CCMR Educational Programs

Title:	**Understanding Interference and Diffraction Patterns through Drawing**
Date Created:	August 2006
Author(s):	Jordan Pekor
Appropriate Level:	Regents Physics
Abstract:	Students often have difficulty understanding how interference and diffraction patterns are formed, and how changing variables (slit separation, wavelength, and distance from slits to screen) can affect the pattern. This lesson addresses these issues by using a model for double slit diffraction and by having students draw diagrams of diffraction patterns.
Time Requirement:	One or two 45 minute periods
Objectives:	Students will be able to… • Identify crests and troughs of a wave. • Measure wavelength. • Use the equation $v = f\lambda$ and $T = 1/f$. • Draw interference and diffraction patterns. • Explain the effects of changing wavelength, slit separation, or distance to screen on the spacing of the diffraction pattern.
NY Standards Met:	• Standard 1—Analysis, Inquiry, and Design Students will use mathematical analysis, scientific inquiry, and engineering design, as appropriate, to pose questions, seek answers, and develop solutions. • Standard 4—Science Students will understand and apply scientific concepts, principles, and theories pertaining to the physical setting and living environment and recognize the historical development of ideas in science. • Standard 6—Interconnectedness: Common Themes Students will understand the relationships and common themes that connect mathematics, science, and technology and apply the themes to these and other areas of learning. Models are simplified representations of objects, structures, or systems used in analysis, explanation, interpretation, or design. • Standard 7—Interdisciplinary Problem Solving Students will apply the knowledge and thinking skills of mathematics, science, and technology to address

	real-life problems and make informed decisions.
Equipment/Materials List:	• Foam board • ½" Ribbon • Thumb Tack • Masking Tape • Wave cutting scissors • 1/8" eyelets • 1/8" hole punch • Eyelet stamp • Hammer • Oak Tag (Yellow and Green) • Masking Tape • Razorblade Knife • Pen and Pencil • Letter-sized paper

Notes to Teacher

This lesson should be used to introduce interference and diffraction patterns to students in high school Regents Physics. Students should already know how to measure wavelength, should be familiar with electromagnetic waves, and should understand the concepts of interference and diffraction. This lesson will help students to understand what causes interference patterns to form, and what factors affect the spacing of these patterns. Construction of the model should be done prior to this lesson, and due to the amount of time it takes to construct, students may be selected to help with its construction.

Construction of Model

1. Cut three slits in Styrofoam board with razor blade knife, as shown in diagram.
2. Run ribbon through the top slit and the middle slit. Run another ribbon through the bottom slit and the middle slit.
3. Place a piece of masking tape on each ribbon to indicate slits in a barrier.
4. Push a thumbtack through the middle of the masking tape.
5. Cut waves of varying wavelengths using wavy scissors often used in scrapbook making. In my setup, I used yellow paper for the longer wavelength wave and green for the shorter wavelength wave.
6. Fasten white eyelets long the wave at each crest and black eyelets at each trough.

Suggestions for Instruction

I suggest demonstrating double-slit diffraction with a laser and two slits. As students what they think they might see prior to actually demonstrating it. When they see that more than two bright stops appear, they may get interested start asking questions about what causes this pattern.

At this point, introduce the model of diffraction, and have student complete the hands-on activity provided. This will walk them through the concepts that lead to diffraction patterns as well as review the concepts of wavelength, period, electromagnetic radiation, crest, trough, interference, and diffraction.

After this lesson, I suggest moving on the lab "Diffraction and Interference of Light" developed by the Cornell Center for Materials Research, available at www.ccmr.cornell.edu.

Name	______________________
Partners	______________________
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Date	______________________

Interference and Diffraction Patterns

Theory

When a wave passes through an opening in a barrier, the wave spreads out, or **diffracts**, as shown in Figure 1. When two waves occupy the same location, they **interfere**. When this interference results in a larger wave, we call it **constructive interference**. When the size of the wave is reduced, it is called **destructive interference**.

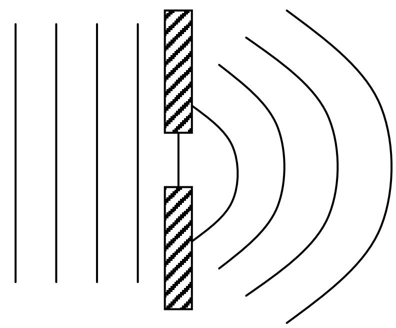

Figure 1 - Diffraction

Suppose a wave is incident upon a barrier that has two opening, as shown below. The wave will pass through each opening and diffract. These two diffracted waves will then overlap, and interference will occur (see Figure 2a). This interference result in a fringe pattern called an **interference and diffraction pattern** (see Figure 2b). It is this pattern, and the factors that affect it, that we will study in this activity.

