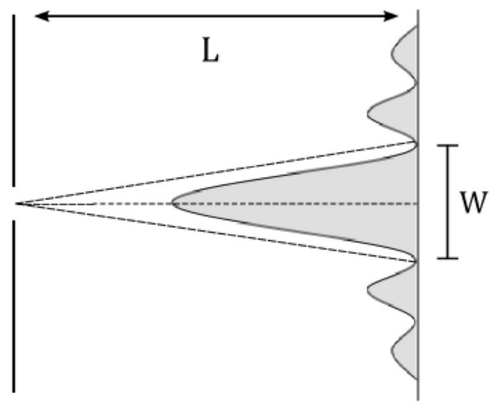
Name: ______________________________ Section: __________ Date: ______________

Worksheet - Wave Optics

Objective: This experiment will study diffraction and interference of coherent light. Students will pass laser light through narrow slits to determine the wavelength of the light.

Theory: Light passing through a narrow slit (of width D approximately equal to the wavelength of light) will produce a diffraction pattern. The pattern consists of a series of light and dark bands, or envelopes.

The central bright envelope spans an angle 2ϕ, where $\boldsymbol{\phi = \lambda/D}$. This angle will be determined using the following trigonometric relationship: $\boldsymbol{\tan\phi = W/2L}$.



1. Solve the two single-slit equations above for λ in terms of the measurable quantities D, W, and L. You may use the small angle approximation: $\boldsymbol{\tan\phi \approx \phi}$. (4 pts)

When coherent light passes through two slits that are close together, an interference pattern of light and dark fringes results. These fringes result from constructive and destructive, respectively. Bright fringes can be found where $\boldsymbol{d\sin\theta = m\lambda}$, where θ is the angle spanned by vertical distance y from the center. This experiment will determine angle θ using the relationship: $\boldsymbol{\tan\theta = y/L}$.

2. Solve the two double-slit equations above for λ in terms of the measurable quantities d, y, m, and L. You may use the small angle approximation: $\boldsymbol{\sin\theta \approx \tan\theta}$. (4 pts)

3. The fringe number $m = 0, 1, 2, \ldots$ can be calculated from the number of bright fringes in the central envelope: $\boldsymbol{m = (\#fringes - 1)/2}$. Count the number of fringes in the central envelope of the following interference pattern and use this value to calculate m. (4 pts).

$m =$ ______

(show any calculations below)

Procedure:

Part 1: Single-Slit Diffraction

4. Place the single-slit slide on the slide holder. Align the slide holder in front of the laser aperture.
5. Set up the clipboard and paper at least one meter away *from the slide holder.* Record this distance: (2 pts)

   $L =$ ____________________

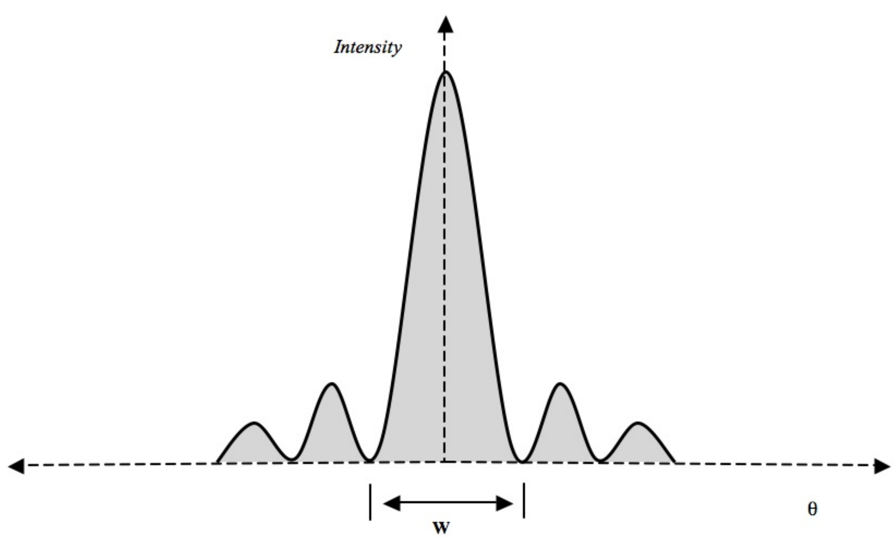
6. Turn on the laser to create a diffraction pattern on the clipboard. Begin with the widest slit. Slit width is provided on the slide; its uncertainty is $\delta D = \pm 0.005$ mm.

7. Mark the width, W, of the central band. Measure from the center of the dark bands on either side. Take measurements in a tidy manner, use extra paper as needed.

8. Close the shutter. Calculate λ; show your work. [The mathematical model uses radians.]

9. Repeat for the three remaining slits. Calculate average λ_{ss} for the single-slit procedure.

Slit:	Slit width: $\boldsymbol{D}$	Band width: $\boldsymbol{W}$	Wavelenth: $\boldsymbol{\lambda}$
A			
B			
C			
D			
(26 pts)		Average: λ_{ss}:	

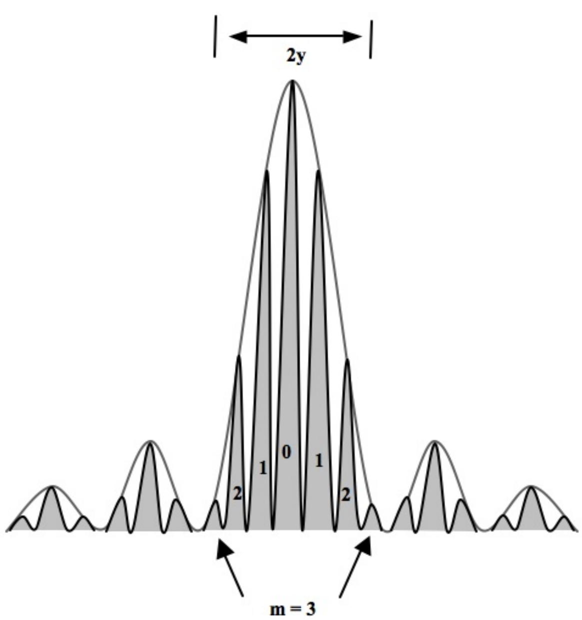


Part 2: Double-Slit Interference

10. Place the double-slit slide on the holder. Turn on the laser. Begin with the widest spacing.
11. Mark a line through each of the bright fringes in the central bright envelope. The distance between the outermost fringes is $2y$.
12. Close the shutter. Determine $2y$ and m.
13. Calculate λ. Show your work.

14. Repeat for the remaining pairs of slits. Calculate average λ_{ds} for the double-slit procedure.

Slits:	Slit spacing: $\boldsymbol{d}$	Half-envelope: $\boldsymbol{y}$	$\boldsymbol{m}$	Wavelenth: $\boldsymbol{\lambda}$
A				
B				
C				
D				
(26 pts)			Average: λ_{ds}:	



15. Calculate the total average λ from your measurements. Compare this to the laser's theoretical wavelength: $\lambda = 6328\ \mathring{A}$ $[\mathring{A} = 10^{-10}$ m]. Show your work below. (6 pts)

λ_{avg}
% Error

16. What color is the wavelength you calculated? Refer to an electromagnetic spectrum chart. Is this color the same as the color of your laser? (6 pts)

17. Explain and compare diffraction and interference. (6 pts)

18. What are some major sources of uncertainty for this experiment? (6 pts)

Attach all data sheets with measurement markings to the back of this data sheet. (10 pts)