Richard Kass
Physics 416

Problem Set 4
Due May 10, 2007

1) The probability distribution function (*pdf*) as a function of radial distance (r) from the nucleus for an electron in the lowest energy level (n=1) state of a hydrogen atom is given by:

$p(r) = \frac{4}{a^3} r^2 e^{-2r/a}$ with a = constant (know which one ?)

a) Show that this is a properly normalized *pdf*.
b) What is the average radial distance (in terms of a) of the electron?
c) Calculate the probability for the electron to be found at $r \geq a$.

2) Assume we have the *pdf* from problem 1) and we have taken a bunch (n) of measurements of the position of the electron ($r_1, r_2, r_3, \ldots r_n$). We want to use the Maximum Likelihood Method to find the best value of a from our measurements.
a) Write down the likelihood function for this problem.
b) By maximizing the likelihood function (actually its log) find an expression for a in terms of the measurements (r's) and the number of measurements. How does your answer to this part compare with the answer from Problem 1b)?

3) Read the handout "The Art of Experimental Physics" and answer the following:
a) Describe the following physics processes in a few sentences:
   i) Compton Scattering
   ii) Photo electric effect
   iii) Pair production
b) Which of the radioactive sources used in lab5 emits a gamma ray(s) with enough energy for the pair production process? (In lab5 you will have Co60, Na22, and Cs137)
c) A student in P416 notices that their Co60 gamma ray spectrum contains a small peak at an energy of 2.505 MeV. What could cause such a peak?

4) Do exercise #1 in appendix B, P378, of the handout "The Art of Experimental Physics".

5) Do exercise #4 in appendix B, P384, of the handout "The Art of Experimental Physics".

6) Taylor P8.20, page 204 (hint: look at the example on page 190).

7) Taylor P12.7 page 280.