LAB 01: CIRCUMFERENCE AND DIAMETER

The Objectives

The purpose of this exercise is simply to get some practice with the techniques of writing an error analysis report. To this end, we will be performing a simple experiment, and paying close attention to how we document what we have done. As a bonus, we get to practice some important analytical skills: graphing data and linear regression.

This experiment is pretty simple, and you should already know the answer. Every scientific experiment starts with a question to be answered or an hypothesis to be tested. In this case, the questions is:

What is the relationship between the circumference and the diameter of a circle?

This is a good question to explore, because we can easily test what we think the answer is. The specific objectives are:

▸ Make accurate, precise, and repeatable measurements using a meter stick and vernier calipers

▸ Make detailed notes on your experimental procedure

▸ Record data neatly, completely, and accurately in your lab notebook

▸ Use *LoggerPro* to construct a graph with correctly labeled and accurately scaled axes

▸ Understand the relevance of a correlation coefficient to a series of linear data

▸ Identify sources of random error and calculate a relative (%) error

▸ Identify sources of systematic error and explain their effect on the results

The Procedure

Measure and record the diameter and the circumference of several cylindrical objects of varying size. You should collect a minimum of ten data pairs from differently sized objects. Document your measuring methods in your notebook.

The Data

Record your measurements in a neat table in your notebook. Label your data with units, and include the uncertainties based on the measuring tool used.

The Reduction

Graph your data. Plot **diameter** on the **x–axis**, **circumference** on the **y–axis**. Use the *LoggerPro* software on the computer (*MS Excel* is also available on the computers, but this is rarely the best choice for scientific graphing). Manuals and instructions for using the *LoggerPro* software are located in the lab.

The Analysis

Error Propagation: Let the *LoggerPro* perform a linear regression on your data. Make sure that you record the equation of the best–fit line in your notebook. When your graph is complete, you may print a copy to attach in your notebook. We can also compare our slope to the expected value (π). Calculate the percent error in your slope (m):

$$\%error = \left[\frac{\pi - m}{\pi}\right] \times 100\%$$

Random Error: Identify the sources of random error that you have quantified. Discuss whether your results have been compromised by these errors, and how you could either eliminate or minimize the effect of these errors. Use the value of the correlation coefficient (r^2) to support your arguments.

Systematic Error: Identify possible sources of systematic error, and where systematic error shows up in your results. Determine whether there is a genuine systematic effect on your data (the correlation coefficient can be useful here as well). Discuss methods for removing or reducing systematic error.

The Conclusions

Unless something went horribly wrong, you should not have anything outstanding to discuss here; comment on whether your experiment concluded successfully. Does your slope correlate with the known value, to within your ability to measure it? Do you have any suggestions for improving the quality of the data, or the accuracy of the results?

You should make sure that you have documented your activities fully in your lab notebook, as you will be quizzed over this experiment next week. You will be allowed to use your notebook as a resource when you take the quiz.

A sample report for this experiment has been posted on the course web. When you are ready to write your formal report later in the semester, you should use this report as an example of appropriate format and content.

References

Gaspar, Joaquim Alves "Using the Vernier Caliper" From *Wikimedia Commons*.
http://commons.wikimedia.org/wiki/Image:Using_the_caliper_new_en.gif

Weisstein, Eric W. "Correlation Coefficient." From *MathWorld—A Wolfram Web Resource*.
http://mathworld.wolfram.com/CorrelationCoefficient.html