PHGN 480: Laser Physics due 4 Nov 2013
Homework 5

1) Pump laser optics: a Ti:sapphire laser is pumped with a collimated green laser beam (532nm, diameter d=2mm) and lases at 800nm. To get good pump overlap with the laser mode, the pump beam is focused through the curved dielectric mirror that is near the laser crystal. This curved optic is coated to reflect 100% at 800nm, but is transparent at 532nm. Therefore it acts like a negative lens for the pump beam. The substrate has a refractive index of 1.5.

   a. If the curved mirror radius of curvature is 100mm, and the pump lens focal length is 75mm, determine the distance the lens must be from the curved mirror to place the geometric pump beam focus at the focal point of the curved mirror. Treat both optics as "thin". You can solve this either with ABCD or the imaging equation.

   b. What is the f-number of the final beam focus? (f-number = dist to focus/beam diameter). If we now treat the beam as a Gaussian laser beam ($d = 1/e^2$ diameter), what would the diffraction-limited focal spot diameter be?

2) A CW laser beam has a Gaussian intensity profile $I(r) = I_{pk} \exp\left(-2r^2 / w_0^2\right)$.
   a. Calculate an expression for the power in the beam, in terms of I_{pk} and w_0.

   b. Suppose we set up a 1W laser beam ($\lambda = 514nm$) here in Golden to signal to a team at DIA airport 35 miles away. To get the minimum spread in the beam, we would have a slight focus to put the beam waist at half of the distance. What is the smallest initial beam size that we can use under this condition?

   c. What is the intensity of the beam at the target?

3) *Working with Gaussian beams.*
   a. Suppose you know the complex q beam parameter at a given position. Derive expressions for the location and size of the beam waist from the q parameter.
   b. A Gaussian laser beam is focused with a lens (focal length f) from air into a dielectric sample (refractive index n) at normal incidence to the flat interface. The distance from the lens to the interface is less than the lens focal length. What is the spot size of the focused beam waist, and how does it compare to the spot size that would be obtained by focusing in air?

4) Svelto problem 5.3. You may find Problem 5.2 useful as a guide (solutions to 5.2 are in the back of the book.

5) We have a laser resonator with a flat output coupler and a concave high reflector. If the gain medium is 3mm in diameter and placed close to the high reflector, what cavity length best fills the gain medium? Aim for a 1/e2 beam diameter at the high reflector of 2.5mm.