

Physics 168: Study Guide for Midterm #1:

The test is closed-book. You may bring one or two 8.5x11 pieces of paper with notes and equations. Also, you will need a calculator.

Sections and Concepts covered:

Basic Concepts (Chapter 1) Key components of a laser, properties of lasers, Quantum aspect of light, general concept of stimulated emission, energy levels, 3- and 4- level lasers, general concept of how lasers work. Index of refraction, conversion of frequency/wavelength/photon energy; diffraction angles. Thermal equilibrium calculations, for a given temperature.

Light-Atom Interaction: Use and calculation of spontaneous emission coefficient (A), Line Shapes $g(\nu)$, Cross section (very important!), gain coefficient, broadening (lifetime, collisional, Doppler). Be able to use the fact that the area under the line shape curve is 1 to solve for the peak value of $g(\nu)$. Know how to convert A coefficients to lifetimes, and how to combine multiple decay possibilities into a total lifetime, and vice-versa.

Be able to set up the rate equations, even if photons are participating in a transition. Be able to solve a system of equations for steady-state populations, and determine where (and if) there is a usable population inversion that can amplify light.

Key equations that are hard to find in the book:

$$\sigma = \frac{A\lambda^2 g(\nu_0)}{8\pi n^2} ; g(\nu - \nu_0)_{Lifetime} = \frac{1}{2\pi} \frac{\Delta\nu}{(\nu - \nu_0)^2 + (\Delta\nu/2)^2} ; F \cong \frac{2\pi}{1-S} ; \Delta\nu_{FSR} = \frac{1}{\tau_{rt}}$$

Cavities: The most important aspects are the ABCD matrices (be sure to have the basic matrixes on your cheat sheet), and how to use the roundtrip matrix to test cavity stability. Know the special case for a 2-mirror cavity very well. Understand concepts such as Finesse, free spectral range, roundtrip time, survivability, width of cavity modes, and understand what a Fabry-Perot cavity does. Also be able to use a ABCD matrix to translate any ray through any optical element, seeing how slope, distance from axis, and Radius of curvature change in the process.

As always, budget your time wisely (don't spend the first half of the test on one problem!), show your work for partial credit, and don't be expecting problems that you can simply plug in numbers into the equations on your sheet -- make sure you understand the concepts well enough to use them in an unfamiliar context.