Laser Physics I (PHY 464)

Final Exam, Closed Book, Two CheatSheet, Time: 5:30-7:30
FALL 2001

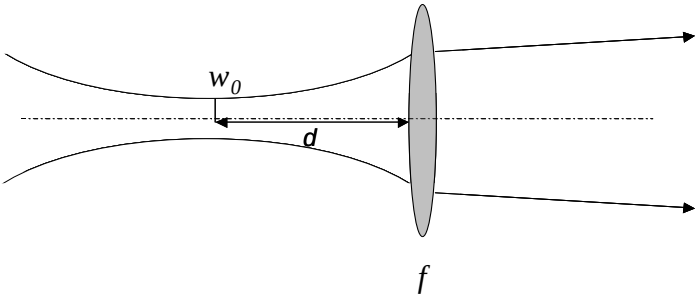
NAME ....
last *first*

grade

Happy Holidays!

Please staple and return these pages with your exam.

1. A laser beam (λ=1 μm) is focused to a spot size w_0=*100 μm.* You are given a thin lens of focal length *f*=10 cm. F*ind* the positions (d) of the lens from the minimum spot size that makes the beam "collimated". (15 points)



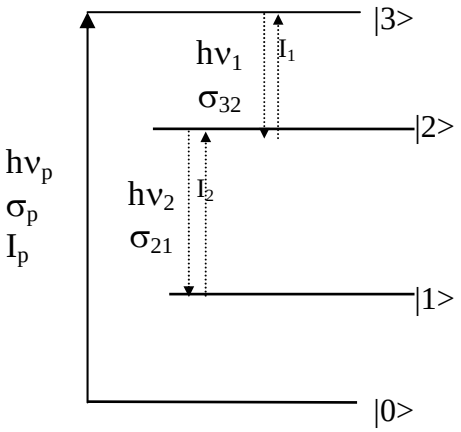
f

Lens Transformation of a Gaussian beam:

$$\frac{1}{R_{out}} = \frac{1}{R_{in}} - \frac{1}{f}$$

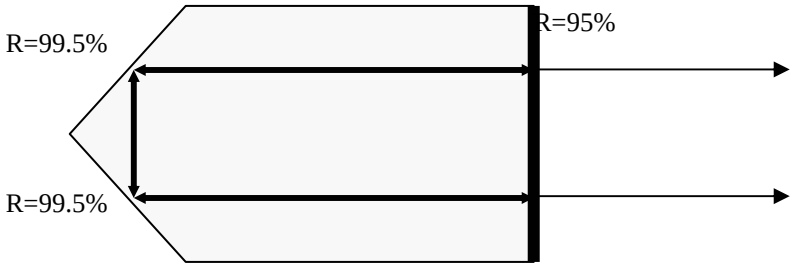
2. Write down the general rate equations for the four-level system shown below. The excitation is from 0-to-3 with a pump laser ($h\nu_p$) while the gain can be formed simultaneously at two wavelengths associated with levels 3-to-2 at $h\nu_1$ and 2-to-1 at hν2. The total concentration of atoms is N_t**.** *Assume all possible recombination (decay) routes.*

(15 pts.)



3. Consider the "Monolithic Cavity" solid-state laser (shown below) where the gain medium and the cavity (formed by two total internal reflections at the corner and two normal reflections) are one monolithic unit. The following data are known about this system:

-Geometric length of the cavity (= length of the gain medium) L= 2 cm.
-Refractive index $n=n_g=1.5$, Wavelength $\lambda=1\ \mu m$
-Gain cross section $\sigma=10^{-16}\ cm^2$
-Upper-state lifetime $\tau_2=1$ ms, Lower-state lifetime $\tau_1\approx 0$
-Homogeneous linewidth $\Delta\lambda=20$ nm.
-Scattering loss in the gain medium is characterized by an effective absorption $\alpha_s=0.025\ cm^{-1.}$
-Beam area (uniform across the cavity) $A=2\ mm^2$



a. What is the threshold upper state population (N_2^{th})? (15 pts.)

b. What is the total average output power at $N_2^0/N_2^{th}=5$ (15 pts.)

c. If modelocked, *estimate* the shortest (transform limited) pulsewidth Δt_p. (5 pts.)

d. If modelocked, *estimate* the peak power from each port $N_2^0/N_2^{th}=5$ (10 pts.)

e. If modelocked, draw the output pulse train for each port (quantify the time axis only). (5 pts.)

Assume high-Q cavity.

4. *Briefly* yet *clearly* (in less than 30 words, and mostly using drawings) answer ONLY 2 out of the following 4 questions. Each question is worth 10 points.

(a). Explain the mechanism, main features and operation of a Q-switched laser?

(b) Explain the main features and operation of a typical discharge-excited CO_2 laser.

(c) Describe Kerr-Lens Modelocking.

(d) Explain the main features and operation of a semiconductor diode laser.