Activity P35: Light Intensity in Double-Slit and Single-Slit Diffraction Patterns (Light Sensor, Rotary Motion Sensor)

Concept	*DataStudio*	*ScienceWorkshop* (Mac)	*ScienceWorkshop* (Win)
Interference	P35 Diffraction.ds	P58 Diffraction Patterns	P58_DIFF.SWS

Equipment Needed	Qty	Equipment Needed	Qty
Light Sensor (CI-6504A)	1	**Diode Laser (OS-8525)**	1
Rotary Motion Sensor (CI-6538)	1	**Linear Translator (OS-8535)**	1
Aperture Bracket (OS-8534)	1	**Slit Accessory (OS-8523)**	1
Basic Optics System (OS-8515)	1		

What Do You Think?

The wave nature of light can be investigated by studying diffraction patterns. What is diffraction and just how can the observance of diffraction patterns be used to verify the wave nature of light?

Take time to answer the 'What Do You Think?' question(s) in the Lab Report section.

Background: Part One

In 1801, Thomas Young obtained convincing evidence of the wave nature of light. Light from a single source falls on a slide containing two closely spaced slits. If light consists of tiny particles (or "corpuscles" as described by Isaac Newton), we might expect to see two bright lines on a screen placed behind the slits. Young observed a <u>series</u> of bright lines. Young was able to explain this result as a wave interference phenomenon. Because of diffraction, the waves leaving the two small slits spread out from the edges of the slits. This is equivalent to the interference pattern of ripples produced when two rocks are thrown into a pond.

In general, the distance between slits is very small compared to the distance from the slits to the screen where the diffraction pattern is observed. The rays from the edges of the slits are essentially parallel. Constructive interference will occur on the screen when the extra distance that rays from one slit travel is a whole number of wavelengths in difference from the distance that rays from the other slit travel. Destructive interference occurs when the distance difference is a whole number of half-wavelengths.

For two slits, there should be several bright points (or "maxima") of constructive interference on either side of a line that is perpendicular to the point directly between the two slits.

Background: Part Two

The interference pattern created when monochromatic light passes through a <u>single</u> slit is similar to the pattern created by a double slit, but the central maximum is measurably brighter than the maxima on either side of the pattern. Compared to the double-slit pattern, most of the light intensity is in the central maximum and very little is in the rest of the pattern.

The smaller the width of the slit, the more intense the central diffraction maximum.

SAFETY REMINDER

- Follow all safety instructions.

THINK SAFETY
ACT SAFELY
BE SAFE!

For You To Do

In Part A of this activity, use the Light Sensor to measure the intensity of the maxima in a double-slit diffraction pattern created by monochromatic laser light passing through a double-slit. Use the Rotary Motion Sensor (RMS) to measure the relative positions of the maxima in the diffraction pattern.

In Part B, use the Light Sensor to measure the intensity of the maxima in a single-slit diffraction pattern created by monochromatic laser light passing through a single-slit. Use the Rotary Motion Sensor (RMS) to measure the relative positions of the maxima in the diffraction pattern.

Use *DataStudio* or *ScienceWorkshop* to record and display the light intensity and the relative position of the maxima in the pattern and to plot intensity versus position.

PART IA: Computer Setup – Double-Slit Diffraction Pattern

1. Connect the *ScienceWorkshop* interface to the computer, turn on the interface, and turn on the computer.

2. Connect the Light Sensor into Analog Channel A on the interface.

3. Connect the Rotary Motion Sensor stereo phone plugs to Digital Channels 1 and 2.

4. Open the document titled as shown:
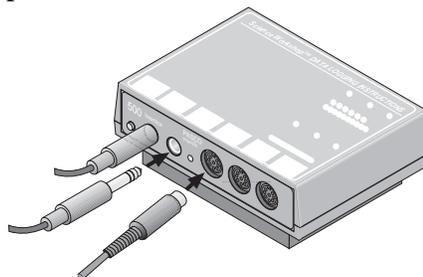
DataStudio	*ScienceWorkshop* (Mac)	*ScienceWorkshop* (Win)
P35 Diffraction.ds	P58 Diffraction Patterns	P58_DIFF.SWS

- The *DataStudio* document has a Workbook display. Read the instructions in the Workbook.

- The *ScienceWorkshop* document opens with a Graph display of light intensity vs. position.

- Data recording is set at 50 measurements per second (50 Hz).

PART IIA: Sensor Calibration & Equipment Setup – Double-Slit Diffraction Pattern

- You do not need to calibrate the sensors.

