PHYS 310 — Homework #5

Reading:

- Read sections 8.1–8.6

The data sets for these problems are available at: `www.eg.bucknell.edu/~phys310/skills/data_analysis/hw5_data`.

For these problems, it will be helpful to look at the materials from the most recent week's class (in the "Class Materials" section on the main course web page), and you're welcome to copy code segments from that.

1. **Linear fits and χ^2 contour plots**.

   Download the following four data sets: data1.dat, data2.dat, data3.dat, data4.dat (the link is at the top of this HW page). The 3 columns in each data file are: x, y, σ_y. For each data set, create a notebook to perform a **linear fit** via chi-squared minimization. The notebook should contain the following plots:

   (a) the data by themselves (always inspect data before you fit! comment: does it look linear?)

   (b) the data with the best fit model (comment: report the fit parameter results with correct sig figs, and address whether the fit looks like it matches the data)

   (c) the normalized residuals (comment on the shape and how large they are)

   (d) a $\chi^2 - \chi^2_{min}$ contour plot

   (e) a $\chi^2 - \chi^2_{min}$ contour plot showing only the $\chi^2 = 1$ contour and horizontal/vertical lines marking the uncertainties from the fit (comment on whether the contour is roughly consistent with the uncertainties from the fit)

   You can copy pieces of code from the class notebook to help with this, and then once you have your first notebook, you can copy and paste it for the others.

   At the end of each notebook, **write a short paragraph commenting on what you think about the data and whether a linear fit is reasonable based on χ^2 and your graphs.** Save four separate notebooks (or one long notebook with four

sections) so that the instructor can see the four separate cases clearly without needing to re-run your code.

2. **Fitting to a nonlinear function (a Lorentzian in this case)**.

   Download the data file fit_4.dat from the link at the top of the HW. Each line in the data file contains a value of x_i, y_i, and u_i, where u_i is the uncertainty in y.

   (a) Make a plot (with errorbars) of the data in fit_4.dat.

   (b) Fit a Lorentzian function of the form

   $$y(x) = a\left(\frac{c^2}{(x-b)^2+c^2}\right) + d$$

   to the data, and plot your best fit with the data.

   (c) Write the best fit values for a, b, c and d with uncertainties in standard form.

   (d) Comment on the quality of the fit.

   (e) Make contour plots of $\chi^2 - \chi^2_{min}$ as a function of a and b in the vicinity of χ^2_{min}. Does this contour plot show uncertainties in a and b that are consistent with what the fitting program determined?

   (f) Make contour plots of $\chi^2 - \chi^2_{min}$ as a function of c and d in the vicinity of χ^2_{min}. Does this contour plot show uncertainties in c and d that are consistent with what the fitting program determined?