University of California, Berkeley Physics

137A Spring 2011
MidTerm Exam II
Maximum score: 100 points

1. (50 points)

At time t=0 a particle in a harmonic oscillator potential $V(x)=\frac{1}{2}m\omega^2x^2$ has a wavefunction $|\psi(t=0)\rangle=|0\rangle+2|1\rangle$, where |0> and |1> are normalized ground and first excited states.

(a) Normalize $|\psi(t=0)\rangle$.

(b) How does the wavefunction evolve with time?

(c) What are the average position and momentum of the particle at t=0?

(d) How do the position and momentum expectation values of the particle change as a function of time?

2. (50 points)

Let's consider a linear molecule composed of three atoms. Quantum mechanically the electron can stay at one atom or tunneling between the adjacent ones. The Hamiltonian of the molecule is then described by

$$H=\begin{pmatrix} E_0 & -A & 0 \\ -A & E_0 & -A \\ 0 & -A & E_0 \end{pmatrix}.$$

(a) Find the eigenvalues of energy of the system, and the corresponding eigenvectors.

(b) If the electron stays at the first atom at t=0, i.e. $|\psi(t=0)\rangle=\begin{pmatrix}1\\0\\0\end{pmatrix}$. How will the wavefunction evolve as a function of time?