



Laser Physics I (PHYC/ECE 464)
FALL 2012

Final Exam, Closed Book, Closed Notes

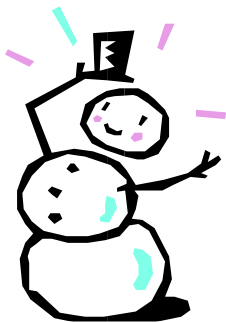
Dec. 12, 2012
Time: 5:30 – 7:30 pm

NAME
last *first*

Score

Total= 100+5 points

Please staple and return these pages with your exam.

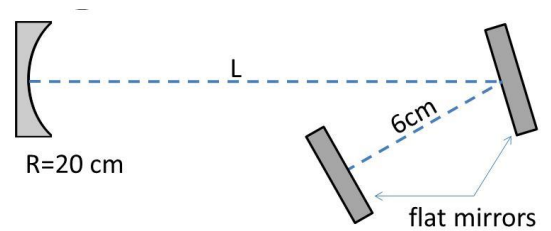


Happy Holidays!
Happy Holidays!

Instructor: M. Sheik-Bahae

1. (25 points)

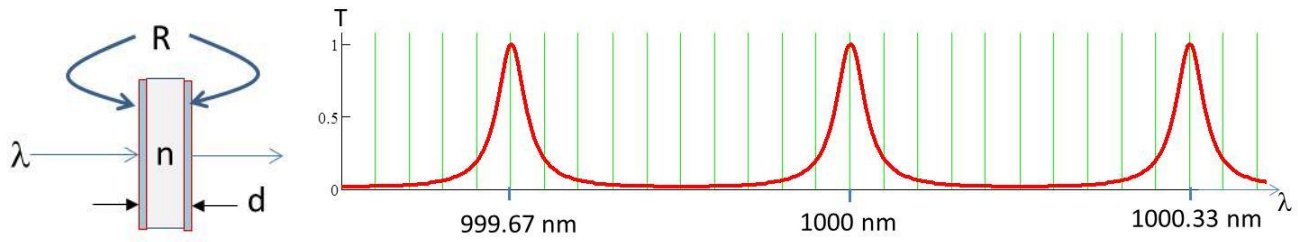
a. Using the method of matching phase fronts (beam curvatures), find Z_0 in terms of L . (10 points)



b. Use the results in (a) to obtain the range of L for which the cavity is stable. (5 points)

c. Choose L so that the beam area at the folding flat mirror is twice the area of beam at the end flat mirror. What is the location and magnitude of the minimum spot size for $\lambda = 1 \text{ }\mu\text{m}$. (10 points)

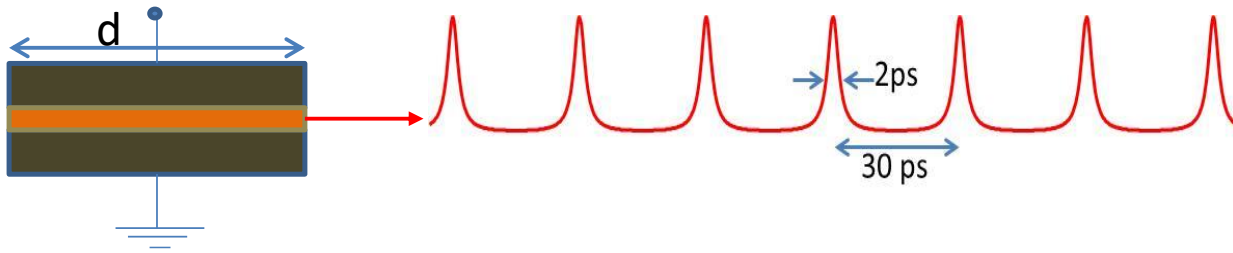
2. (15 points) Drawn to scale on the graph below is the relative power transmission of a tunable light source through a Fabry-Perot etalon as the wavelength is varied. The etalon is made from of glass having index $n=1.515$ and thickness d with both sides mirrored with reflectivity R .



a. What is d ? (8 points)

b. What is the reflectivity R ? (7 points)

3. (30 points) An edge-emitting diode laser is mode-locked (e.g. by gain modulation), outputting a pulse train consisting of 2ps (bandwidth limited) pulses separated by 30 ps (as shown). The refractive index of the gain medium is $n=4$.



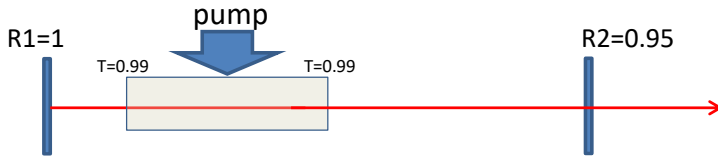
(a) What is the length (d) of the diode laser? (5 points)

(b) Qualitatively graph the power spectrum of the pulse train indicating the number of longitudinal modes that are lasing. (Be quantitative for the frequency axis). (12 points)

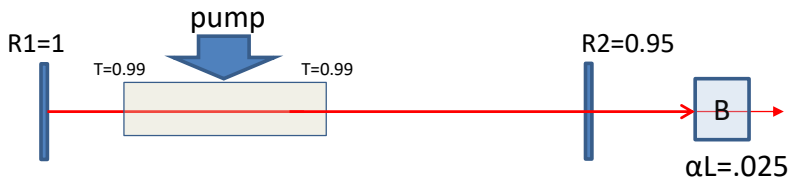
(c) The output of this laser is pigtailed to an optical fiber having $\beta_2 \sim 100 \text{ ps}^2/\text{km}$. Describe (qualitatively draw) the pulse train after propagating through 100 m of this fiber. (13 points)

4. (30 points)

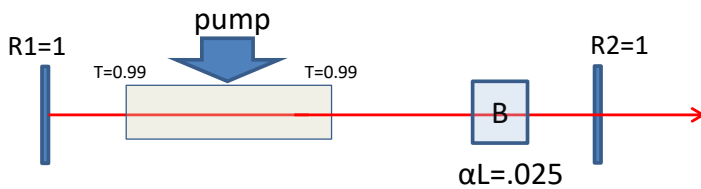
(a) Calculate the integrated threshold gain ($g_{th}=\gamma_{th}L_g$) for the system below. (5 points)



(b) For $g_0=5g_{th}$, calculate the *output power* (under proper approximation), and the *power absorbed in the cell B* having an absorbance ($\alpha \times L$) of 0.025. Assume homogeneously broadened gain with saturation power $P_s=3W$. (10 points)



(c) The absorber cell B is now placed inside the cavity, and mirror 2 is replaced with one having $R2=1$. What is the new threshold? If pumped 5x above the threshold, what is the absorbed power in cell B? (15 points)



5. Bonus Problem: (5 points) Given that the gain cross section $\sigma_{21}(\nu)$ of a transition is fully known, show that the spontaneous lifetime τ_{sp} can be obtained by:

$$\tau_{sp} = \frac{K}{\int \sigma_{21}(\nu) d\nu}$$

What is K?