Laser Physics I (PHYC/ECE 464)
FALL 2006

Final Exam, Closed Book, Closed Notes

Time: 5:30 – 7:30

OPTICAL SCIENCE & ENGINEERING
University of New Mexico

NAME ....
last *first*

grade

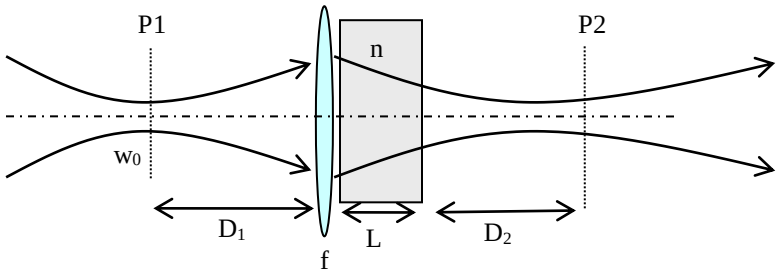
Total= 100 points

Please staple and return these pages with your exam.

1. A Gaussian laser beam (wavelength λ_0) has a beam waist w_0 at plane P1 (see Fig. below).

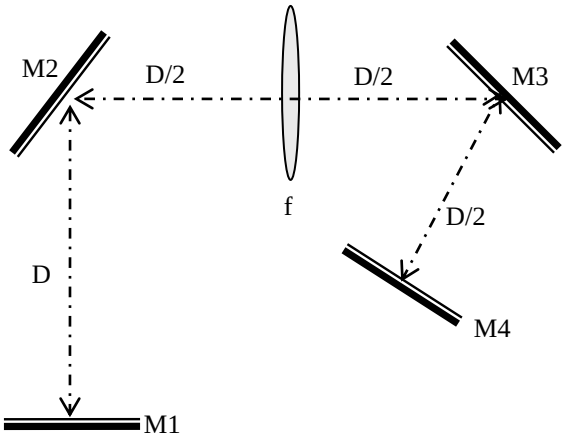
(a) Write down the "matrix product" corresponding to the propagation from P1 to P2. (DO NOT multiply the matrices). *8 points*

(b) Assuming the ABCD matrix from P1-P2 (in part a) is known, what is the beam radius (w) and radius of curvature (R) at P2 in terms of the known parameters (A,B,C,D, λ_0,w_0). *8 points*

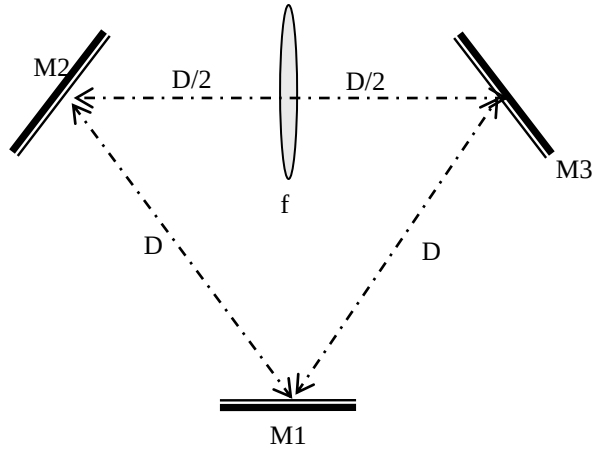


2. Locate the minimum beam waist(s) of the stable cavities shown below (explain your answers; Hint: use only geometrical and symmetry arguments):

