Physics 325 Homework

1. For a single slit, the minima are at

\[ \beta = \frac{\pi d \sin \theta}{\lambda} = m \pi \]

where \( m \) is an integer \( \neq 0 \).

The first minimum is at \( m = 1 \)

\[ \frac{\lambda}{d} = 1 \]

\[ \sin \theta = \frac{\lambda}{d} = \frac{x}{f} \]

\[ x = f \left( \frac{\lambda}{d} \right) = 40 \times \frac{5.46 \times 10^{-5}}{0.045} = 0.485 \text{ cm} \]

This is Fraunhofer diffraction.

2. For a circular aperture and Fraunhofer diffraction, the central max is at \( d = 0 \), the 1st min is at \( \theta = 1.22 \frac{\lambda}{d} \) and the 1st bright ring is at \( \theta = 1.635 \frac{\lambda}{d} \).

Thus the radius of the 1st bright ring is

\[ r = 1.635 \times \frac{56}{3} \times 5.5 \times 10^{-3} = 1.67 \times 10^{-3} \text{ cm} \]

The diameter of the 1st bright ring is

\[ d = 2r = 3.34 \times 10^{-3} \text{ cm} \]
b = 5a so orders \( m = 5, 10, 15, \ldots \)
are missing i.e. The single slit zeros fall on the 5th, 10th, \( 5 \) maxima for the double slit.

The double slit has maxima when \( \sin \theta = m \lambda \).

At this angle \( \sin \theta = \frac{3}{5} \lambda \), so that

\[
\beta = 2 \pi a \sin \theta / 2 \lambda = \frac{3}{5} \pi
\]

Thus the 3rd max has an intensity of about 0.25 of the central max.

4. \( \sin \theta \times \theta = \frac{\lambda}{b} = \frac{5.89 \times 10^{-7}}{2.0} = 2.94 \times 10^{-5} \) radians

\( x = 1.9 \times 0.8 \times 10^{-5} = 1.52 \times 10^{-7} \) in.

\( \phi = \frac{x}{25} = \frac{1.52 \times 10^{-7}}{25} = 6.08 \times 10^{-9} \) rad = 0.2 minutes of arc.

If the eye can resolve 1 minute of arc, the \( m = 5 \) is required.
8a. The number of 2-slit maxima under each single slit lobe is
\[ \frac{20}{5} - 1 = 39 \]

The central max is twice as wide as each side lobe so there are
\[ 2 \times \frac{20}{5} - 1 = 79 \]

two slit maxima under it

5. \( L = 10 \text{ ft} \quad 1 \text{ inch} = 121 \text{ inches} = 307.3 \text{ mm} \)

\[ \lambda = 1.22 \frac{\lambda}{L} = 1.22 \times 5.70 \times 10^{-5} / 307.3 \]

\[ = 2.26 \times 10^{-7} \text{ rad} = 0.047 \text{ minutes of arc} \]