Indian Institute of Technology Guwahati
Department of Physics
PH306/Lasers & Ultrafast Optics/2022-23/Tutorial-3/AKSharma
Due date: 12.04.23

1. A Fabry-Perot interferometer consisting of two identical mirrors, air-spaced by a distance *d*, is illuminated by a monochromatic light. Measurement of transmitted intensity versus frequency showed the free spectral range to be 3 GHz and its resolution 60 MHz, respectively. Calculate the spacing *d* of the interferometer, its finesse, and the mirror reflectivity. If the peak transmission is 50%, calculate the mirror loss.

2. An argon ion laser can support steady state lasing over a range of frequencies of 6 GHz. If the length of the laser cavity is 1 m, estimate the number of longitudinal cavity modes in the laser output. Find the minimum length of an etalon that can be used to limit this laser to single-mode operation.

3. Consider TEM_{21} mode. Plot (a) the variation of electric field distribution and (b) the intensity distribution in the transverse plane. Also, draw the mode pattern in the transverse plane.

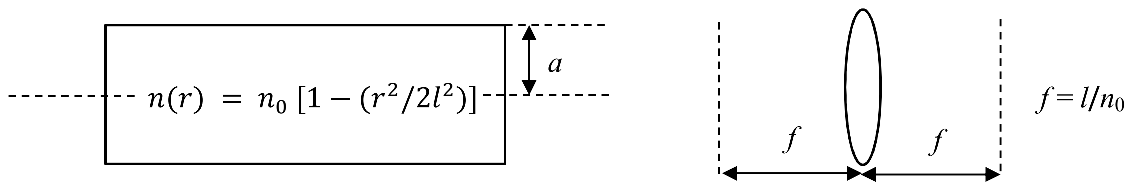
4. The optical intensity of a Gaussian beam as a function of radial and axial distance is

$$I(r,z) = I_0 \left[\frac{w_0}{w(z)}\right]^2 exp\left[-\frac{2r^2}{w^2(z)}\right]$$

   where the symbols have their usual meaning.
   (a) Plot I/I_0 as a function of r with $z = 0$, z_0, $2z_0$.
   (b) Obtain an expression for the intensity on the beam axis and hence show that for $|z| >> z_0$, the intensity decreases with distance as an inverse-square law.

5. A TEM_{00} Gaussian beam is allowed to pass through an aperture whose radius is equal to the spot size of the beam. Show that 86.5% of the total beam power will be transmitted through the aperture.

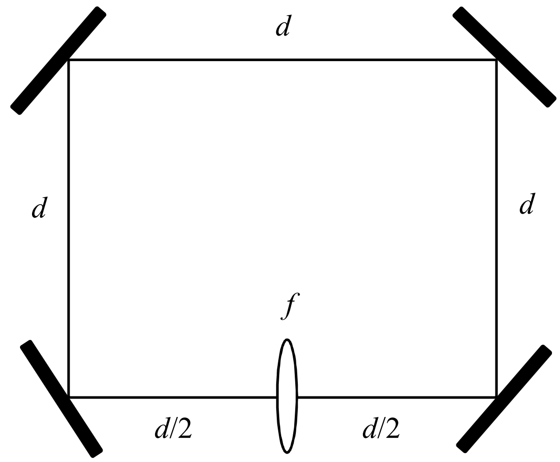
6. The graded index lens shown in the diagram below consists of a graded index fiber with $n(r) = n_0\,[1-(r^2/2l^2)]$ of length *d*. The parameter *l* is simply a scale factor that indicates how fast *n* varies with *r*. Start with the equation of propagation of a ray in an inhomogeneous medium given by $\frac{d^2r}{dz^2} = \frac{1}{n(r)}\frac{dn(r)}{dr}$. Assume $z = 0$ to be the input plane where r_1 and θ_1 are known.



   (a) Find the *ABCD* matrix for this lens. Do not ignore the air-index boundary. Keep *d* arbitrary.
   (b) Evaluate for $d = \pi l/2$.
   (c) Show that this lens is equivalent to the system shown at the right.

(d) If $n_0 = 1.53$, $n(a) = 1.525$, and $a = 2$ mm, find f.

7. Consider the cavity shown in the figure. Draw the equivalent lens diagram for this cavity. What would be the values of d/f that are stable in this cavity? Use the complex beam parameter analysis along with ABCD matrices. For $d = 0.2$ m and $f = 0.5$ m, what would be the spot size at the lens for a wavelength of 500 nm?



8. Discuss the stability of the cavity by constructing a diagram in the form $0 \le g_1 g_2 \le 1$.