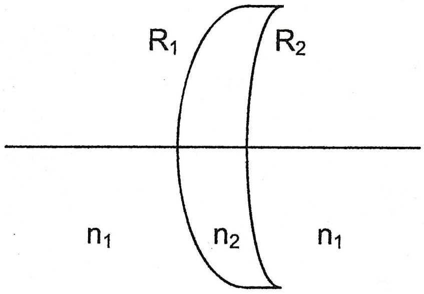
1.

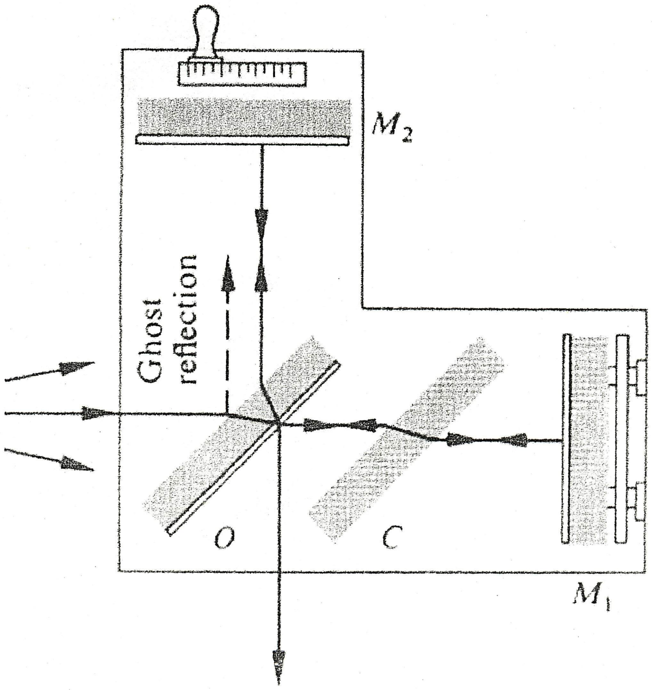
(a) (7%) Derive the ABCD matrix for the thin lens shown below.

(b) (3%) From your result in (a), discuss the physical meaning when $R_1=R_2$.



2.

(A)(10%) Below is an illustration of a Michelson interferometer in a viewing telescope. Suppose one of the mirrors is moved and 1000 finge-pairs shift past the hairline during the process. (a) Please derive the confitions for constructive interference for this interferometer. Define clearly each variable. (b) If it is illumintated with light at 500nm wavelength, how far is the mirror moved?

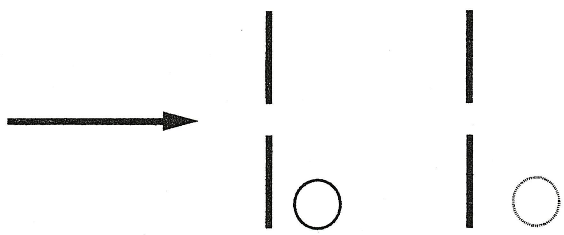


(B)(5%) A thin film of ethanol (n = 1.36) coated on a flat glass plate and illuminated with white light shows a color pattern. One region in the film strongly reflects green light (500 nm). What is the thickness of the film at that point?

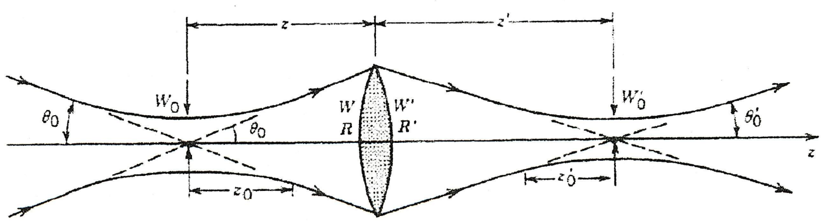
3.

(10 %) Please answer the following questions briefly:

(a) Is it possible for the laser light from the left be detected by the photodetector (solid circle) located behind the first aperture as shown in the figure below? Is it possible for the laser light be detected by the photodetector (dotted circle) located behind the second aperture? Why?



(b) For a Gaussian beam passing through a thin lens with a diameter matches the divergence angle θ_0 as shown in the figure below, will the intensity and optical power measured at z' equals the intensity and optical power measured at z? Why?



4.

Discuss from the point of Fourier analysis and discuss in detail the relationship between a two dimensional object and its far field diffraction pattern. Give two examples to demonstrate your answer. (15%)

5.

The slowly-varying envelope wave equation can be written as

$$\frac{\partial^2 A(z,t)}{\partial t^2} + j\frac{4\pi}{D_f}\frac{\partial A(z,t)}{\partial z} = 0,$$

where A is the slowly-varying envelope, and D_f is the dispersion coefficient.

a. Use the above equation and show that when D_f is close to zero, the temporal dispersion disappears. (5%)

b. For fibers made of fused-silica, at what wavelength will D_f be close to zero? (5%)

c. The paraxial Helmholtz equation can be written as

$$\nabla_T A(z,f) + j2k\frac{\partial A(z,f)}{\partial z} = 0.$$

Use the above analogy, and show that under what conditions the spatial diffraction disappears. (5%)

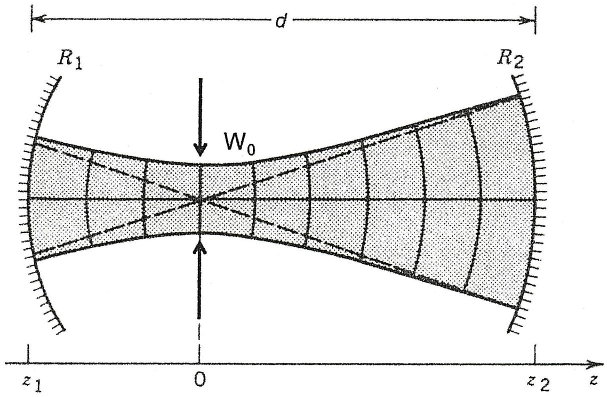
6.

(10%) The Jones vector of a time-harmonic plane wave linearly polarized along +45° (with respect to the +x-axis) is: $\vec{J}_{45^\circ} = \frac{1}{\sqrt{2}}\begin{bmatrix}1\\1\end{bmatrix}$. The Jones matrix of a quarter-wave plate (QWP) (fast axis is along the +x-axis) is $T_{QWP} = \begin{bmatrix} 1 & 0 \\ 0 & -j \end{bmatrix}$.

What is the output state of polarization if $\vec{J}_{45^\circ}$ passes through two QWPs whose fast-axes make angles of $\theta_1 = 90^\circ$ and $\theta_2 = -45^\circ$ with respect to the +x-axis?

7.

(15%) Consider a spherical-mirror resonator with a Gaussian beam mode as shown in the figure. What is the beam waist W_0 at the resonant frequency λ_0?



8.

(10%) Plot the photon number distribution, $P(n) = |\langle n|\varphi\rangle|^2$, as a function of photon numbers for the state, $|\varphi\rangle$

(a) Number state, $|\varphi\rangle = |n = 3\rangle$;

(b) Coherent state, $|\varphi\rangle = |\alpha = 3\rangle$;