Homework 07

General comments:

- pay attention to error bars
- All data files provided at the class web page.
- everywhere in this homework use built in `fittype` to define fitting function with the following call to `fit` for the fitting.

Problem 1 (5 points)

Recall one of the problem from the previous homework 2.

Download data file 'hw02dataset.dat' from the class webpage. It represents result of someone attempt to find resistance of a sample via measuring voltage drop (V), which is the data in the 1st column, and current (I) listed in the 2nd column passing through the resistor at the same conditions. Judging by the number of samples it was an automated measurement.

Using Ohms law $V = RI$ and linear fit with one free parameter (R) find the resistance (R) of this sample. What are the errorbars/uncertainty of this estimate? Does it come close to the one which you obtained via method used in homework 2?

Problem 2 (5 points)

You are making speed detector based on the Doppler effect. You device detects dependence of the signal strength vs time, which recorded in the 'hw_fit_cos_problem.dat' file (first column is time and second is the signal strength).

Fit the data with

$$A\cos(\omega t + \phi)$$

where A, ω and ϕ are the amplitude, the frequency and the phase of the signal, and t is time.

Find fit parameters: the amplitude, the frequency and the phase of the signal and their uncertainties.

Bonus (2 points)

Provided that above radar was using radio frequency range, could you estimate velocity measurement uncertainty. Is it good detector to measure ground car velocity?

Problem 3 (5 points)

Experiment to do at home. Make a pendulum of variable length (0.1m, 0.2m, 0.3m, and so on up to 1m). Measure how many back and forth swings such pendulum with a particular length does in 20 second (clearly you will have to round to the nearest integer). Save your observations into the simple text file with 'tab' separated columns. The first column should be the length of the pendulum in meters, the second column the number of full swings in 20 seconds.

Write a script which loads this data file, and extract acceleration due to gravity (g) from the properly fitted experimental data. Recall that period of the oscillation of a pendulum with the length L is given by the following formula

$$T = 2\pi\sqrt{\frac{L}{g}}$$

Problem 4 (5 points)

In optics propagation of the laser beams are often described in the Gaussian beams formalism. Among other things, it says that optical beam intensity cross section is described by Gaussian profile (hence the name of the formalism)

$$I(x) = A\exp\left(-\frac{(x - x_o)^2}{w^2}\right) + B$$

where A is the amplitude, x_o is the position of the maximum intensity, w is the characteristic width of the beam (width at $1/e$ intensity level), and B is the background illumination of the sensor.

Extract the A, x_o, w, and B with their uncertainties from the real experimental data contained in the file 'gaussian_beam.dat', where the first column is the position (x) in meters and second column is the beam intensity in arbitrary units.

Does the model perfectly describes the experiment? Why so?