EEE 6503 Laser Theory
Homework 1
Due Date: 5 October 2019

1. Make a table with 3 columns for a photon wavelength, frequency, and energy (joules). The following is the entry for one of the columns for a given row:
   a. 95 MHz
   b. 2.5 GHz
   c. 300 μm
   d. 16 μm
   e. 5500 Å
   f. 1250 Å
   Fill in the other columns.

2. Using the energy levels for a Hydrogen atom, what is the level *n* that would yield a 4 GHz photon frequency for emission to the level $n-1$?

3. What energy, frequency, and wavelength would a photon have if its energy $= kT$, where $T = 77\,\text{K}$, $T = 4\,\text{K}$, and $T = 1000\,\text{K}$?

4. Suppose you have a large collection of atoms in thermal equilibrium. Use Boltzmann statistics to find the ratio of N_2 / N_1 if N_2 is the number of atoms in state 2 and 1 is the ground state level. Find N_2 / N_1 at 300 K when the energy difference $E_2 - E_1$ is:

   a. 1.2 Electron Volts,

   b. An energy difference that would give a photon wavelength $= 14$ μm,

   c. An energy difference that would give a photon wavelength $= 6000$ Å.

5. Consider a Nd:YAG laser (λ = 1.06 microns). Suppose due to pumping it initially has an upper laser level that is almost fully inverted i.e. $N_2 = 1\times10^{16}\,\text{Nd}^{3+}$ ions in state 2 per cm^3. Thus the lower level (state 1) is almost empty $(N_1 \approx 0)$. If a fast electro-optic switch suddenly turns the laser on, a short intense pulse is emitted via stimulated emission. In this process the ions lose energy (go from state 2 to state 1) and with a final result that $N_2 = N_1$. If the Nd laser rod has a length = 50 mm, and diameter = 5 mm, and assuming the pulse is rectangular in time (i.e. has a constant intensity for the duration of the pulse) and has a duration of 1 nsec:

   a. What is the total emitted energy in this laser pulse?

   b. What is the total emitted power in this laser pulse?