Spring 2010

Physics 137B Section 1: Problem Set #8
Due: 5PM Friday April 9 in the appropriate dropbox inside 251 LeConte (the "reading room")

Suggested Reading for this Week:

- Bransden and Joachain (B& J) Sections 11.1 - 11.6 (Note: We did not cover the material in Section 11.1 that depends on knowledge of the vector potential $\vec{A}$. You therefore might find the treatment of this topic in Griffiths to be a better match to what we did in lecture. Also, we did not cover the section going from the bottom of page 531 through page 532)
- Although we covered B& J Section 12.3 on Wed March 31, problems on this section will be part of next week's homework.

Homework Problems:

1. B&J 11.1. The purpose of this problem is to show that the statement on page 516 of B&J that number of photons even in a weak electromagnetic field is very large, which means we can treat this number as a continuous rather than a discrete variable.
2. B&J 11.5
3. (modified version of B&J 11.7) B&J calculate on pages 530 to 531 the transition rate for spontaneous emission from the $2p$ to the $1s$ state of hydrogen. Use this result and the expressions in section 11.2 and 11.3 to calculate the rate of stimulated emission from the $2p$ to the $1s$ state of hydrogen contained in a large cavity at a temperature of 2000K.
4. B&J is *very* sloppy on page 537 in its use of the term *half-life*. The half-life of an excited state is defined as the time it would take for half the atoms in a large sample to decay. Using Equation 11.114, find a relationship between the half-life $t_{\frac{1}{2}}$ and τ.

5. (Griffiths problem 9.13) An electron in the $n = 3$, $\ell = 0$, $m = 0$ state of hydrogen decays by a sequence of electric dipole transitions to the ground state.

   (a) What decay routes are open to it? Specify them in the following way:

   $$|300\rangle \rightarrow |n\ell m\rangle \rightarrow ... \rightarrow |100\rangle$$

   (b) If you had a bottle full of atoms in this state, what fraction of them would decay via each route?

   (c) What is the lifetime of this state? Hint: Once it's made the first transition, it is no longer in the $|300\rangle$ state so only the *first* step in each sequence is relevant in computing the lifetime. When there is more than one decay route open, the transition *rates* add.