Final Exam
ECE 4300
Fall 2014

You have 2 hours to complete this exam, attempt all problems.

Part 1: Yes/No questions (3 pts each)

(For questions 1-5, consider this scenario: I take you in the lab where an infrared laser is traveling through free space, and I tell you that at a particular point along the beam the q parameter is q=10+j45. No further measurements are made.)

1. (Y N) Can you tell me the q-parameter of the beam everywhere else along the beam path?
2. (Y N) Can you tell me the exact size, in microns, of the beam?
3. (Y N) Can you tell me the exact curvature of the phase front if I move 1 meter away from that point?
4. (Y N) Can you tell me if the beam travelling in a TEM_{00} mode?
5. (Y N) Can you tell me how much power is in the beam?

(The following questions do not depend on a particular situation, they are general questions)

6. (Y N) In a particular laser cavity, is it possible for a TEM_{00q} mode and a $TEM_{nm(q+1)}$ mode to have the same frequency?
7. (Y N) In an operating laser, it is possible for the gain to ever saturate below the threshold inversion, N_{th}?
8. (Y N) Does the lineshape function, $g(\nu)$, describes the probability that a photon will be emitted or absorbed at that particular frequency, ν?
9. (Y N) Is the absorption cross section that describes the pumping process in a 4 level laser identical to the emission cross section that describes the laser transition?
10. (Y N) Is the A-coefficient always equal to $1/\tau$, where τ is the measured spontaneous emission lifetime of a transition?

Part 2: Short answer questions (6 pts each)

1. What is the difference between Q-switching, Gain switching, and Mode locking?

2. Does a semiconductor laser have inhomogeneous broadening? Explain your answer.

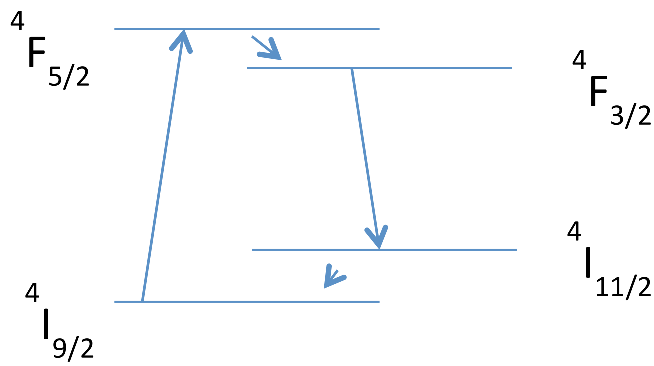
3. A candle gives off light when microscopic particles of soot leave the wick and get very hot, emitting a bright light die to their high temperature. If you put a candle between two mirrors, could you make a "candle laser"?

4. A particular laser beam does not transmit through a window made of Germanium (bandgap 0.7 eV) but it does travel through a window made of Silicon (bandgap 1.1 eV). What can you tell me about the wavelength of the beam?

5. We were told that a plane parallel cavity was marginally unstable, meaning that any deviation from perfect normal would mean a ray leaves the cavity. Yet we were also told that semiconductor lasers typically are made with cleaved facets that act like plane parallel mirrors. Why does a semiconductor laser operate with this marginal cavity?

Part 3. Problems involving calculation

1. A simplified energy level diagram for the Nd:YAG laser is shown below



a. Is this a 2, 3, or 4 level laser?
b. Which levels are involved in pumping the laser?
c. Identify any transitions that are non-radiative in this system
d. The branching ration for the $^4F_{3/2}$ → $^4I_{11/2}$ transition is 0.135. The lifetime of the $^4F_{3/2}$ state is 230 usec. What is the A-coefficient for the transition?
e. The lifetime of the lower $^4I_{11/2}$ state is 12 psec. If the transition is lifetime broadened, what is the lineshape half-width ($\Delta\nu_{1/2}$) for the $^4F_{3/2}$ → $^4I_{11/2}$ transition?

A fiber amplifier is made with an inversion as plotted blow. The first meter of fiber has an inversion of $N_2=10^{18}$ cm^{-3} and the second meter has an inversion of $N_2 = 5x\ 10^{17}$. Sigma= $6\ x10^{-20}$ cm^2. For this medium, the saturation intensity is I_{sat} = 1000 W/cm^2.

What is the small signal gain for this amplifier?

If the input intensity is 1000 W/cm^2, what is the output intensity for this amplifier? I do not need an exact number, but would like a n approximate figure. Outline the steps to find this gain.

Repeat the question above for light entering the other direction. Wat is the gain if the beam with intensity 1000 W/cm^2 enters the amplifier at the 2m point and propagates toward zero?