Physics 404
First Homework Assignment
Due Wednesday April 4

Choose any 4 of the following 6 problems. The students from Fresno who are going to CERN in the summer need to do the Relativistic Kinematics and the Root programming problems.

Problem 1 (3.38). Consider the ground state of the simple harmonic oscillator $|\psi_0>$. Find the momentum space function, $<p|\psi_0>$, for this state. What is the probability (to two significant figures) that a measurement of p on a particle in this state would yield a value outside of the classical range (for the same energy)?

Problem 2 (3.14).
a) Prove the following commutator identity:

$$[\hat{A}\hat{B}, \hat{C}] = \hat{A}[\hat{B}, \hat{C}] + [\hat{A}, \hat{C}]\hat{B} \tag{1}$$

b) Use this result to show:

$$[\hat{x}^n, \hat{p}] = i\hbar n\hat{x}^{n-1} \tag{2}$$

Problem 3. Show that if the state $|\psi>$ has the following properties:
$<x|\psi>=<\psi|x>$ and $lim_{x\to\infty} <x|\psi> \to 0$ then $<p>= 0$. Hint: you can solve the problem in coordinate space, and integrate by parts.

Problem 4. (6.1) Consider a particle trapped in a one dimensional infinite square well that goes from 0 to a. Suppose there is a delta-function bump in the center of the well:

$$H' = \alpha\delta(x - a/2) \tag{3}$$

where α is a constant. Find the first-order correction to the allowed energies. Explain why the energies are not perturbed for even n.

Root Programming Problem. Write a computer program in root that will plot the data in the data file "data1.txt". The file "data1.txt" can be downloaded from the homework page. Your graph should include error bars which are equal to the square root of the data value. The data are the counts recorded in a series of channels from

our high resolution gamma detector.

Relativistic Kinematics Problem. Suppose you have a beams of muons traveling along the x-axis all with the same speed. At $x = 0$ there are 1000. However at $x = 10000\ m$ there are on average only 500 left. How fast are the muons traveling? Note that the lifetime of a muon is $\tau = 2.2 \times 10^{-6}$ sec.