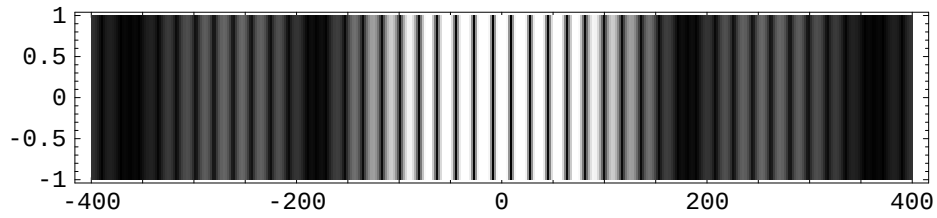
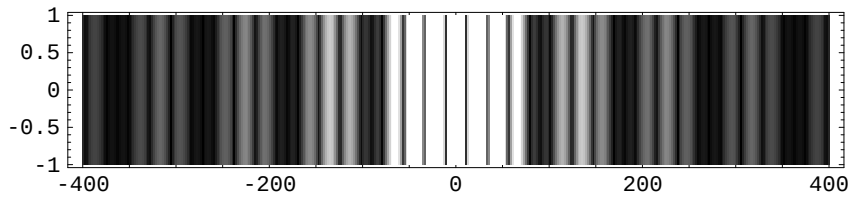
3. (40 pts.) Green laser light of wavelength 542 nm is incident upon two narrow slits of width a_1 and separation d_1. The pattern shown below is visible on a screen a distance of 4 m away from the slits. (The scale markings in the figure are in mm.



a. (10 pts.) What is the width of each individual slit?

b. (10 pts.) What is the spacing between slits?

The slits are then replaced by two narrow slits of width a_2 and separation d_2. The pattern shown below is visible on the screen.

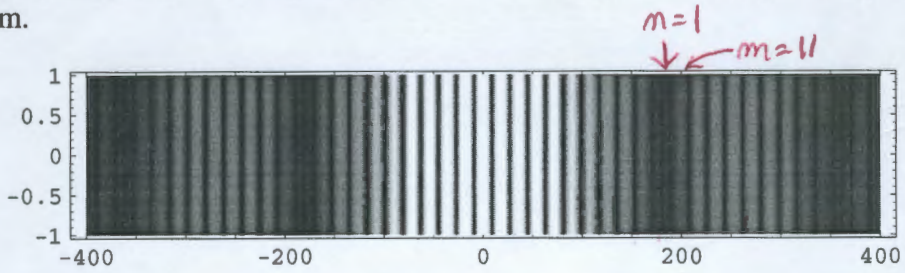


c. (5 pts.) Is a_2 less than, equal to, or greater than a_1? Explain your reasoning carefully but briefly.

d. (5 pts.) Is d_2 less than, equal to, or greater than d_1? Explain your reasoning carefully but briefly.

e. (10 pts.) If the entire apparatus were placed under water, would the bright spots get closer together, farther apart, or stay the same? Explain your reasoning carefully but briefly.

3. (40 pts.) Green laser light of wavelength 542 nm is incident upon two narrow slits ow width a_1 and separation d_1. The pattern shown below is visible on a screen a distance of 4 m away from the slits. (The scale markings in the figure are in mm.



a. (10 pts.) What is the width of each individual slit?

First min for diffraction is about at $y \approx 180$ mm

$a \sin\theta = 1\lambda$

$a = \frac{1\lambda}{\sin\theta}$ $\sin\theta \approx \frac{y}{L} = \frac{180}{4{,}000} = 0.045$ radians

$a = \frac{542\text{ mm}}{0.045} = 12{,}000\text{ mm} = \boxed{0.012\text{ mm}}$

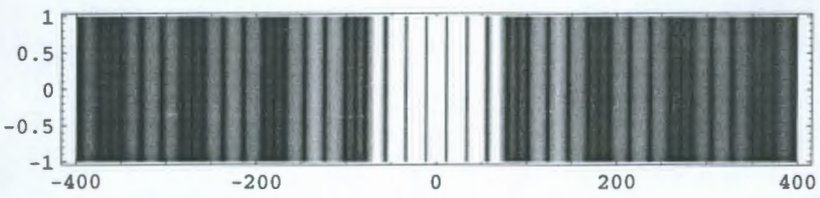
b. (10 pts.) What is the spacing between slits?

11th diffraction max is at $y \approx 200$ mm

$d \sin\theta = 11\lambda$ $\sin\theta \approx \frac{y}{L} = \frac{200}{4{,}000} = 0.05$ rad.

$d = \frac{(11)(542)}{0.05} \approx 119{,}000\text{ mm} = 0.119\text{ mm} \approx \boxed{0.12\text{ mm}}$

The slits are then replaced by two narrow slits of width a_2 and separation d_2. The pattern shown below is visible on the screen.



c. (5 pts.) Is a_2 less than, equal to, or greater than a_1? Explain your reasoning carefully but briefly.

$a_2 > a_1$. The single slit diffraction maxima are closer to the center.

d. (5 pts.) Is d_2 less than, equal to, or greater than d_1? Explain your reasoning carefully but briefly.

$d_2 < d_1$. The small interference bright spots are larger, implying $d_2 < d_1$.

e. (10 pts.) If the entire apparatus were placed under water, would the bright spots get closer together, farther apart, or stay the same? Explain your reasoning carefully but briefly.

Use $d \sin\theta = m\lambda$. If it is immersed under water, λ decreases to λ/n. This means θ decreases and the spots get closer together. Note that since there are no air/water interfaces, Snell's Law is irrelevant here.