Fourier Optics EOP 513
Second Exam (in-class)
Due 6 August 2001

1. Explain the difference between coherent and incoherent light. (10 points)

2. Define the Optical Transfer Function (OTF) and give analytic expressions for the incoherent transfer function of a system with a circular lens of diameter D and focal length f for wavelength λ and object at infinity. (10 points)

3. Compare the imaging properties of coherent and incoherent optical systems. (10 points)

4. Find the analytic expression for the Fourier Transform of a circular pupil of diameter $2w$. (10 points)

5. The amplitude transmittance function of a thin triangular-wave absorption grating is shown below. Assume a period of L and wavelength λ. Find the following properties of this grating. (15 points)

   (a) The fraction of incident light transmitted by the grating.

   (b) The fraction of incident light that is not diffracted (zero order).

   (c) The fraction of light transmitted into a single first order.

6. An input function U_o, bounded by a circular aperture L and illuminated by a normally incident plane wave, is place in the front focal plane of a circular positive lens of diameter$D$. The intensity distribution is measured across the back focal plane of the lens. Assume $D > L$. (15 points)

   (a) Find an expression for the maximum spatial frequency of the input for which the measured intensity accurately represents the squared modulus of the input's Fourier spectrum (free from effects of vignetting).

   (b) What is the numerical value of the spatial frequency (in cycles/mm) when $D =$ 4 cm, $L = 2$ cm, f (focal length) $= 50$ cm, and $\lambda = 0.6$ μm?

   (c) Above what frequency does the measured spectrum vanish, even if the input may have nonzero Fourier components at such frequencies?

7. Given an NeNe laser beam ($\lambda = 633$ nm) with a Gaussian beam waist of $b = 1$ mm located 50 mm in front of a 10 mm focal length lens. (15 points)

   (a) Find the distance to and size of the imaged beam waist.

   (b) Find the location and focal length of a positive lens required to generate an output Gaussian beam with $b = 20$ mm with the waist just after the lens (i.e. the final output beam has infinite radius of curvature).

8. Given the geometry of problem 5.9, find Δ such that the resulting quadratic phase term inside the integral is less than 1/4 wave (i.e. the phase shift is less than $\pi/2$). Assume a wavelength of 550 nm, a lens focal length of 50 mm, and lens diameter of 20 mm. (15 points)