Assignment 2

1. Curve Fitting Part I – Linear Fit – No Uncertainties on the Data

Begin with the Jupyter Notebook called graph_fitting_matrix.ipynb that has been uploaded to GitHub.

Modify this program to fit the following data using a linear least-squares fitting algorithm. Rather than using a generating function to create the fit data, you can either read the data below in from a file, or initialize the data arrays directly within the notebook. There are no uncertainties on the data points themselves. You should calculate the fit parameters, as well as the uncertainties on the fit parameters.

X	Y
1	1.6711
2	2.00994
3	2.26241
4	2.18851
5	2.33006
6	2.42660
7	2.48424
8	2.63729
9	2.77163
10	2.89610
11	2.89083
12	3.08081
13	3.05305
14	3.24079
15	3.36212

2. Curve Fitting Part II – Linear Fit – Uncertainties on the Data

Using the data from part I, assign an uncertainty, Δy, to each data point. Start with having equal uncertainties on each data point (say, +/- 0.1). Modify the program from part I to take into account the uncertainties. You should find that the fit parameters will not change in value, but the uncertainties on the fit parameters will now be somewhat larger.

Next, assign non-equal uncertainties. Now, you should find that both the fit parameters and the uncertainties on the fit parameters should change should both change.

3. Wavepackets – Initial Investigation

Begin with the Jupyter Notebook that has been uploaded to GitHub called graph_wavepacket.ipynb

Use the program to compare the case of adding nine equal amplitude waves distributed between –Delta(k) and +Delta(k) to the exact Fourier transform result using a uniform distribution from –Delta(k) to +Delta(k).

How do the two power spectra compare in width and amplitude?

4. Random Number Generation

Modify the above macro to compute the power spectrum for the sum of 100 waves with a wavenumber chosen randomly between –Delta(k) and +Delta(k).

Compare each of the following cases to the uniform distribution Fourier transform result:

a) a uniform distribution of randomly chosen wavenumbers
b) a gaussian distribution of randomly chosen wavenumbers with sigma=Delta(k)/3.0

5. Runge Kutta Methods

In class, we developed a program (graph_runge_kutta_all.ipynb on GitHub) that compared various Runge Kutta methods to solve a first order differential equation.

Modify this program to solve the following differential equation:

y'(t) = (t+y(t))*exp(t*y(t))

for 0 < t < 10, and with y(0) = 5.

You will have to consider what reasonable values are for the timestep, tau, as well as the limits on the axes for both y and t. You should notice some odd behaviour for t > 5 … what's going on there? Also, I did not calculate the exact analytical solution (I don't even know if there is one). Bonus points for anyone that can figure this out ☺