(a) *7 points*

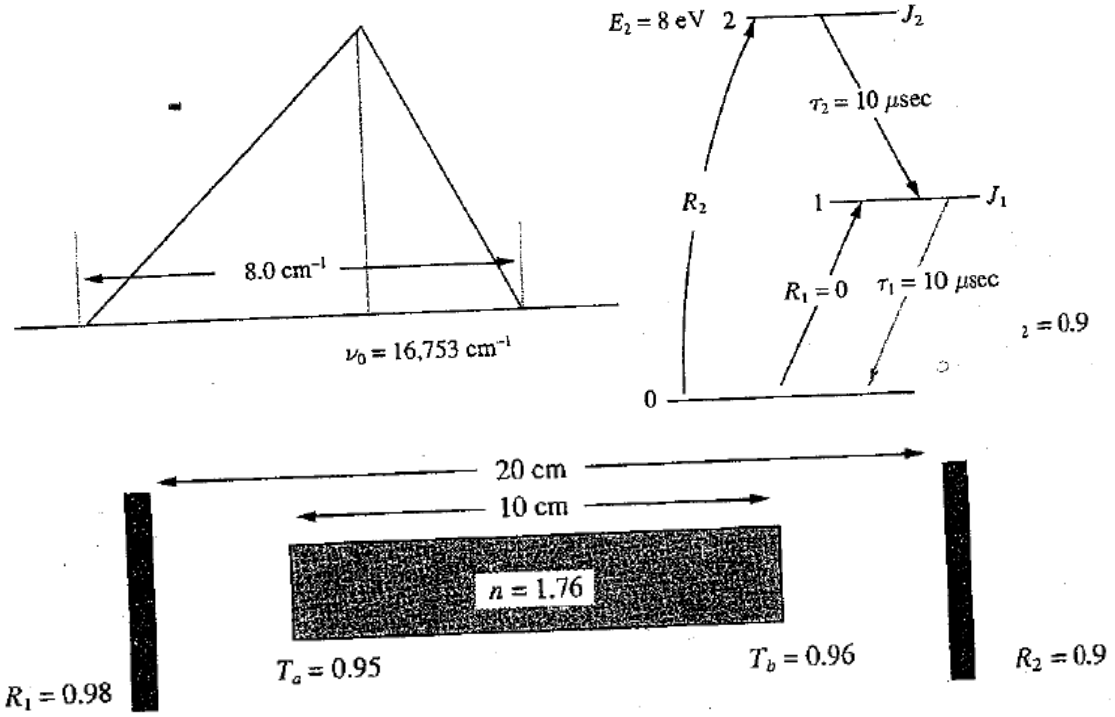


(b) Ring Cavity, 7 *points*



3. (a HW problem) The following parameters describe the laser system shown below: The spontaneous emission profile can be approximated by the triangular shape shown, only state 2 is pumped at a rate of R($cm^{-3}sec^{-1}$); state 2 decays to 1 by radiation and by collision with lifetime of 10 μs, which is also the lifetime for state 1; the Einstein coefficient for the 2 → 1 transition is $5xl0^4$ sec^{-1}; $J_2 = 1$ and $J_1 = 2$; and the active media has an index of refraction of 1.76.

(a) What is the quantum efficiency of this laser system? 4 *points*
(b) What is the stimulated emission cross section (at line center)? 4 *points*
(c) Write down the rate equations for this system. *10 points*
(d) What is the minimum pumping power (per unit of volume) required to bring the laser to threshold in the cavity shown below? Assume steady state. *15 points*



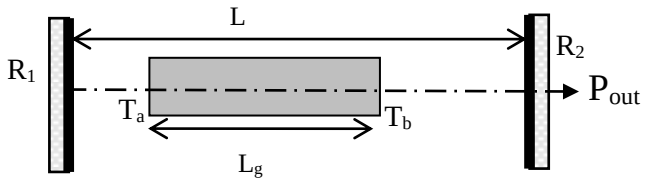
4. For the laser shown below the following parameters are known:
The emission cross section σ, upper state lifetime τ_2, homogeneous broadening $\Delta\nu$, wavelength λ, cavity length L, gain medium length L_g , and its refractive and group indices (n and n_g) at λ, beam area **A**, reflectivities R_1 , R_2 , transmissions T_a, and T_b.

(a) What is the cw output power (in terms of the known parameters) if the laser is pumped at **M** times above threshold. Assume high-Q approximation. 8 *points*

(b) If the laser is modelocked, describe (draw) the ideal (bandwidth limited) pulse train and identify the pulse width and repletion rate. *6 points*

(c) Write down the expression for peak power when modelocked and pumped at **M** times above the threshold. *4 points*

(d) Briefly discuss the need and method for group velocity dispersion compensation. 4 *points*



5. *Briefly* yet *clearly* (in less than 30 words, and using drawings where needed) answer only **2** of the following **3** questions. (15 pts.)

(a) Explain the basic operation of a semiconductor laser diode.

(b) Describe Q-switching of a laser. Give an example of Q-switching technique and explain the pulse shape.

(c) Describe the operation of another specific laser of your choice (gas, solid-state, dye)