Name: ______________________________
Partners: ______________________________
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PHYSICS 221 LAB #8: WAVE OPTICS

The diffraction or spreading of the straight wavefronts as they pass through an opening can be seen in the picture above. The same effect occurs for light waves although the wavelength is very small for visible light.

OBJECTIVES

1. To observe some of the effects of the wave nature of light.
2. To make measurements of single-slit diffraction and double-slit interference patterns.
3. To measure the diameter of a thin wire using diffraction.

OVERVIEW

Do not look into a laser beam because eye damage is likely to result!

1. For single-slit diffraction, the angle between the center of the middle bright fringe and the center of the first dark fringe is found by using $\sin\theta_C = \lambda/W$, where W is the width of the slit and λ is the wavelength of the light.
2. For double-slit interference, the difference in the path from the two openings to a spot at an angle θ from the center of the pattern is $d\sin\theta$, where d is the separation between the slits. The bright fringes are located at angles where the path difference is 0, λ, 2λ, etc. (constructive interference) and the dark fringes are located at angles where the path difference is λ/2, 3λ/2, etc. (destructive interference). The effect of each individual slit being narrow shows up as a more gradual variation in the intensity like that for single-slit diffraction. The fringes due to the double-

slit interference are narrower than the variation due to the narrowness of the individual slits.

3. According to Babinet's Principle, the diffraction pattern resulting from light shining on a small barrier is the same as the pattern for an opening of the same size and shape.

PART ONE: Single-Slit Diffraction

1. A red laser is set up to pass through a single narrow slit. Sketch the pattern that appears on the wall labeling which fringes are bright and which are dark. Also, mark the middle of the pattern.

Question: How does the width of the central bright fringe compare to the widths of the other bright fringes?

2. Measure the distance between the slit and the wall.

L = ______________

3. Measure the distances (y) between the middle of the *central bright* fringe and the middle of the first *dark* fringe on one side of the pattern. Enter the measurements below.

y = ______________

4. Using trigonometry, calculate the angle θ_C to the middle of the first dark fringe. (Hint: Sketch what you measured.)

θ_C = ______________

5. Using the width of the slit (W) written on the slide, calculate the wavelength of the laser. Show your work.

W = ______________

λ = _______________

Question: How does your measurement compare to the known wavelength of the red laser (633 nm, 1 nm = 10^{-9} m)?

Question: Qualitatively, how do you expect the single-slit diffraction pattern to change if a green laser (λ = 544 nm) is used instead of a red laser? Assume everything else about the setup remains the same. Explain your reasoning.

6. Compare your predictions to what you observe with a green laser. If your predictions don't match what you see, explain.

PART TWO: Double-Slit Interference

1. A red laser is set up to pass through a pair of narrow slits. Sketch the pattern that appears on the wall labeling which fringes are bright and which are dark. Also, mark the middle of the pattern. (Note: Concentrate on the smaller pattern that is due to the interference of light from the two slits.)

Question: How does the width of the central bright fringe compare with the widths of the other bright fringes?

Question: How does the brightness of the fringes vary?

2. Measure the distance between the slit and the wall.

L = _______________

3. Measure the distances (y) between the middle of the central bright fringe and the middles of the next three bright fringes in the pattern. Enter the measurements in the second column of the table below.

Bright Fringe	**y = Distance to bright fringe (m)**	q **= Angle to bright fringe**	**d_{exp} = slit distance (m)**
1st			
2nd			
3rd			

4. For each bright fringe, calculate the angle from the middle of the central bright fringe. (Hint: Sketching what you measured will be helpful again.) Enter the results in the third column of the table above. Show your <u>first</u> calculation.

5. For each bright fringe, use the known wavelength of the red laser (633 nm, 1 nm = 10^{-9} m) and your measurements to calculate the "experimental" distance between the slits and enter the results in the fourth column of the table above. Show <u>each</u> calculation.

6. Calculate the average of the experimental distance between the slits found in step 5.

$$d_{avg} = \_\_\_\_\_\_\_\_\_\_\_\_$$

Question: How does the average value compare to the value written on the slide?

Question: Qualitatively, how do you expect the double-slit interference pattern to change if a green laser (λ = 544 nm) is used instead of a red laser? Assume everything else about the setup remains the same. Explain your reasoning.

PART THREE: Diffraction around a Narrow Object

1. A red laser is set up to shine on a thin wire. Sketch the pattern that appears on the wall labeling which fringes are bright and which are dark. Also, mark the middle of the pattern.

Question: Which does the pattern look most like, single-slit diffraction or double-slit interference?

2. Make measurement of the pattern to determine the thickness of the wire using the known wavelength of the red laser (633 nm). Describe your measurements and show your calculations. Show your work on the back of this page.