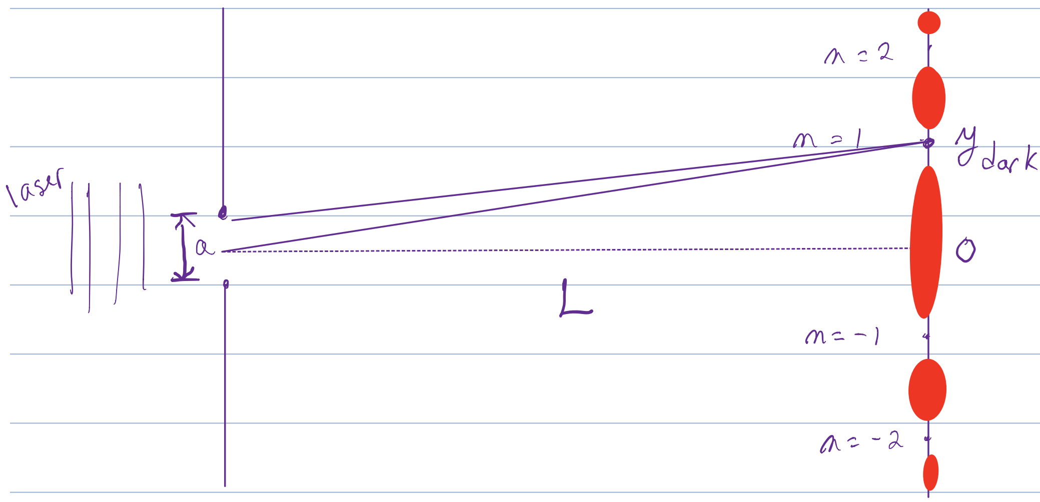
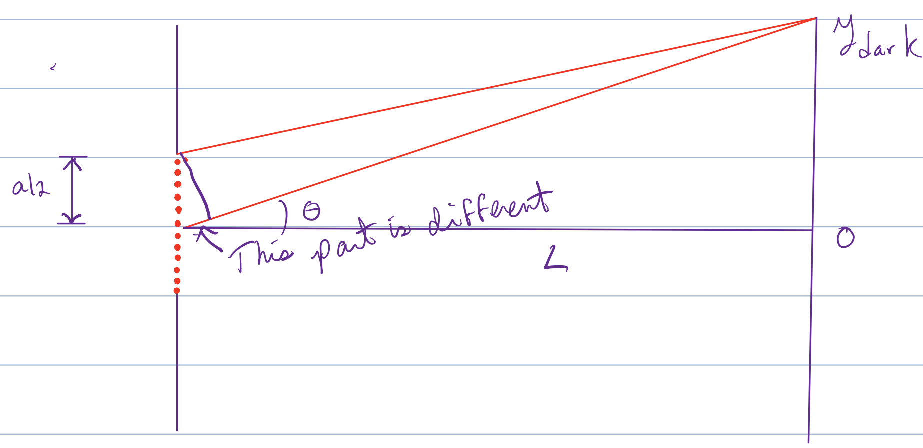
17.5 Single Slit Diffraction

Suppose you send laser light through a single slit. What do you see? If the slit is small enough (not too much larger than the wavelength) then you see a diffraction pattern.



What is going on? What is interfering with what? Different parts of the single slit interfere with each other. Simplest case — top half of the slit interferes with bottom half.



Destructive interference: $\Delta r = \frac{1}{2}\lambda$

$$\frac{a}{2}\sin\theta = \frac{1}{2}\lambda$$

$$a\sin\theta = 1\lambda$$

Generalize:

Single Slit Minima: $a \sin\theta = n\lambda$

$n = \pm 1, \pm 2, \pm 3, \ldots$

e.g. Red HeNe laser $\lambda = 632.8\,nm = 632.8 \times 10^{-6}\,mm$

$L = 5.00\,m = 5000\,mm$

Let $a = 0.02\,mm$

where are the dark spots?

