

Double Slit Interference

Warning: Never look into the laser.
Never shine the laser into someone else's eyes.

Name:

Group Members:

Date:

TA's Name:

Slits are delicate and finding replacements is very difficult. They come in little bags. Please be sure to put them back into their bags before returning them to the equipment cart at the end of the experiment.

Apparatus: A set of double slits, a slit holder, red, green and blue laser pointers, a laser pen holder, screen with screen holder, meter stick, and plastic ruler.

Objectives:

1. To observe the formation of interference patterns due to a single slit and due to a double slit.
2. To investigate the parameters that determine the separation of bright fringes in a double slit interference pattern.
3. To experimentally find out the wave length of a given color laser.

Part 1: Introduction

Single and double slits

You have already discussed two-source interference both in the class and in the tutorial class. Carefully inspect the single and double slits given to you. One of the rectangular piece of glasses contains different single slits and the other contains different double slits. The important dimension of the single slit is the slit width, "a". There are 4 slits with different "a" values. The most important dimension of the double slit is the slit spacing or separation between slits, "d." There are 5 double slits with different "d" values.

When we shine monochromatic (single wavelength) light on these slits, instead of observing an image of the one or two slits, we observe bright and dark fringes on the screen (or wall). These bright and dark fringes demonstrates the wave nature of light. Light traveling on different paths arrive at the same point on the screen and interfere to make the observed pattern.

Setting up the experiment

Setup the laser pointer and the slit as shown in the picture where the pattern of light after passing through the slit(s) is showing up on the wall of the room.

In the class you learned that when light goes through a small opening (ex: single slit) it displays wave properties. Two light waves with the same frequency and wavelength which travel on different paths can interfere and make bright fringes with constructive interference and dark fringes with destructive interference. Since the single slit has a width "a", there are a range of paths that the light takes to arrive at a point on the screen. With a double slit, light also takes many paths as it passes through each of the two slits and so it will interfere when arriving at the same point on the screen.



Practice lining up the laser to pass through single slits and double slits. Investigate the pattern of bright and dark fringes produced by each of these single slits and double slits.

Part 2: Interference Patterns from Single Slits and Double Slits

1. Describe the pattern you observe when the laser light passes through a single slit. Pay close attention to the width of the central bright fringe compared to the other bright fringes.

2. Compare the patterns you observe from the wider single slit and the narrower single slit. List similarities and differences.

Similarities:

Differences:

3. Describe the pattern you observe when the laser light passes through a double slit. Pay close attention to the fine detail.

4. Compare the patterns you observe from the narrower double slit and the narrower single slit just above it. List similarities and differences. Pay close attention to the fine detail.

Similarities:

Differences:

When you shine the light on the narrower double slit what you first notice is the single slit pattern. Carefully observe that the single slit pattern is superimposed on the bright fringes of the double slit pattern. If you didn't notice the closely spaced bright and dark pattern earlier, go back to Question 4 and revise your answers.

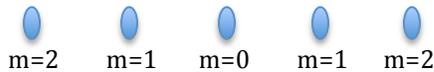
5. Now observe the pattern from the more widely separated double slit. The closely spaced fringes from the wider double slit are hard to notice because they are so close to each other. Be careful when you make observations not to interpret single slit fringes as double slit fringes. Carefully describe what you observe.

Part 3: Double Slits with Different Wavelengths

6. Make the following observations using three different color lasers. During your observations do not make any changes to the distance (L) between the slit and the screen. We keep this parameter constant for our first observations.

Color	Sketch the interference pattern. Pay attention to relative center to center distance between the bright fringes. Draw only the center bright fringe and two other fringes to both sides. Follow a same scale for drawing for comparison.	
	Narrower double slit	Wider double slit
Red		
Green		
Blue		

7. Now name the fringes on your sketches in Question 6 as follows with an order “m.”
 Central bright fringe: Zero order fringe or central maximum; $m=0$.
 Two bright fringes (to the left and ant right) next to the central fringe: first order fringes; $m=1$.
 Second set of two bright fringes: second order fringe etc.: $m=2$.



8. For the narrower double slit which color gave you the largest separation between bright fringes?
9. For wider double slit, which color gave you the largest separation between bright fringes?
10. Which double slit and color gave you the largest separation between the bright fringes?
11. For the double slit and color you answered in Question 10, is the center to center distance between any two consecutive (adjacent) bright fringes the same, that is, are the centers of the bright fringes evenly spaced apart?

12. How does intensity of the fringes change as you go from zero to higher orders?
13. Now select the color and slit which gave you the largest separation for bright fringes. Increase or decrease the distance between the slit and the screen and observe what happens to the center to center distance between the central fringe and the 1st order bright fringes. Record your observations below.

Part 4: Testing a Mathematical Model for the Double Slit Interference Pattern

Based on the observations you made so far one of your colleagues suggests that the distance to the center of the first bright fringe from the center of the center fringe, y , can be expressed mathematically as follows.

$$y = \frac{\lambda L}{d}$$

Where L = distance between the screen and the double slit
 d = slit separation in the double slit
 λ = wavelength of the light

This is a hypothesis that we need to investigate, but we have already done some experiments.

14. Is the hypothesis above consistent with the dependence of fringe separation on wavelength that you observed (that is, the data in the table in Question 6)? Explain how it is or is not.
15. Is the hypothesis above consistent with the dependence of fringe separation on slit separation that you observed (that is, the data in the table in Question 6)? Explain how it is or is not.

16. Is the hypothesis above consistent with the dependence of fringe separation on the distance between the screen and the slits that you observed (that is, your answer to Question 13)? Explain how it is or is not.
17. You just finished an investigation in which you found an empirical formula to find out the separation of two consecutive bright fringes in a double slit interference pattern. You did not follow a theory to come up with that formula. It was purely based on observations. In your physics class you learned that “light is an electromagnetic wave and results of double slit experiment can be explained as an interference pattern of light waves coming from two sources.” That raises a question. You had only a single laser pointer. What were the two sources that produced the interference pattern for a given color?
18. When you developed theory for double slit interference you learned that $d \sin \theta_m = m\lambda$ and then using small angle approximation it was reduced to $y_m = \frac{m\lambda L}{d}$. Measure the separation between fringes and the distance from the slit to the screen and show that the angle θ_m is small for $m=1$.