

Do the following problems; SHOW YOUR WORK

1. Consider monochromatic light of wavelength λ_0 incident on a single slit of width b along the x -axis and infinite length along y . The light is observed in the Fraunhofer diffraction region at a distance L . Derive an approximate expression for the *angular width at half-maximum irradiance* of the central peak of the diffraction spot (i.e., the FWHM).
2. The Fraunhofer diffraction pattern of a pair of rectangular slits of width b separated by the center-to-center distance d is illuminated by monochromatic light with $\lambda_0 = 650$ nm. The Fraunhofer diffraction pattern is viewed at the back focal plane of a lens with focal length $\mathbf{f} = 800$ mm. The center-to-center separation between fringe maxima is observed to be $D = 1.04$ mm. The fifth maximum of the interference pattern on each side is “missing,” which means that it coincides with a zero in the diffraction “envelope” due to the width of the slit. Determine b and d .
3. Monochromatic light with wavelength λ_0 is incident on a circular aperture of diameter d . The circularly symmetric diffraction pattern observed at a distance L in the Fraunhofer diffraction region has radius r from the central maximum to the first zero:

$$r \cong 1.22 \frac{L\lambda_0}{d}$$

(this distance is the separation required of the diffraction patterns from two point sources for them to be distinguished under the *Rayleigh criterion* for resolution)

- (a) Compare this result to the linear distance from the central maximum to the first zero for a square aperture of width equal to the diameter d of the circular aperture.
- (b) If the monochromatic light at λ_0 illuminates a circular lens of diameter d and focal length \mathbf{f} , the Fraunhofer diffraction pattern is observed at the focal plane so that $L \cong \mathbf{f}$ and :

$$r \cong 1.22 \frac{\mathbf{f}\lambda_0}{d}$$

If observed in blue visible light, find an approximate relation between the **diameter** of the diffraction spot and the focal length of the lens. This is a very convenient “rule of thumb” for imaging systems.

4. Compare the diameters of the diffraction spots for telescopes with primary optics having diameters $d_1 = 200$ in (Hale Telescope on Palomar Mountain) and $d_2 = 90$ mm (Questar).