Course and Section________ Names ______________________________

Date____________________ ______________________________________

INTERFERENCE AND DIFFRACTION EXPERIMENT

Introduction

In this experiment you will use interference effects to investigate the wave nature of light. In particular, you will measure interference and diffraction patterns produced by one or more slits. The results will be used to determine the wavelength of the light.

Equipment

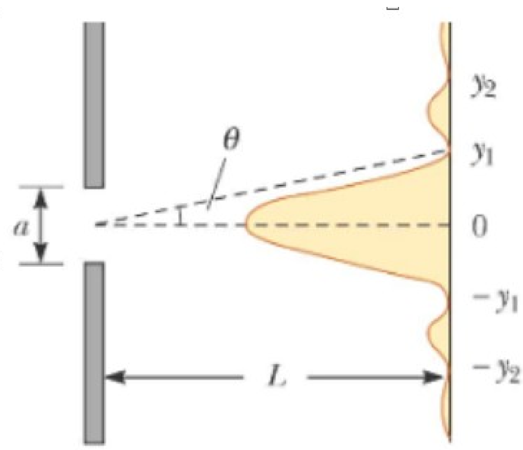
Optics bench, red laser, multiple-slit accessory, white screen, ruler, a sheet of paper.

Theory

When coherent light, such as that from the laser used in this experiment, passes through one or more slits, interference and diffraction patters form on a viewing screen.

PART 1 - Diffraction

The figure on the right shows the intensity distribution of the diffracted light for a single slit of width *a*. At the center of the pattern *y* = 0 the rays from all parts of the slit add (constructive interference). At the location of the minima they add to zero (destructive interference).
The viewing screen is located and distance *L* from the slit.



The positions of the **minima** are given by

$$\lambda n = a \sin\theta \quad n = 1, 2, 3 \ldots$$

Using the small angle approximation, the positions of the minima are

$$y_n = \frac{\lambda L}{a} n \quad n = 1, 2, 3 \ldots$$

The locations of the **maxima** are about halfway between two minima.

Preliminary questions

Light of wavelength 600 nm passes through a single $a = 0.1$ mm slit. The screen is at $L = 2.0$ m.

1. What is the angular width of the central diffraction maximum?

2. What is the width in cm of this maximum on the screen?

3. If the slit width is increased, how does the distance between minima change?

__ increases __ decreases __ does not change.

Procedure

Step 1. Set up the laser at one end of the optical bench. Place the single slit disk in its holder about 3 cm in front of the laser and select the variable width slit.

Step 2. Turn on the laser and adjust the position of the laser beam from left-to-right and up-down until the beam is centered on the slit. Place the white screen on the other side of the bench.

Step 3. Vary the slit width and observe the diffraction pattern on the screen.

4. How is your observation compared to your answer to question 3?

Step 4. Select $a = 0.04$ mm slit by rotating the slit disk until the 0.04 mm slit is centered.

Step 5. Place a sheet of paper over the side of the screen facing the laser. Use a pencil to mark the locations of the 1^{st} order minima $n = \pm 1$, and the two 2^{nd} order minima $n = \pm 2$.

5. Sketch in the box below the pattern you observe.

6. Measure the distance from the slit to the screen.

L =__________ (cm)

Analysis

7. Use the ruler to measure the distances between the marks and calculate the wavelength λ.

Order of the minima	Distance between the two marks (mm)	λ (nm)
$n = \pm 1$		
$n = \pm 2$		

8. Calculate the percentage difference of the two wavelengths.

9. Calculate the average wavelength.

λ = __________ (nm).

10. The wavelength of the laser beam is λ = 650 nm (exact value). Calculate the percentage error. If it's more than 20%, check your calculations or repeat you measurements

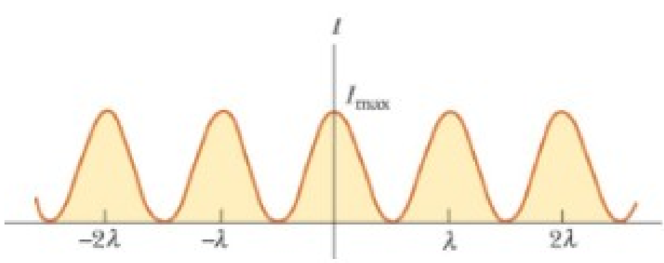
Step 6. Change the slit width to a = 0.02 mm. Sketch in the box below the pattern you observe.

