Physics 266. Fall 2016. Homework 2

Due on 14 Oct 2016

SHOW ALL WORK AND HAND IN ANY CODE YOU WROTE TO DO THE CALCULATIONS.

1. Applying the central limit theorem:

In class I mentioned the central limit theorem. In this problem you will test how it works. Here, again, hand in both the plots and the code that you used to generate them.

(a) Generate 3 random numbers that are drawn from a uniform distribution between 0 and 1. Find the mean of the three values, and record the result. Repeat this 99 additional times and plot the 100 mean values that you found as a histogram.

(b) Repeat part (a), but instead of taking the means of 3 numbers, take the means of 100 sets of 6 random numbers between 0 and 1.

(c) Repeat again, but take the means of sets of 20 numbers.

2. Poisson converging to a Gaussian:

In this problem, you are going to see how quickly a Poisson distribution converges to a Gaussian, especially in the wings of the distribution. Use python's random number generator to create three data sets with 10,000 members each. The data in the three samples should be drawn from Poisson distributions with means of 10, 100, and 1000, respectively. As usual, submit all your code for this problem.

(a) For each of the data sets, calculate the percentage of points that are contained within the $\mu \pm n\sigma$ regions, where $n = 1, 2, 3$, and where σ in each case is the theoretical value predicted from a Poisson distribution with the given mean. Make a table, where the rows are "1 σ", "2 σ", and "3 σ" and the columns are the three data sets.

(b) Find the boundaries of the regions that contain 68%, 95.4%, and 99.7% of the data sets that you generated. Compare these boundaries to those defined by the corresponding $\mu \pm n\sigma$ regions. *Hint:* Sorting each one of the data sets makes it pretty easy to determine the boundaries of the regions.

3. Fun with magnitudes

(a) If you image a galaxy with a CCD, one thing that you may want to do is to convert the galaxy brightness to the astronomer's traditional units of magnitudes. You do this by first converting to count rate, R, (in counts/second) and then taking

$$m = -2.5 \log(R) + ZP$$

where "ZP" stands for "zero-point" and is the value that is used to convert "instrumental magnitudes" to ordinary magnitudes. Assume that ZP is known essentially perfectly, i.e., its error is tiny compared to all other errors in the problem. If your determination of R has an uncertainty of σ_R, what is the corresponding uncertainty on m? **NB: In this course log will always mean $\log_{10}$. Natural logs will be designated as ln.**

(b) Assume that the fractional error in the countrate is 5%, $\sigma_R/R = 0.05$, what is the corresponding error in m? How about if the fractional error in R is 1%? Notice a pattern?