$a \sin\theta = n\lambda$

For small angles, $\sin\theta \approx \tan\theta = y/L$ -

$$a \frac{y_{dark}}{L} = n\lambda$$

$$y_{dark} = \frac{n\lambda L}{a} = \frac{n(632.8\times 10^{-6}\,mm)(5000\,mm)}{0.02\,mm}$$

$$y_{dark} = n\,(158\,mm) = n\,(15.8\,cm)$$

$n = \pm 1, \pm 2, \ldots$

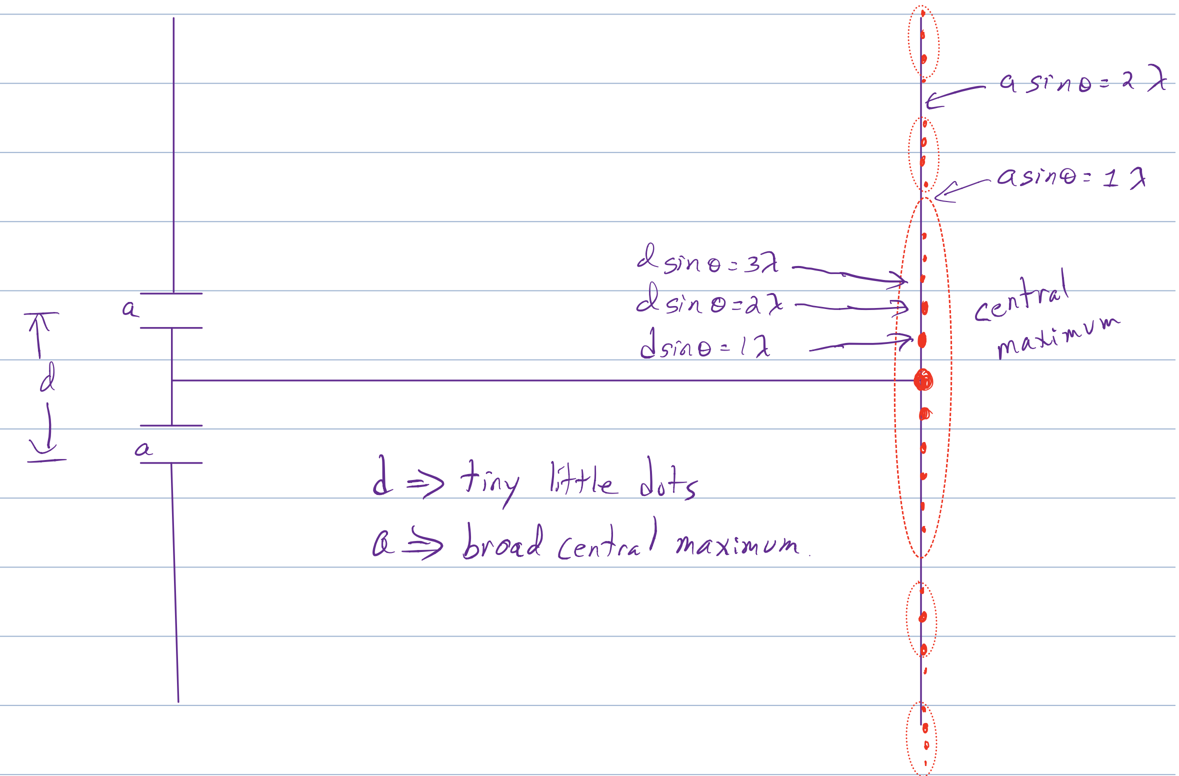
Smaller $a \Rightarrow$ pattern is more spread out.

width of the central maximum: Goes from $(-y_1)$ to (y_1), a total of $2y_1$.

$y_1 = 1^{st}$ dark spot $= 1\lambda L/a$

width $= 2y_1 = 2\lambda L/a = 31.6\,cm$.

Lastly, look at combined effects of a and d.



Tiny bright spots: $d\sin\theta = m\lambda$

Broad minima: $a\sin\theta = n\lambda$

Demonstration: Mathematica Notebook

Examples: ch17-finite-slits

1 7.6 Circular Aperture Diffraction

Similar ideas hold for circles, not just rectangular slits. Get circular diffraction pattern. The angle to the first minimum is $\theta_1 = \frac{1.22\,\lambda}{D}$ ← diameter

(See pictures in text; not on test.)