Fourier Optics EOP 513
Second Exam (in-class) 1 August 2007

1. Draw a diagram illustrating the definition of effective Fresnel number for a focusing lens. Identify the location of the Fraunhoffer plane and its corresponding effective Fresnel number. (5 points)

2. Find the width (distance from center to first minimum) of the diffraction pattern at focus for a 4-mm square aperture placed 80 mm in front of a 400-mm focal length lens illuminated by a diverging beam of wavelength 0.5 μm originating 800 mm in front of the lens. (5 points)

3. Given a grating with a groove profile of $\mathrm{rect}(x/b)$ where $b = 10$ μm and total size of 40 mm, sketch the resulting diffraction pattern for groove separations of 20 μm and 40 μm assuming a wavelength of 0.5 μm. (5 points)

4. Find the analytic expression for the incoherent optical transfer function of a system with a square lens of width $2w$ and focal length f for wavelength λ and object at infinity. (5 points)

5. Define (3 points each)
   (a) fringe visibility

   (b) photographic density

   (c) optical circulator

   (d) Hurter-Driffield curve

   (e) Strehl ratio

6. Given an NeNe laser beam ($\lambda = 633$ nm) with a Gaussian beam waist of $b = 10\ \mu$m. Find the value of the Raleigh range. g(5 points)

7. Explain the difference between coherent and incoherent light. (5 points)

8. Compare the imaging properties of coherent and incoherent optical systems in terms of convolution. (5 points)

9. Describe the basic operation of optical matched filtering. (5 points)

10. Explain the difference between the normal (orthoscopic) and conjugate (pseudoscopic) holographic-reconstructed images. (5 points)

Fourier Optics EOP 513
Second Exam (Take-Home)
Due 1 August 2007

1. Given an NeNe laser beam ($\lambda = 633$ nm) with a Gaussian beam waist of $b = 2$ mm located 200 mm in front of a 50 mm focal length lens. (10 points)

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

   (b) Repeat the calculation for a wavelength of $\lambda = 10.6\ \mu$m.

2. An input function U_o, bounded by a circular aperture of diameter L and illuminated by a normally incident plane wave, is placed 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 $D > L$. (10 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 this spatial frequency (in cycles/mm) when $D =$ 10 cm, $L = 1$ cm, f (focal length) $= 80$ cm, and $\lambda = 0.6\ \mu$m?

3. Use the Matlab function `quad` to numerically generate a plot of the Fourier-Bessel transform of $r^2\text{Gaus}(r)$. Compare the result to the result obtained using `fft2`. (10 points)

4. Plot the point spread function versus image radius for a unit-radius circular pupil with $A = 1$ wave of defocus, that is, a multiplicative phase factor of $\exp(j2\pi Ar^2)$. Then plot the Strehl ratio of the point spread function as a function of the magnitude A of the aberration over a range of A sufficient to decrease the Strehl ratio below one-fourth. (10 points)