PHYS 3701 - Assignment #7
Due Wednesday April 1, 2015

1. Suppose the electron in a hydrogen atom occupies the combined spin and position state $|\psi\rangle = A\left[6|4\ \ 2\ \ -2\rangle\left|\frac{1}{2}\ \ \frac{1}{2}\right\rangle - 8|3\ 1\ 1\rangle\left|\frac{1}{2}\ \ -\frac{1}{2}\right\rangle\right]$

   a) Determine the normalization constant *A*. What energies might be measured for particles in this state and with what probabilities?

   b) What values of the total and z-component of orbital angular momentum might be measured and with what probabilities?

   c) What values of the total and z-component of spin angular momentum might be measured and with what probabilities?

   d) For the **ground state** of hydrogen determine $\langle \hat{r}^n \rangle$.

2. a) Construct the wave function for hydrogen in the state n=4, l=3, and m=3 in spherical coordinates.

   b) Calculate $\langle \hat{r} \rangle$.

   c) If you could measure the observable $\hat{L}_x^2 + \hat{L}_y^2$ on an atom in this state, what value(s) could you get and what is the probability of each?

3. A sping-1/2 particle with mass m and charge e is at rest in a constant magnetic field, B, oriented in the z-direction.

   a) Write down the Hamiltonian for this system and the most general vector, including time dependence, describing this system (i.e. solve for the energy eigenstates).

   b) At time t=0 you start in the state $A\begin{bmatrix}1\\-1\end{bmatrix}$. Normalize this state. At what later times are you definitely in this state again? What is the associated frequency? Hint: write this state as a linear combination of energy eigenstates etc.