11. How is the distance between the minima compared to the slit width a = 0.04 mm?

__ shorter __ longer __ the same.

PART 2 - Interference

When light passes through *two* slits, if they are infinitely narrow and are separated by a distance d, the the intensity distribution looks like



The positions of the **minima** are given by

$$\lambda(n+1/2) = d\sin\theta \quad n = 0, 1, 2 \ldots$$

and the positions of the **maxima** are given by

$$\lambda n = d\sin\theta \quad n = 0, 1, 2 \ldots$$

Using the small angle approximation, the positions of the **maxima** are

$$y_n = \frac{\lambda L}{d} n \quad n = 0, 1, 2 \ldots$$

Preliminary questions

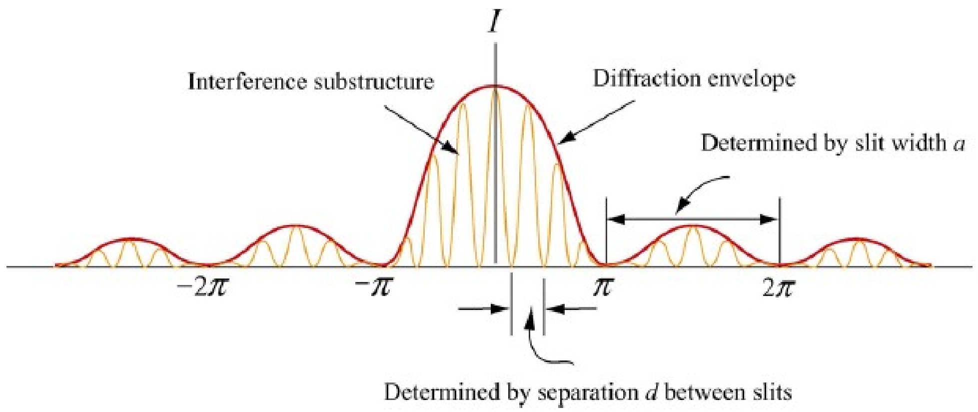
12. Light of wavelength 600 nm passes through a double slit with a separation d = 0.3 mm . The screen is at L = 2.0 m. What is the angular width of the interference maximum?

13. What is the width in cm of the interference maximum?

14. If the slit separation is increased, how does the distance between maxima change?

__ increases __ decreases __ does not change.

If the slits are not infinitely narrow, both diffraction and interference occurs resulting in an overall pattern as shown below



Procedure

You will now do much the same set of measurements as in part 1 however, you will mark the maxima, not the minima

Step 1. Select the multiple slit (depending the equipment, replace the ‘single slit’ disk with the other ‘multiple’ slit disk). Set the separation between the slits to d = 0.125 mm and a = 0.04 mm.

Step 2. Place a sheet of paper over the side of the screen facing the laser. Use a pencil to mark the locations of the two 1st order maxima $n = \pm 1$, and the two 2nd order maxima $n = \pm 2$.

15. Sketch in the box below the pattern you observe.

Analysis

16. Use the ruler to measure the distances between the marks and calculate the wavelength λ.

Order of the maxima	Distance between the two marks (mm)	λ (nm)
$n = \pm 1$		
$n = \pm 2$		

17. Calculate the percentage difference of the two wavelengths.

18. Calculate the average wavelength.

λ = __________ (nm).

19. The wavelength of the laser beam is λ = 650 nm (exact value). Calculate the percentage error. If it's more than 20%, check your calculations or repeat you measurements

%error = ____________

20. Select the slit separation d = 0.50 mm. Is what you observe in agreement with question 14?

21. Compare the results of the average wavelength obtained from part 1 and part 2. What is the percentage difference?

22. What are the reasons of the different values?

23. Turn in the drawings done on the sheet of paper used over the screen. Staple them with your lab report.