Fourier Optics EOP 513
First Exam (in-class)
2 July 2001

1. Define (3 points each)

   (a) Fresnel number

   (b) Huygen's wavelets

   (c) Fraunhoffer approximation

   (d) Optical wavefront

   (e) Convolution integral

2. Describe the optical phenomenon of diffraction. (5 points)

3. Describe the general appearance of the diffraction pattern of an aperture in the *near* and *far* fields. Give our definition for the boundary between the near and far field. (5 points)

4. Given a thin slit of width 0.20 mm illuminated by light of wavelength 0.55 μm which is focused a distance 60 mm from the slit. Find the lateral distance of the first diffraction minimum. (5 points)

5. Given a sharp edge diffracting light of wavelength 0.633 μm. What is the approximate size of the diffraction pattern at a distance of 2 meters. (5 points)

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

   (a) $\delta(x)$

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

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

   (d) $\mathrm{rect}\left(\frac{x-x_0}{w}\right)$

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

7. Describe the effects on the Fourier Transform of (a) shifting the input function and (b) multiplying the input function by a linear phase factor. (4 points)

8. Define the function $\mathrm{comb}(x)$ and describe how it is used to define the discrete sampling of a function $f(x)$. (3 points)

9. Describe how the δ-function is obtained as the limit of a sequence of functions. (3 points)

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10. Find and plot the input functions and convolution $h(x) = f(x) * g(x)$ over the domain $-8 \leq x \leq 8$. Use `convn(f,g,'same')`. (15 points)

$$\begin{aligned} f(x) &= \text{gaus}(x+2) - \text{gaus}(x-2) \\ g(x) &= \text{rect}(x+2) + \text{rect}((x-1)/0.75) \end{aligned}$$

11. 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=1 and either the real or imaginary part of its Fourier Transform (as appropriate). (5 points)

    (c) 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)

12. Given the two-dimensional function $f(x, y)$, display the function and its Fraunhoffer pattern (using logarithmic enhancement over 3 decades). (15 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.