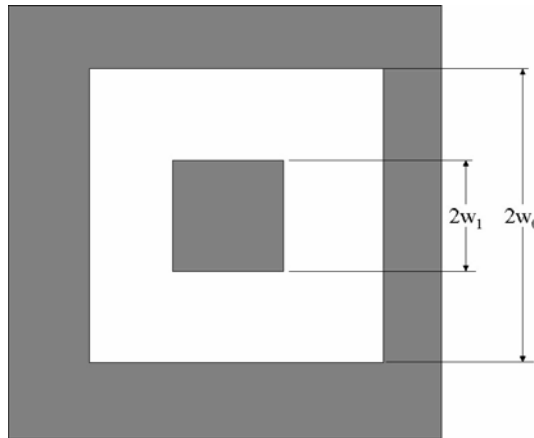


Finish reading §3 *Optical Diffraction and Imaging*

1. Find AND GRAPH the irradiance distribution (squared magnitude of the amplitude) of the Fresnel diffraction pattern *on the optical axis* (i.e., a function of z instead of a function of $[x, y]$) if $f[x, y] = CYL(r)$ (HINT: write down the Fresnel diffraction formula as integral and change variable to more convenient form).
2. The Fresnel diffraction pattern from a rectangular aperture of width b_0 propagated over the distance z_1 is $g[x, y]$. Find the width d_0 of the aperture in the same plane as the original aperture that produces a scaled replica of $g[x, y]$ if the propagation distance is $2 \cdot z_1$.
3. For the aperture distribution shown, where the aperture is square and has a square central obscuration, and “white” represents transparent regions and “gray” represents opaque, and assuming normally incident monochromatic plane-wave illumination with λ_0 :
 - (a) Find an expression for the “intensity” (i.e., irradiance) distribution for light that has propagated a distance z_1 into the Fraunhofer diffraction region
 - (b) Sketch the x -profile of this distribution for the propagation distance.



MORE→→→→

4. A diffracting screen has a circularly symmetric amplitude transmittance function given by:

$$t_1(r) = \frac{1}{2} (1 + \cos [\beta r^2]) \cdot CYL \left(\frac{r}{d_0} \right)$$

where β is a constant and $CYL(r)$ is defined as before:

$$CYL(r) \equiv \begin{cases} 1 & \text{for } r < \frac{1}{2} \\ \frac{1}{2} & \text{for } r = \frac{1}{2} \\ 0 & \text{for } r > \frac{1}{2} \end{cases}$$

- (zzzz) What are the dimensions of β ?
- Sketch $t_1(r)$ for the case where d_0 is chosen so that the largest phase angle in the cosine is 16π radians
- In what ways does this screen act like a lens? (HINT: Euler relation).
- Sketch the transmittance after thresholding at $t_0 = \frac{1}{2}$:

$$t_2(r) = \frac{1}{2} (1 + SGN [\cos [\beta r^2]]) \cdot CYL \left(\frac{r}{d_0} \right)$$

- Describe the *qualitative* difference in performance in the systems using $t_1(r)$ and $t_2(r)$.
5. Consider a grating whose transmittance is a sinusoidal function of x :

$$f[x, y] = \left(\frac{1}{2} + \frac{\alpha_0}{2} \cos \left[2\pi \frac{x}{L_0} \right] \right) \cdot 1[y]$$

where $\alpha_0 \leq 1$.

- Use the transfer function of light propagation in the Fresnel diffraction region to find the spectrum of the Fresnel diffraction pattern at some propagation distance z_1 .
- Find a relationship for the propagation distances z_1 that produce replicas of the amplitude of the original grating function, even though the system includes no lenses. Your relationship should demonstrate that the same result is obtained for many propagation distances z_1 , which means that the periodic grating forms images of itself at various distances in the Fresnel diffraction region. These are called *Talbot images*, after William Henry Fox Talbot, who first explained them. Note that Talbot images are produced for any periodic object, not just for gratings.