Double Slit Interference and the Wavelength of Light

Equipment List: Simulation (phet.colorado.edu): Wave Interference.

In this experiment you will observe the interference pattern of a simulated double slit experiment. Measurements will be taken of the pattern and the setup of the double slit to determine the wavelength of the incident light. The wavelength of the light is adjustable, as well as the separation distance between slits, to allow us to explore how changes in these parameters affect the interference pattern.

Measurements of the separation of the slits and of the resulting interference pattern are to be used to calculate the wavelength of the incident light. An alternate method of determining the wavelength of the incident light will also be used. A comparison of the wavelengths will be done.

A source of monochromatic light will emit wave fronts of light at a particular frequency. The amount of time from one wave front to the next wave front is equal to the period, T, of oscillation. The distance between wave fronts is equal to the length of the wave (1 wavelength, λ). Light, in vacuum, travels at a velocity, c, equal to 2.99792458 x 108 meters/second. In air, the velocity is very nearly equal to this value. For this experiment, the rounded value of **3 x 108 m/s** will do fine. The wavelength of the incident light can be determined using the following relationship:

When planar wave fronts of monochromatic light strike a barrier with two slits the light that interacts with each slit will be diffracted into circular wave fronts. The circular wave fronts from each slit will then overlap with each other, interfering with each other. This interfering will generate an interference pattern, the spacing of each line dependent upon the wavelength of the light, the separation of the slits, and how far away the screen is from the slits, showing the interference pattern.

p = 0

p = -1

p = +1

p = -3

p = -2

p = +3

p = +2

Ɵ

Figure 1

For the Double Slit Experiment the relationship is:

Where p is the order number, λ is the wavelength, d is the separation between the centers of the two slits, and Ɵ is the angle as measured from the center of the p = 0 order (central maximum).

The angle Ɵ will be determined from measuring the distance between the barrier with the two slits to the screen, and the distance the center of the interference maxima to the center of the p = 0 order.

Ɵ

L

y

The angle Ɵ is then determined:

Measure the distances using the virtual tape measure in the simulation.

Open the simulation called Wave Interference and click on the choice called “Slits”. The default setting opens to using a water wave generator. Change this to the Light Generator by clicking on the icon for a laser pointer in the box located on the right hand side of the screen. Once this is done you will see a slide button that controls the Frequency of the incident light.

**Part 1: Green Light**

Do not change the setting, yet. You will use this initial setting for your first wavelength of light. It should be in the green range of the available colors.

**Determining the Wavelength of the Incident Light by Measuring the Period.**

For each of the wavelengths used in this experiment, and to reduce the amount of uncertainty in starting and stopping the stopwatch, measure how long it takes for 20 wave fronts to pass the same point in space. Using the right hand edge of the space that the wave fronts travel is a good point. Once the total time is measured divide this by twenty to determine the time for one period.

Click on the drop down arrow next to where it says “One Slit” and choose “No Barrier”. In the upper right hand corner of your screen you should see an icon of a digital stop watch. Click and drag the stop watch down to use it. This virtual stop watch measures in femto-seconds (1fs = 1 x 10-15 seconds). Click on the green button on the Light Generator to start the wave fronts traveling. Record the amount of time for 20 wave fronts passing your chosen point onto the Excel worksheet. Repeat this 4 more times (total of 5 timings).

Determine the time it takes for one Period for each timing, then take the average of these. Use the average time for a Period and the velocity of light to determine the wavelength.

**Determining the Wavelength of the Incident Light by Measuring the Interference Pattern.**

1. **Original Distance Between Barrier and Screen**

Change “No Barrier” to “Two Slits”. Adjust the Slit Width to 300 nm and the Slit Separation to 1600 nm. For this part you do not need the stop watch. Use the virtual tape measure to measure the distance L between the barrier and the screen. Check the “Screen” option, and then check the “Intensity” option. This will open a screen to “see” the interference pattern, and a grid to see the intensity of the pattern. Turn on the Light Generator and you will see the interference pattern form.

Each peak in the pattern (shown best on the grid) represents the middle of each maxima of the pattern. The center peak corresponds to the p = 0 order (central maximum), with increasing (+/-) order numbers on either side as you move away from the central maximum.

Use the virtual tape measure to measure from the peak of the central maximum to each of the other maxima peaks, recording these distances on the worksheet. This distance between the central maximum and each of the numbered maxima is the distance y.

Determine the angle for each and the wavelength for each. Average the wavelengths.

1. **Change the Barrier Position**

This procedure is just like part A., except that you change the barrier position with the slits to a position given by your lab instructor. The number of maxima may change and your lab instructor will ask you to either measure more, or less maxima distances from the central maxima. Since the barrier has changed position you will need to re-measure the distance L between the barrier and the screen.

1. **Change the Positions of the Slits**

Keep the same position of the barrier as is in part B., but change the positions of the slits to a distance given by your lab instructor. Again, the number of maxima may change. Repeat the procedure given in part A. to complete this section.

On your worksheet determine the percent error between the wavelengths found in parts A,B, and C as compared to the wavelength found by measuring the period. Also, determine the percent error between the wavelength found in part C as compared to the wavelength found in part A.

**Part 2: Red Light**

Adjust the Frequency Slide Button so that you are in the middle of the red region of wavelengths. For part 2 you will determine the wavelength of the chosen red light. Repeat with the same procedure as for part 1. To acquire the same beginning position of the barrier re-open the simulation and start new. Adjust parameters as you did in part 1 and adjust the frequency to the middle of the red region.

**Results:**

State whether, or not, that the wavelengths determine for the green light using interference are in agreement with the wavelength determined by using the period. Look up the range of wavelengths for green light and compare with your values. Repeat for the red light.

**for Discussion:**

1. Describe what happened to the interference pattern (either for green light, or for red light) when the barrier distance was changed. Was there a change in the wavelength determined using this new barrier position from the initial barrier position? If so, what may have caused this?
2. Describe what happened to the interference pattern when the slit positions were changed. Does this go along with the equation for the interference? Was the effect more pronounced for the red light, or for the green light? Why did this happen?
3. Using the wavelength determined for the red light and a separation of slits equal to 1600 nm, what is the maximum number of fringes (interference lines) that can be generated? Do this also for the green light wavelength.
4. What kind of interference is occurring at the positions of maxima in the interference pattern? Describe this type of interference. What kind of interference is occurring at the positions of minima in the interference pattern? Describe this type of interference.