# Homework Set #2

**Problem 2.14** In the ground state of the harmonic oscillator, what is the probability (correct to three significant digits) of finding the particle outside the classically allowed region? *Hint:* Classically, the energy of an oscillator is $E = (1/2)\,ka^2 = (1/2)\,m\omega^2a^2$, where $a$ is the amplitude. So the "classically allowed region" for an oscillator of energy $E$ extends from $-\sqrt{2E/m\omega^2}$ to $+\sqrt{2E/m\omega^2}$. Look in a math table under "Normal Distribution" or "Error Function" for the numerical value of the integral, or evaluate it by computer.

***Problem 2.38** A particle of mass m is in the ground state of the infinite square well (Equation 2.19). Suddenly the well expands to twice its original size-the right wall moving from a to 2a-leaving the wave function (momentarily) undisturbed. The energy of the particle is now measured.

(a) What is the most probable result? What is the probability of getting that result?

(b) What is the next most probable result, and what is its probability?

( c) What is the expectation value of the energy? Hint: If you find yourself confronted with an infinite series, try another method.

$*$**Problem 2.5** A particle in the infinite square well has as its initial wave function an even mixture of the first two stationary states:

$$\Psi(x,0) = A[\psi_1(x) + \psi_2(x)].$$

**(a)** Normalize $\Psi(x,0)$. (That is, find $A$. This is very easy, if you exploit the orthonormality of $\psi_1$ and $\psi_2$. Recall that, having normalized $\Psi$ at $t = 0$, you can rest assured that it *stays* normalized—if you doubt this, check it explicitly after doing part (b).)

**(b)** Find $\Psi(x,t)$ and $|\Psi(x,t)|^2$. Express the latter as a sinusoidal function of time, as in Example 2.1. To simplify the result, let $\omega \equiv \pi^2\hbar/2ma^2$.

**(c)** Compute $\langle x\rangle$. Notice that it oscillates in time. What is the angular frequency of the oscillation? What is the amplitude of the oscillation? (If your amplitude is greater than $a/2$, go directly to jail.)

**(d)** Compute $\langle p\rangle$. (As Peter Lorre would say, "Do it ze *kveek* vay, Johnny!")

**(e)** If you measured the energy of this particle, what values might you get, and what is the probability of getting each of them? Find the expectation value of $H$. How does it compare with $E_1$ and $E_2$?