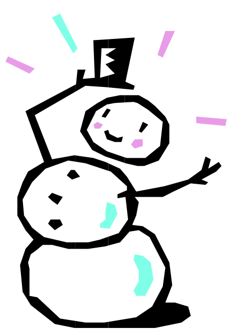
Laser Physics I (PHY/EECE 464)

Final Exam, Closed Book, Two CheatSheet, Time: 5:30-7:30
FALL 2003

NAME ....
last *first*

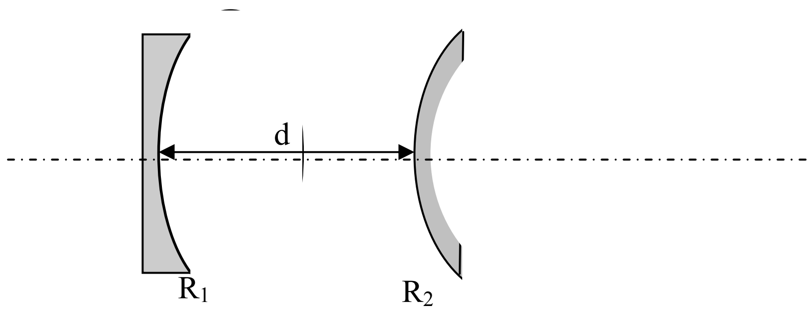
grade



Happy Holidays!

Please staple and return these pages with your exam.

1. Consider the cavity shown below consisting of two curved mirror separated by a distance d. Assume R_1= -R_2= 50 cm, and λ=1 μm.



a) Find the range (d_1<d<d_2) for which the cavity is stable. (5 points)

b) Choose d=30 cm and find the location and magnitude of the minimum spot size for λ=1 μm. Qualitatively indicate your answer on the above diagram as well. (10 points).

c) Derive an expression for the resonant frequencies ($\nu_{q,m,p}$) corresponding to TEM_{mp} for this cavity (q, here, is the longitudinal mode index). Calculate $\Delta\nu=|\nu_{q,0,0}-\nu_{q,1,1}|$. (10 points)

d) An external laser beam is to be coupled (matched) into this cavity. This is done by matching the **q**-parameter (i.e. spot size and curvature) of the incident beam with that of the cavity. If the incident beam is coupled from the left (i.e. mirror 1), what should be the incident beam spot size (w) and curvature (R) at the flat surface of mirror 1. (Assume thin mirror substrates with index n=1.5). (10 points).

2. Consider the following *unidirectional* ring laser. The following parameters are known for the *homogeneously* broadened gain medium:

$\Delta\nu \cong 1\times 10^{13}$ Hz , Gain cross section: $\sigma(\nu_0)=2\text{x}10^{-17}$ cm^2 , $\lambda_0=1$ μm.
Upper state lifetime ≈1 μs, spot size (w) inside the gain medium =100 μm (Gaussian beam) n(gain medium)=1.5. Cavity parameters are given in the Fig. A.

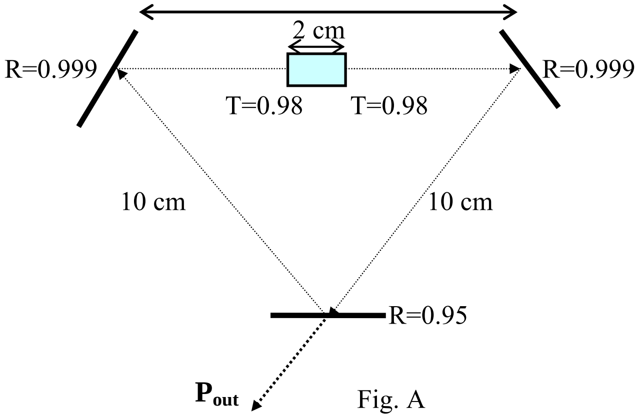


Fig. A

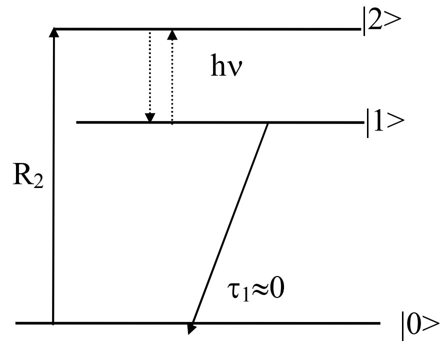


Fig. B

(a) What is the threshold upper state population (N_2^{th})? *(5 pts.)*

(b) What is the cw output power if this laser were to be pumped ×6 above the threshold? *(10 pts.)*

(c) Estimate the *minimum* excitation power required to sustain the output power in (b). Assume that the lower laser state (level 1 in Fig. B) is 3 eV above the ground state. (10 points)

(d) If this laser were to be cw-modelocked, quantitatively describe (and graph) the temporal behavior of the output pulse-train. Assume the shortest possible pulse and ignore dispersion. Estimate the number of longitudinal modes that are oscillating. Estimate the peak output power if pumped at ×6 above the threshold. *(10 pts.)*

(e) If this laser were to be Q-switched, estimate the pulse width. (5 points)

(f) What is the spontaneous lifetime of the gain medium? (5 points)

3. ***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) In a CW laser, why does the gain saturate at slightly below the loss level? What fundamental limitation does this process impose on the output characteristic of the laser?

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

(c) Describe both active and passive modelocking and give examples for each technique.

(d) Explain the main features and operation of an excimer laser.

Total= 100 points