Problems

1- Determine the expectation value of the position and the momentum in the ground state of the quantum oscillator. Also determine the expectation value of the square of the position and the momentum in the ground state. Determine the numerical value of $\Delta x \Delta p$ for the ground state. What can you say about these same quantities for other energy states?

2- For the classical harmonic oscillator, the particle cannot go beyond the points where the total energy equals the potential energy. Identify these points for a quantum-mechanical harmonic oscillator in its ground state. Calculate the probability that the particle will go beyond these classically-allowed points.

3-Evaluate the average (expectation) values of potential energy and kinetic energy for the ground state of the harmonic oscillator. Comment on the relative magnitude of these two quantities.

4- For a quantum particle in a harmonic oscillator in 1D, at time $t = 0$, its state is given by

$$|\Psi\rangle = \frac{1}{\sqrt{2}}|0\rangle + \frac{1}{\sqrt{3}}|1\rangle + \frac{1}{\sqrt{6}}|2\rangle$$

(a) If the energy is measured, what values can be found and with what probabilities?

(b) Find the average value of the energy, <H>.

(c) Find the explicit forms of the basis functions for this expansion, and write the form of the wavefunction at time t .