ECE 4300, Fall Semester 2016
Lasers and Optoelectronics

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Prelim Exam 1

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 (Short answer)

How is the ABCD law applied to describe Gaussian Beams in an optical cavity, and what parameters of the laser beam do we obtain by applying the law?

Problem 2 (Stable Cavities)

A graduate student is instructed by her advisor to align a laser with a confocal resonator using two mirrors of nominal radius of curvature $R = 200$ mm. Unfortunately, due to manufacturing errors, the radii of curvature of the two mirrors are $R_1 = R+\Delta R$ and $R_2 = R-\Delta R$, with $\Delta R = 3$ mm. After spending long nights unsuccessfully in the lab trying to obtain laser oscillation with the cavity length at the nominal confocal distance $d = 200$ mm, she found that the laser works if the two mirrors are moved either slightly closer, or slightly farther than the nominal confocal position. Explain this result and find the mirror spacings at which the laser starts working.

Problem 3 (Laser beam to the Moon)

When Apollo 11 landed on the moon, the astronauts deployed a retro-reflector so that a laser on earth could be used to measure the range between the earth and moon precisely. The distance from the earth to the moon is $z = 384403$ km. Assuming they used a ruby laser with $\lambda = 694$ nm, how big was the laser spot on the moon if:

a) the laser had a $\omega_0 = 2$ cm beam diameter on the earth?

b) the laser beam was sent through a telescope that expanded the beam diameter to $\omega_0 = 2$ meters?

c) Eyes can be damaged by optical powers in excess of 10 W/cm^2. If a 10 MW (yes, Megawatt) laser intensity was used for the probing in the TEM$_{0,0}$ mode which has an intensity distribution $I(r) = I_0 e^{-2\frac{r^2}{\omega^2}}$, were the astronauts in danger with either probe beam? [You may need $\int_0^\infty dx \cdot x \cdot e^{-2\frac{x^2}{a^2}} = \frac{a^2}{4}$.]