Fourier Optics and Diffraction Pre-Lab Questions

1. Determine an expression for the ideal size pinhole to spatially filter a laser given the following information: the magnification of the objective *M*, the beam waist w_0, the distance from the beam waist to the objective *L*, the beam divergence θ, and the wavelength of the laser λ.

2. Assume the masks shown in Figure 1 are used as spatial filters.

    a. Classify each of the masks in terms of the spatial frequency range that each lets through, i.e., is it a low–pass filter, high-pass filter, band-pass filter, band-reject filter. The shaded region of each mask is opaque.
    b. How might each set, a-d and e-g, be used differently.

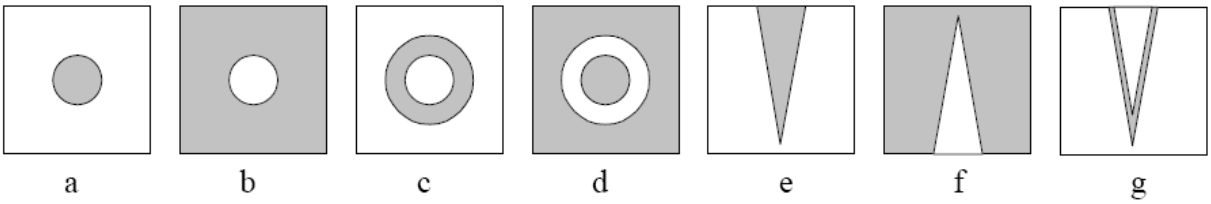

Figure 1

3. Subtlies of Fourier Transforms:
    a. Using Fourier convolution theory and delta functions, show that the Fourier Transform of a function that is displaced from the origin (e.g. $\Im\{A(x-x_0)\}$) is just this Fourier Transform of the original function multiplied by a constant phase factor. In other words, if you move the object being Fourier Transformed (e.g. a slit), the resulting diffraction pattern stays in the same spot, it just has a different phase.

    Huh???!!!!

    **Talk with a friend about why this result seems strange compared to your personal experience. Think about what you need to realize in order for a. to make sense physically. Be prepared to discuss when we meet for lab. If you want to record some thoughts in your pre-lab, they won't be graded, but you will have them for reference.

4. Using what you learned for question 3:
    a. Show that the Fourier Transform of identical functions shifted symmetrically about the origin, will result in the Fourier Transform of the function multiplied by an interference term (i.e. sine or cosine) because of their differences in phase.
    b. Sketch the Fourier Transform of a "V" where the dark lines can be thought of as slits that are long in one dimension and very narrow in the other.
    c. Sketch/describe what happens to the Fourier Transform of a "W" when compared to the "V".

5. Write down the equations you will need for looking at single slit diffraction, multi-slit interference, round apertures, etc.