Experiment 29
Interference and Diffraction

Equipment:
1 Laser
1 double slit slide
1 single slit slide
1 aluminum slit holder
1 meter stick
1 Vernier caliper

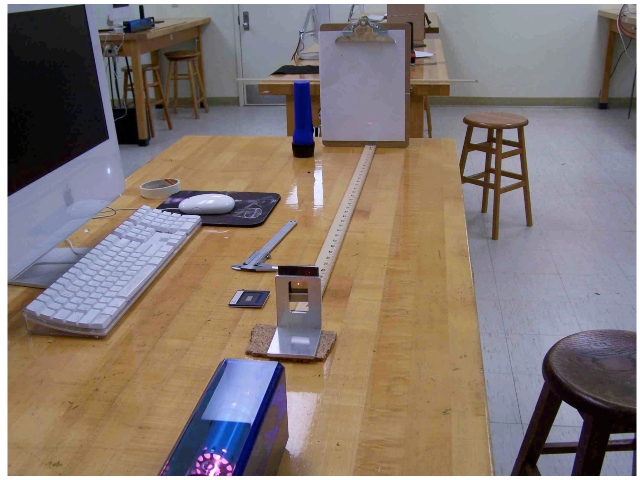

figure 29-1

Objective:
The object of this experiment is to study the diffraction and the interference patterns of single and double slits and from them to determine the wavelength of the laser light.

Theory:
Diffraction

Light passing through a narrow slit (with slit width approximately equal to the wavelength of light), will produce a diffraction pattern if projected on a distant screen. This diffraction pattern consists of a series of light and dark bands.

Figure 29-2 shows a plot of the light intensity in the diffraction pattern on the right and the slit, greatly enlarged, on the left.

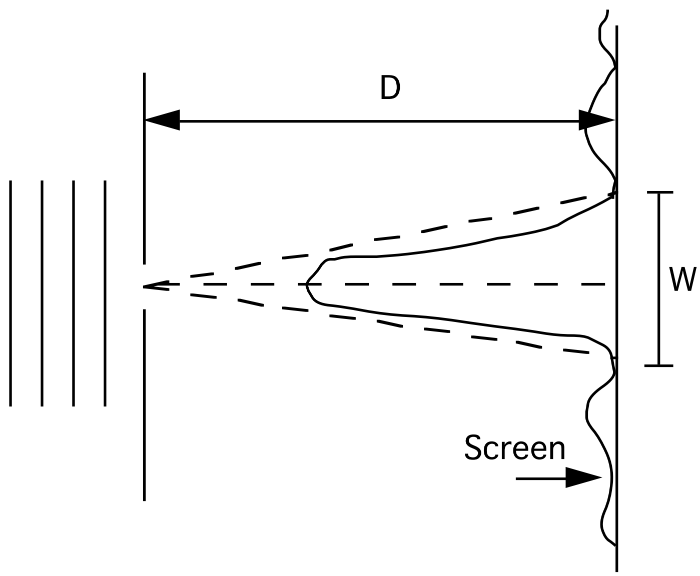

figure 29-2

The central bright band of the diffraction pattern subtends an angle of 2ϕ where ϕ=λ/d, with λ being the wavelength of light and d being the slit width. The angle ϕ can be determined by measuring the distance from the slit to the screen and the width of the central maximum, W. One can see from figure 29-2 that tanϕ=W/(2D). Thus for small angles we see

$$\lambda = \frac{W}{2D_{screen}} d_{slitwidth} \qquad \text{Eq-29-1}$$

Interference-Young's Double Slit

When coherent light (such as laser light) passes through two narrow slits that are very close together, an interference pattern will result. This pattern is caused by the addition, and cancellation of light waves from the two slits and is known as constructive and destructive interference respectively.

The two slits are treated as if they are two points of coherent light.

