Problem set 5

1. Consider this setup:

$$\begin{matrix} \left\{\begin{matrix} + \\ 0\| \\ -\| \end{matrix}\right\} & \left\{\begin{matrix} +\| \\ 0 \\ - \end{matrix}\right\} & \left\{\begin{matrix} +\| \\ 0\| \\ - \end{matrix}\right\} \\ S & T & S' \end{matrix}$$

with T rotated relative to the two S's by $\pi/2$ about the common y-axis of the three apparati. (The S,T amplitudes can be figured out from the formulas in Chapter 5.) This problem is trickier than it appears at first. A little care and thought are required.
a) What fraction of the particles that make it through the first S make it through the T?
b) What fraction of the particles that make it through the first S make it through the second S?
c) What are the answers if the T apparatus is wide open?

2. Use the results for the "warm-up" U on pages 1 and 2 of the handout *Quantum Mechanics II.* Show that if the three φ angles are the same, but not necessarily zero, then the matix elements $\langle j \,|\, U \,|\, i\rangle$ of U are the same in the T basis as they are in the S basis.

3. Again using the "warm-up" example, suppose that $\varphi_0 = 0$, $\varphi_+ = \varphi$, and $\varphi_- = -\varphi$. Get the probabilities $P_{00} = |\langle 0\ T' \,|\, U \,|\, 0\ T\rangle|^2$ and $P_{0+} = |\langle 0\ T' \,|\, U \,|\, +\ T\rangle|^2$ as a function of φ and make a graph of each.

4. Suppose that in some basis, the Hamiltonian for a spin-1/2 (two-state system) has the matrix of amplitudes

$$H_{ij} = \begin{pmatrix} -E_0 & -A \\ -A & E_0 \end{pmatrix},$$

e.g. $H_{12} = -A$. What are the two energies in the definite-energy basis? What is the time dependence of each of these two definite-energy states? (Note you do *not* need to find the definite-energy states themselves to answer these questions.)

5. Suppose that in some basis, the Hamiltonian for a spin-1 (three-state system) has the matrix of amplitudes

$$H_{ij} = \begin{pmatrix} 0 & A & 0 \\ A & 0 & A \\ 0 & A & 0 \end{pmatrix},$$

e.g. $H_{12} = A$ and $H_{13} = 0$. What are the three energies in the definite-energy basis? What is the time dependence of each of these three definite-energy states? What physical situation might this describe? (Note you do *not* need to find the definite-energy states themselves to answer these questions.)