1. A unit-amplitude monochromatic plane wave is normally incident onto the aperture shown in the figure. Find an expression for the intensity distribution in the Fraunhofer diffraction pattern.

![Diagram of an aperture with dimensions 2a x 2a and 2b x 2b]

2. Consider a diffraction grating that is used to spectrally analyze a source composed of two spectral lines separated by $\Delta \lambda$ and centered at $\lambda_0$. The light from the source is collimated and uniformly illuminates the whole grating. A lens of focal length $f$ focuses the diffracted light onto a plane that shows the spectrum. The grating is a periodic array of individual apertures $G(x)$ of width $a$:

$$F(x) = \sum_{m=-N/2}^{N/2} G(x - ma)$$

How many rulings must the grating have to just barely resolve the two spectral lines? Suppose we are given a grating with only 1/3 of the required number of rulings, how can we modify the setup to be able to resolve the source?

3. A laser emits light in two longitudinal modes such that its spectrum can be represented as

$$I(\nu) = I_0[\delta(\nu - \nu_1) + \delta(\nu - \nu_2)]$$, \hspace{1em} with \hspace{1em} $\Delta \nu = \nu_1 - \nu_2 = \frac{c}{2l}$;

$c$ is the speed of light and $l$ is the length of the laser.

a. Calculate the complex degree of coherence $\gamma(\tau)$ and the degree of coherence $|\gamma(\tau)|$ of this source.

b. The laser is used in a Michelson interferometer with a variable delay attained by moving one of the mirrors a distance $\Delta l$. Calculate and draw the intensity at a detector located at the output of the interferometer as a function of $\Delta l$.

c. Calculate the maximum displacement $\Delta l$ that is possible to perform in one of the mirrors (from the position of equal optical path length) before the interference fringes disappear.
4. Consider a monochromatic point source $S$ of wavelength $\lambda$ and a screen (A), located far apart, containing two very small pinholes at distance $d$. In answering the following questions assume a 1D problem.

a. Calculate the intensity pattern and the location of maxima and minima obtained on a screen (B) at distance $L$ ($L \gg d$).

b. The source $S$ is changed by an extended quasi-monochromatic source $S'$ of uniform intensity $I_0$, width $2a$, and average wavelength $\lambda$.
   
i. Calculate the mutual coherence function at the location of the screen A.
   
ii. Give an expression for the new intensity pattern on screen B. How does this pattern differ from that obtained in (a)?