Fourier Optics EOP 513
Second Exam (in-class) 4 August 2011

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 0.4-mm square aperture placed 20 mm after a a 40-mm focal length lens illuminated by a diverging beam of wavelength 0.5 μm originating 60 mm in front of the lens. (5 points)

3. Given a grating with a groove profile of $\mathrm{rect}(x/b)$ where $b = 20$ μm and total size of 50 mm, sketch the resulting diffraction pattern for groove separations of 50 μm and 100 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 w 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) point spread function

   (d) Sparrow's resolution criterion

   (e) Strehl ratio

6. Given an NeNe laser beam ($\lambda = 500$ nm) with a Gaussian beam waist of $b = 3$ mm. Find the value of the Raleigh range. (5 points)

7. Suppose a lens is placed 80 mm from the beam waist of the above laser. If the lens has a focal length of 20 mm, find the approximate location and size of the beam waist after the lens. (5 points)

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

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

10. Describe the basic principles of holography. (5 points)

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

Fourier Optics EOP 513
Second Exam (Take-Home)
Due 4 August 2011

1. Given an NeNe laser beam ($\lambda = 500$ nm) with a Gaussian beam waist of $b = 3$ mm. Suppose a 20-mm focal length lens is placed 80 mm from the beam waist of the above laser. (10 points)

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

   (b) Repeat the calculation for a gaussian beam waist of of $b = 30$ μm.

2. Use MATLAB to load the attached `.mat` file, which contains a modulated phase image. Following the class notes, use phase microscopy methods (dark field and phase contrast) to reveal the original phase object. Show the resulting images and identify the subject of the original image. (5 points)

3. Use MATLAB to plot the self-convolution and autocorrelation functions for $f(x) = 4x\text{Gaus}(x)$. (5 points)

4. 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 the analytic solution. (5 points)

5. Plot the point spread function versus image radius for a unit-radius circular pupil with $A = 0.3$ waves of defocus, that is, a multiplicative phase factor of $\exp(j2\pi Ar^2)$. Find the Strehl ratio of the result. (5 points)

6. Given two circular apertures 100μm in diameter and separated by 500μm (center to center). Assume a converging spherical wave of wavelength 630 nm is incident on the apertures and that the center of convergence is 80 mm from the aperture plane. Find the distance between the fringes in the irradiance at the point of convergence. (5 points)

7. Plot a cross-section of the above problem, using rect functions and a one-dimensional Fourier transform. Remember that we want the irradiance of the result. (5 points)