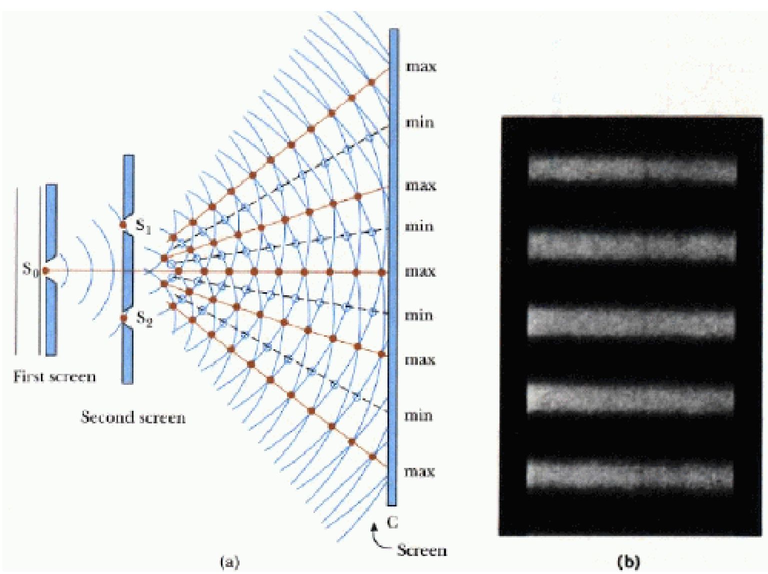

Figure 2 – Double Slit Interference and Diffraction

Procedure

I. Measuring the Wave – In this section, we will measure characteristics of the two waves provided. The waves handed out represent electromagnetic waves. For this entire lab, assume that all the waves are electromagnetic. The same phenomena would occur for all types of waves.

1. Measure the wavelength of each wave, and record it in the table below.
2. Supposing that these are electromagnetic waves, what is the speed of each wave? Record your answer in the table below.
3. Calculate the frequency of each wave in the table below. Show all work.
4. Calculate the period of each wave below. Show all work.
5. What type of electromagnetic radiation would these represent?

Yellow Wave	Red Wave
λ =	Λ =
v =	v =
Frequency	Frequency
Period	Period
Type	Type

II. Constructing a Diffraction Pattern – In this section, we will draw **wave fronts** representing the waves after they diffract through the two openings. Recall that a wave front is the locust of points that are in phase on adjacent waves. We will draw the wave fronts created by the crests in pen, and the wave fronts created by the troughs in pencil.

1. Place a sheet of 8 ½" x 11" paper in the space provided. Label this paper yellow wave.
2. Move the ribbon so that the slits are closely spaced. Measure the distance between the centers of the openings. Record this distance in the space provided.

   d = ___________ m

3. Place the waves such that the first black hole is sitting on the thumbtacks.
4. One wave at a time, place a pen in each black hole, and trace an arch on the paper. These black holes indicate the location of a crest.
5. With a pencil, repeat step five for the white holes. The white holes indicate the location of the troughs.
6. Repeat steps 4 and 5 for the wave on the other thumbtack.

III. Analyzing the Diffraction Pattern – In this section, we will look at the pattern formed by the overlapping waves. We will look for constructive interference, which will result in a bright spot. We will also look for destructive interference, which will result in dark areas.

1. Maximum constructive interference occurs when two crests or two troughs coincide. Find a vertical line along which you find a lot of constructive interference. Fold over the paper from the side furthest from the slits, such that the edge lies along the vertical line.
2. This folded over paper will act like the screen. Write a letter C on the part of the paper you just folded over everywhere you see constructive interference. Write a D where you see a crest meet a trough, and there is destructive interference. Notice that the letters should alternate.
3. Where you wrote a C, there would be bright area. Where there is a D, there would be no light. Notice the alternation of bright and dark areas, as you saw in the demonstration before this activity.

IV. Factors Affecting the Pattern – In this part of the activity, we will do the same thing as in part III, but we will alter the distance to the screen, the slit separation, and wavelength of the wave.

1. Take the diagram you produced in Part III, and fold the edge over even more so as to simulate a smaller distance between the slits and the screen. Again, write a letter C on the part of the paper you just folded over everywhere you see constructive interference. Write a D where you see a crest meet a trough, and there is destructive interference. Notice that the letters should alternate. Describe how the pattern has changed.

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2. Start with a new sheet of paper. This time, slide the ribbons so that the masking tape is further apart. Repeat the procedure in Part II and III. Be careful to fold over your paper about the same amount as you did in Part III of this activity. Describe how the new diffraction pattern differs from your original.

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3. Leaving the slit separation the same as you did in step 2 of this part, interchange the yellow waves with the green waves. Notice that the green wave has longer wavelength. Repeat parts II and III, and describe how this pattern differs from that produced in step 2.

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Questions

1. Circle the correct word in the following table to summarize how the following variables affect the diffraction pattern.

A larger distance to the screen will result in a diffraction pattern that is (more/less) spread out.
A larger slit separation will result in a diffraction pattern that is (more/less) spread out.
A larger wavelength will result in a diffraction pattern that is (more/less) spread out.

2. The diffraction equation is written as follows:

$$w = \frac{Ld}{\lambda}$$

Where w = the pattern spacing
L = distance to screen
d = the slit distance
λ = wavelength

Do your results agree with this equation? How can you tell?

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3. In designing a concert hall, why might it be important to think about diffraction and interference patterns? How might this affect how seats are arranged and where speakers are placed?

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