Week 1: Labs September 15th and 16th, 2015

Lab 0: Python primer/review

Purpose of lab:

The purpose of this lab is to review material in the “Introduction to Python for Science” book, material covered in the course Introductory Experimental Physics. Python will be used for plotting and analyzing data in subsequent labs.

Lab report: The report for the lab this week should include the Python programs, plots and curve fits along with the answers to exercises questions below.

The laboratory report may be (but need not be) submitted in the form of a Python Notebook. This is a very convenient way to document your Python programs and data analysis, which makes them easy to follow and modify. See Appendix B of “Introduction to Python for Science” for how to use Python Notebooks. Once you learn this you will find it much easier to reuse Python code or restart an analysis of data you have begun.

Lab exercises:

1. **Reading and plotting data from an Excel data sheet that is in comma separated value (CSV) format**. In many of the labs you will take data “by hand” noting the values in your laboratory notebook. They will then be transcribed into an Excel document (or other text file format) for later plotting and analysis. In this exercise you will write a Python code that reads and the plots data in CSV format; a code that you can reuse in later labs.

Write a Python script that reads data from the file SampleData.csv and plots the data in this file including the measurement errors. The file contains sample data from the ideal gas law experiment you will preform next week. The file is available on the Classes website under “Resources/Laboratory 0.” Plot temperature versus pressure. Be sure to label the quantities plotted and their units, e.g. P(lb/in^2), T(C).

2**. Linear least squares fit.** Write a Python code that preforms a linear least squares fit to the data in Exercise 1 without considering the error (i.e. not with chi-squared weighting). Plot the data along with a line that shows the least squares fit. Include a plot that illustrates when the y-intercept (the temperature when the pressure is zero).

3. **Linear chi-squared fit.** Write a Python code that preforms a linear least squares fit to the data in Exercise 1 considering the error (i.e. with chi-squared weighting). If available, use the codes you wrote in the course Introductory Experimental Physics for this exercise. Plot the data along with a line that shows the least squares fit. Compare you result for the slope and intercept to that you found in exercise 2. Do you results differ significantly? Why or why not?

4. **Looking ahead to coupled pendulums, lab 5.** In this lab you will learn that the motion of two pendulums that are coupled together can follow the following equations:

$$\theta_a = A\cos\omega_1 t + A\cos\omega_2 t$$
$$\theta_b = A\cos\omega_1 t - A\cos\omega_2 t$$

Where $\theta_{a,b}(t)$ is the angle of the pendulum from a vertical line for pendulum *a* and *b* at time *t*. The constant *A* characterizes the amplitude of motion while ω_1 and ω_2 are angular frequencies. Take $\omega_1 = 2\pi 5$ rad/sec and $\omega_1 = 2\pi 5.2$ rad/sec and A=0.1 rad.

a. Plot $\theta_{a,b}(t)$ versus *t* in two separate subplots for an interval of at least 20 seconds.

Trigonometric identities can use used to rewrite these equations as:

$$\theta_a(t) = 2A\cos\left((\frac{\omega_2-\omega_1}{2})t\right)\cos\left((\frac{\omega_1+\omega_2}{2})t\right)$$
$$\theta_a(t) = 2A\sin\left((\frac{\omega_2-\omega_1}{2})t\right)\sin\left((\frac{\omega_1+\omega_2}{2})t\right)$$

This shows that each pendulum oscillation has a slow (low frequency, ~ ω_2- ω_1) and a fast (~ ω_1+ ω_2) oscillatory component to its motion.

b. Plot these functions on the same graphs you used in part a to illustrate graphically that these functions are identical to the ones above.