Physics 471 – Fall 2009

Homework #4, due Friday, October 2

1. [5] Griffiths problem 2.12. This problem, along with Example 2.5 in the book, shows you a clever and powerful way to calculate expectation values of x^n and p^n in harmonic oscillator states. I didn't have time to cover this material in class, but it is something I would like you to know.

2. [5] Griffiths problem 2.13. This problem has some similarities to problem 2.5, which you did last week. Here are some reminders or hints, and one correction:
   i) Do <u>not</u> do any integrals for parts (a) and (b)!
   ii) The sentence, "Don't get too excited if they oscillate at the classical frequency; what would it have been had I specified $\Psi_2(x)$ instead of $\Psi_1(x)$?" should be in part (b) of this problem rather than part (c).
   iii) In part (c), Once you have found <x>, use the shortcut to find <p>.
   iv) As you do this problem, remember to take full advantage of the fact that the different stationary states of the harmonic oscillator are orthogonal to each other.

3. [5] Griffiths problem 2.38. This problem demonstrates the "sudden approximation" in quantum mechanics. It says that, if the potential changes very suddenly (too quickly for the system to react), then the wavefunction instantaneously remains unchanged. Of course, if you allow time to pass after the potential change, then the wavefunction will evolve according to the Schroedinger equation with the new potential energy.

   Before you start this problem, draw a picture of $\Psi(x,0)$. Then just below that, draw pictures of the first 3 stationary states of the new square well of width 2a. Try to guess which c_n's will be the largest, before you do any integrals.

   Hint: To calculate the c_n's, use the trigonometric identity sin(x) sin(y) = ½ (cos(x-y) – cos(x+y)), but watch out for n=2. You'd better calculate c_2 separately from the others.

4. [5] Griffiths problem 2.22, parts (a) – (c) only.
   Prof. Moore did a more general version of this in class, but I'd like you to do the simpler version to make sure you understand it. What is the difference between this problem and the one I did in class? You may use results from the "Table of Integrals" we derived in class. To make sure you are on the right track in part (b), you should get $\Phi(k) = (2\pi a)^{-1/4}\exp\left(-k^2/4a\right)$.
   The most important part of this problem is the sketch of $|\Psi(x,t)|^2$ as a function of x, at t=0 and at some later time.