Homework 04

General requirements/comments:

- Pay attention to error bars and **report them**.

- Everywhere in this homework use built in `fittype` to define fitting function with the following call to `fit` to do the fitting.

- All data files are provided at the class web page.

Problem 1 (5 points)

Recall one of the problems from the previous homework 2.

Download data file 'hw02dataset.dat' from the class webpage. It represents the result of someone's attempt to find the 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. Judging by the number of samples it was an automated measurement.

Using Ohm's law $V = RI$ and a linear fit of the data 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 the method used in homework 2? Do not use fitting available via GUI interface, construct your own.

Problem 2 (5 points)

You are making a speed detector based on the Doppler effect. Your device detects dependence of the signal strength vs time, which is 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)

This is for the physicists among us. Provided that the above radar was using radio frequency range, could you estimate velocity measurement uncertainty? Is it a 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 that the pendulum with each particular length does in 20 seconds (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, the propagation of the laser beams is often described in the Gaussian beams formalism. Among other things, it says that optical beam intensity cross section is described by the Gaussian profile (hence, the name of the beams)

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

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.

Is the suggested model good to describe the experimental data? Why so?

Bonus (2 points)

Fit the data from the file 'data_to_fit_with_Lorenz.dat' with the above Gaussian profile. Is resulting fit is the good one or not? Why so? Compare it to the Lorentzian model, which we discussed during the lecture 7.