# ECE 4300, Fall Semester 2016
# Lasers and Optoelectronics

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# Prelim Exam 2

Please give answers in analytical formulae before plugging in numerical values. You have 50 minutes, use them wisely. Present your solutions *neatly*. Show the relevant steps, so that partial points can be awarded. BOX your final answers where applicable. Draw figures wherever necessary. Write your name, email address on the cover of your workbook.

**Problem 1 (Spontaneous vs. Stimulated Emission)**

By direct measurements, I find that the rate of stimulated emission from a blackbody is *equal* to the rate of spontaneous emission at the specific wavelength $\lambda_0$. What is the temperature of the blackbody?

**Problem 2 (Measuring the Internal Loss of a Laser)**

To estimate the internal loss coefficient $\alpha$ in a high-power diode-pumped laser of cavity length $d = 100$ cm (where $d = l_g$, the entire cavity is the gain medium), the threshold pump power $P_{th}$ was measured using two different output couplers with reflectivities $R_2 = 90\%$ and $R_2^{'} = 95\%$. The other cavity mirror has a $R_1$ =100% reflectivity at the laser wavelength. If the threshold powers measured respectively are $P_{th} = 1$W and $P_{th}^{'} = 0.6$ W, find an analytical expression for the loss coefficient $\alpha$ in terms of the expressions provided. Then find a numerical value.

**Problem 3 (Photon Lifetime and Population Inversion in a Laser Cavity)**

A Nd:YAG ring laser of total length $d = 10$ cm has a $l_g = 1$ cm long gain medium of refractive index $n = 1.82$ inside a 3-mirror optical resonator with reflectivities $R_1 = 0.95$, $R_2 = 1$ and $R_3 = 0.98$. Neglect internal cavity losses, and assume a stimulated emission cross section $\sigma = 2.8 \times 10^{-19}$ cm$^2$ at the center frequency. Calculate the following analytically first, before finding the numerical values:

(a) the photon lifetime when there is no pumping,

(b) the photon lifetime when pumping rate is *half* the lasing threshold, and

(c) the population inversion needed to reach lasing threshold.