Fourier Optics EOP 513
First Exam (in-class)
20 June 2005

1. Given the function $f(x) = \text{step}(x)\text{tri}(x)$, plot the following (3 points each)

   (a) $f(x)$

   (b) $f(x+4)$

   (c) $f(x/3)$

   (d) $f(x-1) - f(1-x)$

2. If $g(x) = f(x) * h(x)$, what is $f(x-3) * h(x+2)$? (3 points)

3. Find the following Fourier transforms (2 points each)

   (a) $\delta(x)$

   (b) $\text{rect}(x)$

   (c) $\text{gaus}(x)$

   (d) $\text{sech}(\pi x)$

   (e) $\cos(2\pi\xi_o x)$

4. Given the function

$$h_{12}(x,y) = \frac{e^{jkz_{12}}}{j\lambda z_{12}} \exp\left[j\frac{\pi}{\lambda z_{12}}(x^2+y^2)\right]$$

   where z_{12} is the axial distance from a source aperture to an observation location. Explain how the function is used in a diffraction integral, its physical significance in that context, and the domain (pupil or image) of the (x, y) coordinates. (5 points).

5. Define (3 points each)

   (a) Raleigh Range

   (b) Huygen's wavelets

   (c) Fraunhoffer approximation

   (d) Optical wavefront

   (e) Cornu spiral

6. Give the name (if defined) and explain the significance of the following groups of constants and the circumstances in which they arise.

   (a) $\sqrt{\lambda z}$

   (b) $\frac{w^2}{\lambda z}$

   (c) $\frac{\lambda}{w}$

   (d) $\frac{\lambda z}{w}$

   (e) $\frac{w^2}{\lambda}$

   where λ is the wavelength, w is the half-width of a slit or aperture, and z is a propagation distance. (10 points)

7. Given a sharp edge diffracting light of wavelength 0.633 μm. What is the approximate separation of fringes in the diffraction pattern at a distance of 3 meters. (5 points)

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8. Given the functions

$$\begin{aligned} f(x) &= \text{step}(x)\text{tri}(x) \\ g(x) &= \text{gaus}(x+2) - \text{gaus}(x-2) \end{aligned}$$

find the plot the following (5 points each)

   (a) $f(x) * f(x)$.

   (b) $g(x) * g(x)$.

   (c) $f(x) * g(x)$.

9. Plot the two-dimensional function $g(x)g(y)$ in three different ways. (10 points)

10. Given $f(x) = \text{gaus}(x+d) - \text{gaus}(x-d)$

   (a) Find the analytic Fourier Transform of $f(x)$. (5 points)

   (b) Use Matlab to calculate and plot the function $f(x)$ with d=3 and either the real or imaginary part of its Fourier Transform (as appropriate). (5 points)

11. Given the two-dimensional function $f(x, y)$, display the function and its Fraunhoffer pattern (using logarithmic enhancement over 3 decades). (5 points)

$$f(x, y) = \text{or}(\text{cyl}(x, y - 0.5) + \text{cyl}(x, y + 0.5), \text{rect}(x, y))$$

where *or* is the Matlab function constructing the logical or of two operands.