vs. angle). Also enter the uncertainties of your measurements. To do that, double click on the top of the column containing the period and then click on the "Options" tab (see Pic 4).

Pic 5 shows data, from an example experiment, with vertical error bars extending 0.02 s on both sides of each data point. Note that, excluding the last data point, there is a range of values (1.41 s – 1.42 s) where the measured periods overlap, in this example experiment. Therefore, we can argue that the data (in Pic 5) do not violate Statement 1 for the oscillation angels (5° – 25°) and that the proposed theory has survived this test.

Regarding your data, you may analyze it as mentioned above or decide to follow an alternative procedure. In any case, remember that your goal is to test the validity of Statement 1. Therefore, correct arguments must be provided to support to your conclusions.

Statement 2: The oscillation period of a simple pendulum is independent of the oscillating mass.

To test the validity of this statement, you may follow a similar procedure as in the previous statement.

Note that the mass the coins may depend on their production date. For example, a loonie dated 1988 and later has a mass of 7.0 g, while the mass of a toonie is 7.3 g. You may refer to the Royal Canadian Mint website (www.mint.ca) for more information and technical specifications of the Canadian coins. For the American coins see the United States Mint website at (www.usmint.gov). For the purpose of this experiment, you can ignore mass uncertainty and only consider the uncertainties in timing measurements. Make sure to include enough support for your conclusions.

Statement 3: The oscillation period of a simple pendulum is given by the equation $T = 2\pi\sqrt{L/g}$.

Looking at your measurements in Table 3, probably you have noticed that the oscillation period increases with the length of the pendulum. The question now is what mathematical relation between T and L is supported by your data? In particular, do your data support the proposed (nonlinear) relation above or does it suggest a different relation (for example the linear relation $T = mL + b$)? To answer these questions you need to analyze your data.

After calculating the period values (with uncertainties) enter your data into the Graphical Analysis Program to plot T vs. L. It is a good idea to double click on the graph and uncheck the "Connect Points" box. Next, highlight all the data points, go to the "Analyze" menu and select "Linear Fit". This will generate a linear graph which represents the best linear fit to your data. Save your file under a specific name.

Before you do a second fit, "Save As" your file under a different name, close the linear fit box and highlight the data points again. Go to the "Analyze" menu, then to "Curve Fit" and select the "General Equation" form "Ax^B". Click "Try Fit" then "OK" and save your file.

Now you have a proposed theoretical equation and two experimental graphs to study. For easier comparison to your fit, you can rewrite the proposed equation in the form

$$T = \left(\frac{2\pi}{\sqrt{g}}\right) \times L^{1/2}$$

Also, here are some questions you may consider while preparing your analysis and discussion for the validity of Statement 3.

Which fit, do you think, gives the best description of your data and why?

How do the (nonlinear) fit parameters “A” and “B” compare with the expected values?

What value for the gravitational acceleration is predicted from this fit? And how does it compare with the accepted value of g?

What are the main sources of error that affected your measurements and contributed to the uncertainties?

Conclusion

A brief conclusion should be included at the end of your analysis and discussion in your lab report. In the conclusion you state whether or not your experiment supports the proposed theory. Also, you should include a brief summary of the main points in your discussion and mention the major sources of experimental uncertainties.