Constructive interference occurs when the path length difference is equal to a integral number of whole wavelengths. Destructive interference occurs when the path length is an odd number of 1/2 wavelengths. From figure 29-3, we see that constructive interference occurs for $\delta = m\lambda$, but $\delta = d\sin\theta$, and for small angles, $\sin\theta \approx \tan\theta = y/D$. From this we find that:

$$\frac{dy}{D} = m\lambda \text{ or } \lambda = \frac{\mathrm{dy}}{\mathrm{mD}}$$

where m=0,±1,±2,..., with m=0 being the central maximum.

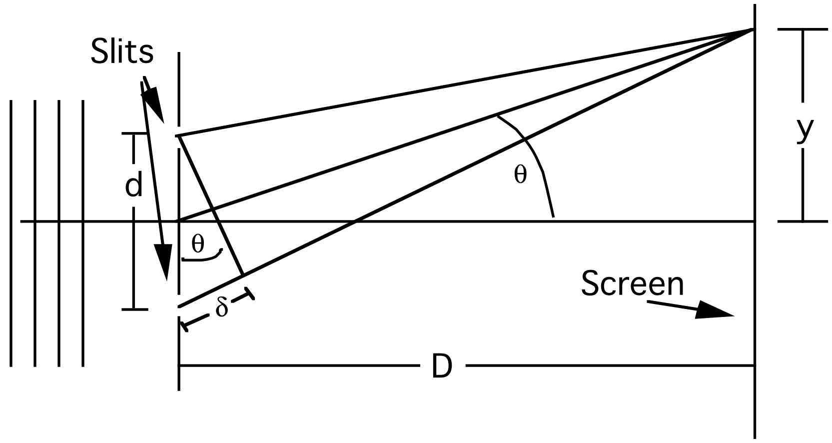

figure 29-3

Procedure:
Part 1: Single slit diffraction

1. Put the smallest single slit (the slit width is printed on the slide) in the path of the laser beam and project the diffraction pattern on the screen. The screen should be about 1 meter from the slit. Measure the width of the central maximum with the Vernier calipers. Measure the distance from the slit to the screen.

2. Repeat for the other three slits.

3. Calculate the wavelength of the laser light for each of the slits and calculate an average value.

Part 2: Double slit interference

4. Place the slide with the closest double slits in front of the laser beam and project the interference pattern on a screen approximately 1 meter away. The pattern should look similar to the one in part 1, only this one will have a series of smaller light and dark places. The lines to be measured are the narrow lines.

5. On the screen (a piece of paper) mark the position of the **all bright fringes to the right and to the left of the central maximum.** Measure the separation between the right hand and the left hand fringes so that the distance between them is. **See PHYS222 Website on this webpage-"How to measure Diffraction Patterns".**

6. Calculate an average y/m value for the above data. Use this average value to find the wavelength of the laser light using the equation:

$$\lambda = \frac{\mathrm{d}}{\mathrm{D}}\left(\frac{\mathrm{y}}{\mathrm{m}}\right)_{\mathrm{av}}$$

7. Calculate the experimental error between the accepted value for the laser (λ =632.8 nm = $6.328 \times 10^{-7} m$) and the **average experimental value for parts 1 and 2.**

Post Lab Questions/Conclusions:

1. What are the primary sources of uncertainty in this experiment? What was the largest source of uncertainty?

2. Explain or compare diffraction and interference.

3. In last columns labeled “Corrected wavelength” of the given data tables, you should have a total of 8 different wavelengths with absolute uncertainties.

You *should rewrite all eight wavelengths and their uncertainties with the correct number of significant figures based upon the uncertainty value.*

Considering uncertainty, did all of your wavelengths fall within the accepted range of **632.8 nm**?

If they did not you should explain why not using uncertainty arguments.

4) Using uncertainty equations on the back page of data table calculate the fractional uncertainties

$\frac{\delta W}{W}$ and $\frac{\delta D_{screen}}{D_{screen}}$ for **single slit A** (**only**) measurement and $\frac{\delta y_{av}}{y_{av}}$ and $\frac{\delta D_{screen}}{D_{screen}}$ for **one double slit A (only)** measurement.

Based upon these uncertainties calculated above discuss whether or not the assumption that these errors are small is an appropriate assumption (i.e., compare the magnitude of these values of your percent uncertainty to the new column you generated in question 3 above).