R. Kass
Physics 416

Problem Set 1. Due April 10, 2007

Note: To receive credit for the homework problem you must show how you arrived at your answer, e.g. give the relevant formula and show your calculations.

1) Taylor, Problem 4.2, page 111. Do part b) if you have a suitable calculator.

2) If a constant c is added to each x_i in a sample (i=1, n) such that $y_i=x_i+c$ how does the mean and variance of the y_i's relate to the mean and variance of the x_i's? If instead of adding a constant to each x_i, supposed we multiplied each x_i by the constant, i.e. $y_i=cx_i$. What is the mean and variance of y in terms of the mean and variance of x?

3) The probability distribution that describes the sum of the dots (x) showing on a pair of six sided dice is:

$$P(x)=\frac{x-1}{36}\ x=2,3,4,5,6,7 \quad and \quad P(x)=\frac{13-x}{36}\ x=8,9,10,11,12$$

Find the mean, variance, and standard deviation of this distribution. Note: this probability distribution is used in Lab1

4) A detector located underground in a salt mine near Cleveland detected a burst of 8 eight neutrinos at the same time as the optical observation of Supernova 1987A. Use Poisson statistics to answer the following questions:

a) If on average the detector would normally find 2.1 neutrino interactions per day what is the probability of observing eight or more neutrinos in one day?

b) Assuming that the experimenters expected, on average, 2.1 neutrino interactions per 24 hours what is the probability of observing 8 or more neutrino interactions in a ten minute time interval (this is what was observed!)?

5) The probability density function describing the time (t) between the creation and decay of a certain unstable elementary particle is given by:

$$f(t)=0 \quad t<0 \ and \ \ f(t)=ae^{-t/\lambda}\ t\geq 0$$

with λ and a constant.

a) Using normalization condition (eqn. 5.13) on page 128 find the normalization constant a in terms of λ. What are the appropriate limits of the integration?

b) Find the average time it takes for a particle to decay in terms of λ.

c) What is the probability for a particle to "live" t >2λ?

d) Find the variance of this pdf in terms of λ.

6) Taylor, Problem 10.3, page 241.

7) Taylor, Problem 10.10, page 242.

8) In the 1650's the following question was discussed by Chevalier de Méré and Blaise Pascal (with Fermat acting as a consultant):

Which of the following is more likely?

a) In one throw of four dice to get at least one six.

b) In twenty four throws of two dice to get at least one double six.

Explain why you think a) or b) is correct.

(Although de Méré and Pascal were smart guys there is only one correct answer.)

9) Taylor, Problem 11.3, page 256.

10) A certain molecule always has a rectangular shape. However, the length of a side is equally likely to have any value between 0.5 and 1Å (1 angstrom $=10^{-10}$ m). For this molecule calculate:

a) the average area of a molecule.

b) the probability that the area of a molecule is ≥0.5 $Å^2$.