Computational Physics
Fall 2019
Homework #2
Due Friday, Oct 11, 5pm

1. Do problem 6.11 from Newman.

2. Do problem 6.13 from the book.

3. Attached in the email with this assignment is a data file that contains measurements of the galaxy stellar mass function from the COSMOS galaxy survey. The columns are:

    1. log M_gal [dex]
    2. n(M_gal) [1/dex/Volume]
    3. error in n(M_gal)

Here, "dex" means base-10 log of the stellar mass. Volume here is $(\mathrm{Mpc}/h)^3$. Measurements of this type are usually described by a "Schechter" function, which for this problem has the form

$$n(M_{\rm gal}) = \phi^* \left(\frac{M_{\rm gal}}{M_*}\right)^{\alpha+1} \exp\left(-\frac{M_{\rm gal}}{M_*}\right) \ln(10)$$

This function (which has the same units as column 2 in the datafile) has three free parameters: ϕ*, the amplitude, M*, the "characteristic mass scale", where the function changes from being a power-law to having an exponential cutoff, and α, the low-mass slope of the function.

Write a code that will implement the gradient descent method in multiple dimensions, using numerical derivatives, to find the minimum of a function. Test your code on a simple function, such as:

$$f(x, y) = (x-2)^2 + (y-2)^2$$

(Remember that we're still using numerical derivatives, even though the derivatives of this function are known.) After confirming that your code works (include a plot demonstrating this result— use your discretion to choose what the plot should show), apply it to the problem of fitting the Schechter function to the data provided. The function you are minimizing is the chi^2 of model. Verify that your result is robust by demonstrating that you get the same result when starting from distinct locations in parameter space (within reason). Attach the following plots:

a) chi^2 as a function of step i.

b) a comparison of your best-fit Schechter function to the data, on a log-log plot.

If you want to attach more plots to help you explain your results, feel free to do so.