Homework 03

General requirements/comments:

- Review the function handle operator @: use `help function_handle`.
- Pay attention to error bars/uncertainties; **report them**.
- Everywhere in this homework use built-in `fittype` to define a 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 web page. 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 the fitting menu available via the GUI interface, use a script or a function to do it.

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 (the first column is time and the 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.

Problem 3 (Bonus 2 points):

This is for the physicists among us. Provided that the above radar was using radio frequency, could you estimate the velocity measurement uncertainty? Is it a good detector to measure a car's velocity?

Problem 4 (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 round trip (back and forth) swings 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 the 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 5 (5 points):

In optics, the propagation of the laser beams is often described in the Gaussian beams formalism. Among other things, it says that the 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 the second column is the beam intensity in arbitrary units.

Is the suggested model describe the experimental data well? Why so?

Problem 6 (Bonus 2 points):

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