Laser Physics I (PHYC/ECE 464)

FALL 2021

Midterm Exam, Closed Book, Closed Notes

Time: 4:00 – 6:00 pm

NAME ....
last *first*

Score

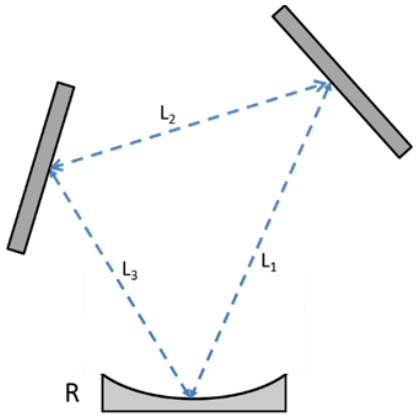
Total= 100 points

Please staple and return these pages with your exam.

Instructor: M. Sheik-Bahae

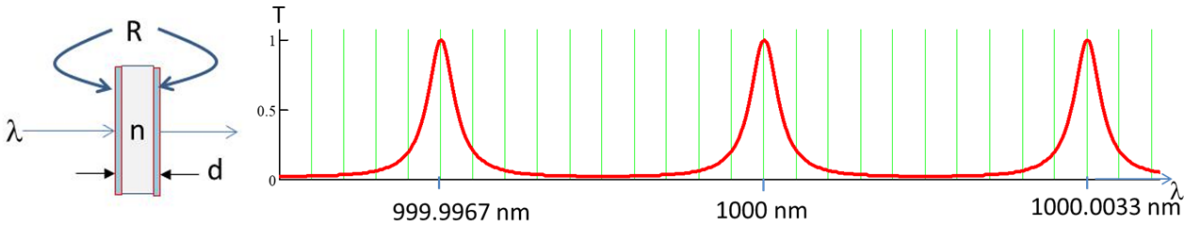
1. *(25 points)*

(a) Using the ABCD matrix for a roundtrip, derive the stability condition for the ring cavity above in terms of of d/R (with $d=L_1+L_2+L_3$) (ignore astigmatism). *(13pts.)*



(b) Obtain the ***position*** and the ***magnitude*** of the minimum beam waist w_0 assuming a wavelength λ. *(12pts.)*

2. ***(25 points)*** Drawn to scale on the graph below is the relative power transmission of a tunable light source at normal incidence through a Fabry-Perot etalon as the wavelength λ is varied. The etalon is made from of glass having index n=1.515 and thickness d with both sides mirrored with reflectivity *R*.

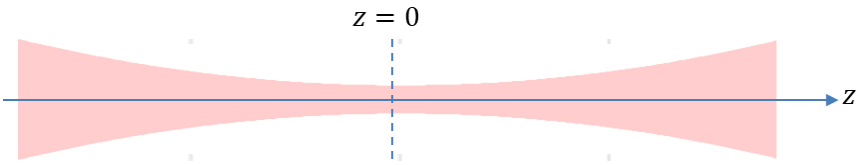


a. What is *d*? (8 points)

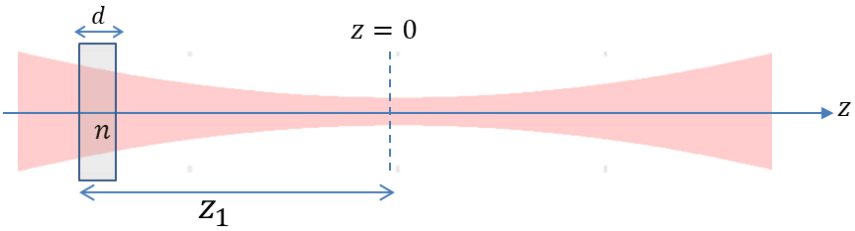
b. What is the *estimated* *Finesse* and the reflectivity *R*? (7 points)

c. Draw (on top of the above graph) the transmission for the case where *R* is purely due to the Fresnel reflectivities at normal incidence (i.e. no coating). What is the *finesse* and the *minimum transmission* in this case? (10 points)

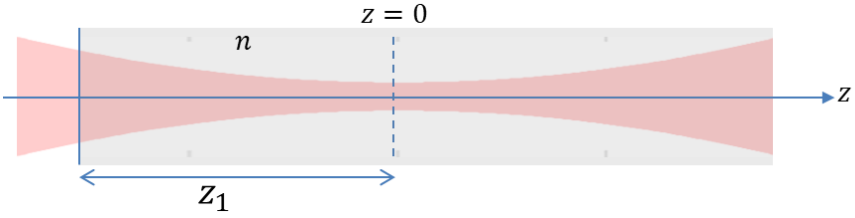
3. ***(25 points)*** Consider a fundamental Gaussian beam with known Z_0 and wavelength λ_0 travelling from *left to right*, as shown below.



(a) A glass window of thickness d and index of refraction n is inserted at a distance z_1 prior to z=0 (focus) plane as shown. Derive the distance ***(Δz)*** and the direction (*sign*) by which the new focal point shifts. What is the new z_0 (does it change at all)?



(b) Repeat part **(a)** for the case when the original Gaussian beam enters a material of index n with infinite thickness- as shown below.



4. (25 points) A two-level medium solid-state laser with the following property:

- *Spontaneous emission lifetime:* $\tau_{sp}=1$ *ms*
- *Homogeneous linewidth* $\Delta\nu_h=1.0$ *THz*
- *Line center wavelength:* $\lambda_0= 1\ \mu m$
- *Density of active ions (concentration):* $N_{total}= 2\times10^{19}\ cm^{-3}$
- *Non-degeneracy factors:* $g_1=8, g_2=6$

(a) What is the absorption coefficient $\alpha(cm^{-1})$ at the line center (1 μm) when all the molecules are in their ground state (level 1)? (15 points)

(b) What fraction of the molecules needs to be excited into level 2 in order to make this gas transparent (i.e. the onset of gain) at 1 μm? (10 points)