Homework 12: One Last Time

ENR/PHY 320 – Math Methods
Professor Lemke

Due: Wednesday 12/11/19

Name: ____________________________

Reading assignment: Kreyszig (9th Ed.) Ch. 25

This is a Matlab (or similar) assignment. For this assignment only, you may hand in your homework together with your partner as one single document. But please include all source code, as well as the outputs and graphs, and your answers to the wordy questions.

1. You and your cousin Jack are having a disagreement about climate change. You take the reasonable position that science is trustworthy, but Jack claims it is a hoax. The two of you agree to look at some data from NASA. Navigate to `https://climate.nasa.gov/vital-signs/global-temperature/` and download the raw yearly temperature data by clicking on the link at the right of your screen.

   (a) First, let's just compare means. What is the difference (and uncertainty) in the mean temperature pre- and post-1950? Be sure to explain how you are calculating the uncertainty of the difference of the two means.

   (b) Given your answer above, what is the 95 % confidence interval for the difference of means?

   (c) Estimate the probability that the warmer temperatures post 1950 are merely a statistical anomaly (i.e. that the actual mean temperature is unchanged, and we just keep getting unlucky as we randomly sample the distribution)?

   (d) Now let's talk about the slope. How fast is the earth temperature rising? You'll have to choose a reasonable number of years to look back and fit a line to. You also need to assign errorbars to the points (how big should they be? Guess.) What is your uncertainty in this warming rate? Was your guess of errorbar about right (and how do you know)? If not, re-run the fit with a better estimate of the errorbars. Use the function 'weightedPoly.m' that is on the course Moodle site.

   (e) Fit the full dataset to a polynomial of varying degrees. How does it look? What would you say is the smallest number of degrees in the polynomial needed to capture the behavior of the curve (i.e. not that it matches every small fluctuation, but it gets the trends correct)?

2. Next we turn toward weighted nonlinear fitting in order to perform the spectroscopist's most important type of data analysis, peak fitting. You can use 'nlinfit' to perform the fits. The data you will fit is on the Moodle site and called "spectrum.txt". (Think of this, for example, as the number of detected photons emitted by a molecule, so the x-axis is some kind of frequency and the y-axis is detector counts.)

   (a) Since these "counts" are integers, they are drawn from a Poisson distribution, and have some appropriate noise added to them. What should you take as the error-bars for these y-values, knowing what you know about the Poisson distribution? Calculate these, and be sure to use them appropriately as weights in your fitting below.

   (b) I have also provided 3 common model lineshape functions (Gaussian, Lorentzian, and Sinc^2) that you will attempt to fit. Perform the fits and comment on the goodness of fit, both by viewing the residuals and observing the mean square error (MSE). Which fits best?

   (c) For the function choice that fits best, what is the uncertainty in the peak center? You can access the standard uncertainty by taking 'sqrt(diag(CovB))', which will output a vector of the uncertainties corresponding to each fitting parameter beta. Is the uncertainty in the peak center greater or smaller than the spacing between individual data points? Does this seem possible?

3. Finally, another example of nonlinear fiting. Download the data file 'mysterycurve.txt' from the course moodle site.

   (a) Make a scatterplot of the data.

   (b) What kinds of functions could you imagine fitting to this data? List at least 3.

   (c) Your job is to determine what function the creator of the dataset used to generate the points. Try fitting the 3 functions you listed above and see which fits the best by quantifying the goodness of fit with MSE (mean square error) and qualitatively by viewing the residuals. You will use the built-in Matlab function 'nlinfit' to do this.