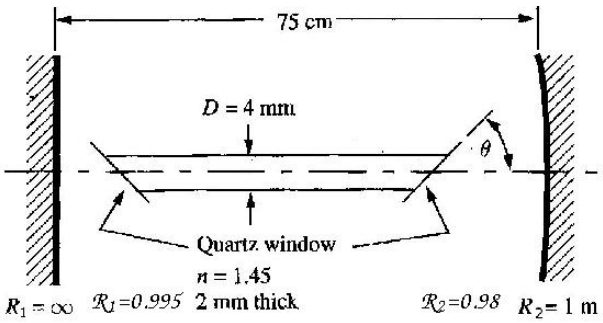
HW 8 due 11/15/2017

1) Exercise 10.2-2 (page 384 of the text book) (1st Ed. exercise 9.2-2 page 333) (10 points)

2) Exercise 10.2-3 (page 386 of the text book) (1st Ed. exercise 9.2-3 page 336) (10 points)

3) Problem 10.2-11 (page 401 of the text book) (1st Ed. problem 9.2-7 page 341) (10 points)



4) Consider the diagram of a cavity designed to be utilized with a HeNe laser at $\lambda_o = 632.8nm$.

a) Is the cavity stable?
b) What is the spot size of the beam at the flat mirror?
c) What is the spot size of the beam at the spherical mirror?
d) The windows are cemented to the tube at Brewster angle. What is the angle θ as shown in the diagram?
e) Assuming that the tube bore is centered with respect to the axis of the $TEM_{0,0}$ mode, compute the loss introduced by the aperturing action of the tube walls.
f) Write an expression for the resonant frequency of a mode with longitudinal mode index p and transverse mode indices m, n. (10 points)

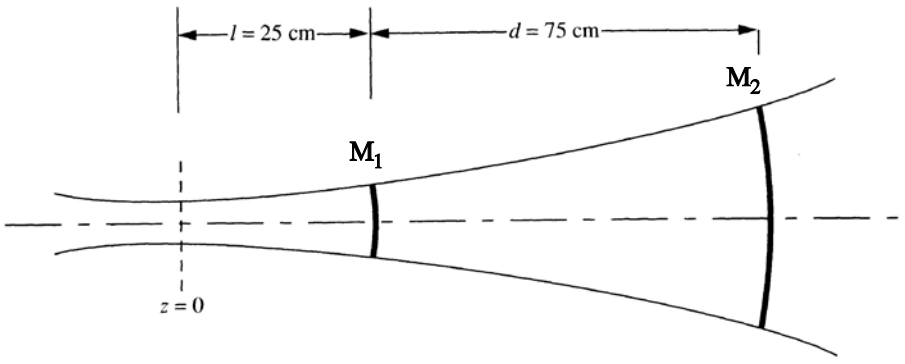
5) Exercise 10.3-1 (page 391 of the text book) (10 points)

Regular problems for graduate students (bonus for undergraduate students)

6) I showed the derivation of density of modes (Eq. (10.3-10) on page 394) for a 3D cavity. It is good for large number of modes in the cavity. In other words, when the dimensions of the cavity become comparable to a wavelength, the approximation is not accurate and one must count modes. This exercise is intended to give you confidence in the formula and also to indicate the exact procedure. Plot the number of modes between 0 and 10GHz as a function of frequency for a rectangular cavity of dimensions 2cm×5cm×6cm using the approximate formula and by actually counting the allowed modes and plotting the resulting stair-step function. (Note: only the index q_x or q_y for TE_{q_x,q_y,q_z} mode may be zero but not both, and only the index q_z be zero for the *TM* mode.) (10 points)

Extra Credit

7) In the stable optical cavity shown in the diagram on the right, the plane z=0 occurs at a distance 25cm to the left of M_1 with the beam parameter $z_o = 125$ cm. The distance between the two mirrors is 75cm



a) Find a formula for the resonant frequency of the $TEM_{p,m,n}$ mode, i.e. high order HG modes.
b) Find the difference between the resonance frequency of the $TEM_{1,2,n}$ and $TEM_{0,0,n}$ modes.
c) Find the radius of curvature for the mirrors M_1 and M_2 (note: My convention assumes diverging mirror and lens have negative radius of curvature. So state what convention, you use.) (10 points)