PHYS 3340
Spring 2009
TE Coan
Due: 25 Feb '09, 6pm via email.

Homework 4

1. Radioactive substances have a simple relationship describing how much of them survive after a time t has elapsed: $N = N_0 e^{-t/\tau}$, where N_O is the starting number of radioactive particles, N is the number of remaining, non-decayed, particles after time t, and τ is a characteristic time, unique to each radioactive substance, that describes how rapidly the substance decays. This quantity τ is often called the "lifetime" of the substance even though not all the particles decay at the same time. The "half-life" $t_{1/2}$ is also used to characterize how long a radioactive substance lasts and is the time required for half of the starting amount to decay. It is related to, but not identical with, τ.

It is also the case that if you could somehow measure the time of decay of each of the decaying particles, equivalent to measuring the decay *rate* dN/dt of the substance, the distribution of decay times would also follow an exponential with the same exponent as above. (Go ahead and take the time derivative of the above expression for N to convince yourself.)

The homework course page has a histogram file containing measurements of the decay time of individual radioactive particles. That is, the horizontal axis contains decay time intervals and the vertical axis contains the number of particles that had a decay time in that interval. What is the half-life $t_{1/2}$ of this substance? See the file `radioactive.hst`. Include the gnuplot commands AND a pdf plot of the fit to your histogram n your answer file. Pay attention to where in the time interval gnuplot plots your y data. Do you need to center your data?

2. Plot histograms of 3 sets of 10,000 random numbers each, drawn from the poisson probability distribution with $\mu = 2.0, 5.0, 10.0$. Use bin widths equal to 1. Choose upper and lower bounds so that most of the bins have a non-zero number of entries. (Go ahead, use your judgement.) Include these plots in your answer file using the zip utility.

3. Test how well the gnuplot fitter works by fitting the histograms you made in problem 2 with a poisson-like function and determining the value of μ for each histogram. Compare the μ values you used to generate the histogram with those returned by the gnuplot fitter. Include the gnuplot fit results in your answer file.

4. Plot a histogram of 10,000 random numbers drawn from a poisson probability distribution with $\mu = 16$. Fit the histogram with a gaussian-like function $f(x) = Ae^{-((x-\mu_g)/\sigma)^2/2}$. Determine A, μ_g, and σ. Compare them with what you expect from the poisson distribution that originally generated the histogram numbers. Include gnuplot commands, histogram with fit, and output showing results in your answer file.