Equipment Setup

1. Mount the Diode Laser on one end of the Optics Bench. Connect the power supply to the laser.

2. Place the MULTIPLE SLIT SET into the Slit Accessory holder. Mount the Slit Accessory holder in front of the Diode Laser on the bench.
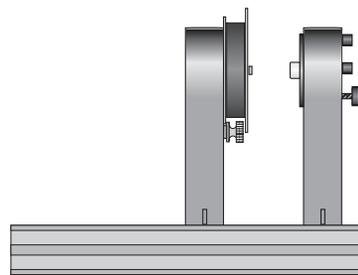
3. Put the rack from the Linear Translator through the slot in the side of the Rotary Motion Sensor. Put the rack clamp onto the rack and tighten its thumbscrew.

4. Place the rack with the sensor onto the Linear Translator so the back end of the sensor rests on the upright edge of the base of the Linear Translator. Use the thumbscrews to attach the
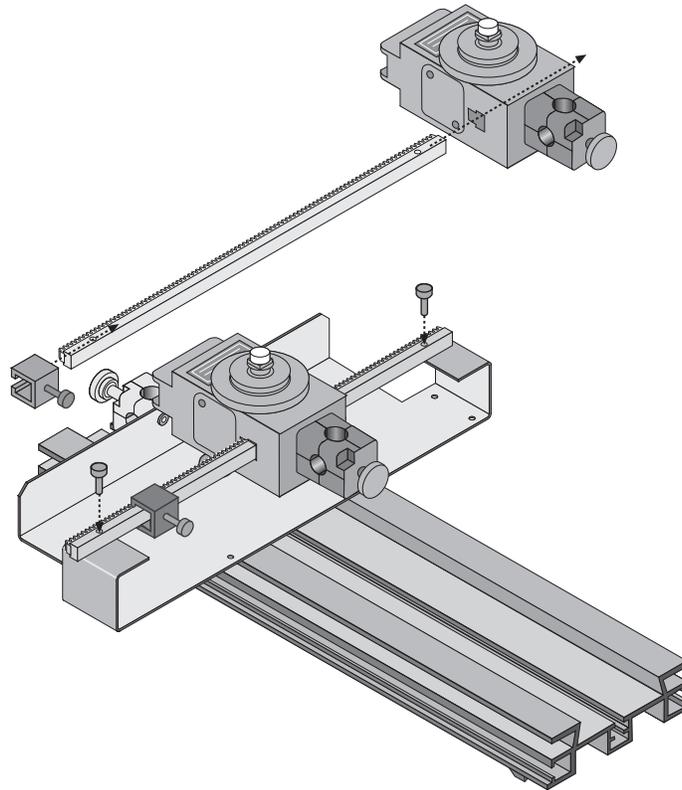
rack to the translator.

5. Remove the 'O' ring and thumbscrew from the Rotary Motion Sensor pulley so they will not interfere with the Aperture Bracket.

6. Mount the Light Sensor onto the Aperture Bracket by screwing the Aperture Bracket post into the threaded hole on the bottom of the Light Sensor.
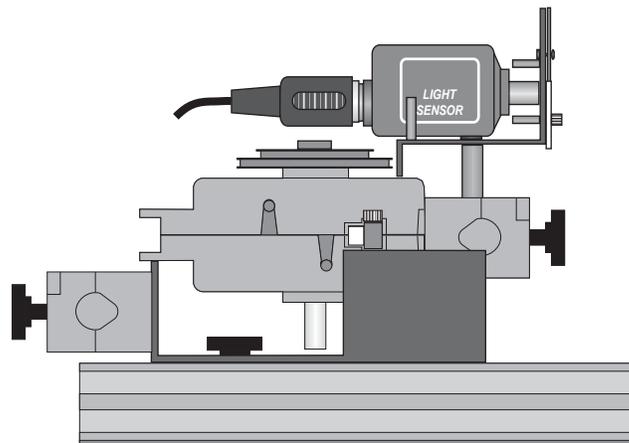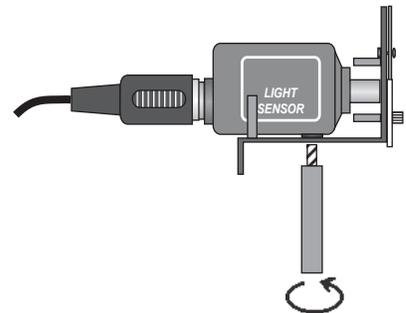
7.   Put the post into the rod clamp on the end of the Rotary Motion Sensor. Tighten the rod
      clamp thumbscrew to hold the Aperture Bracket and Light Sensor in place.

8.   Turn on the power switch on the back of the
      Diode Laser. Adjust the position of the laser
      and the MULTIPLE SLIT SET on the Slit
      Accessory so that the laser beam passes
      through one of the double-slit pairs on the
      SLIT SET and forms a clear, horizontal
      diffraction pattern on the white screen of the
      Aperture Bracket.

Light Sensor

Diode Laser

Rotary Motion
Sensor

Slit Accessory
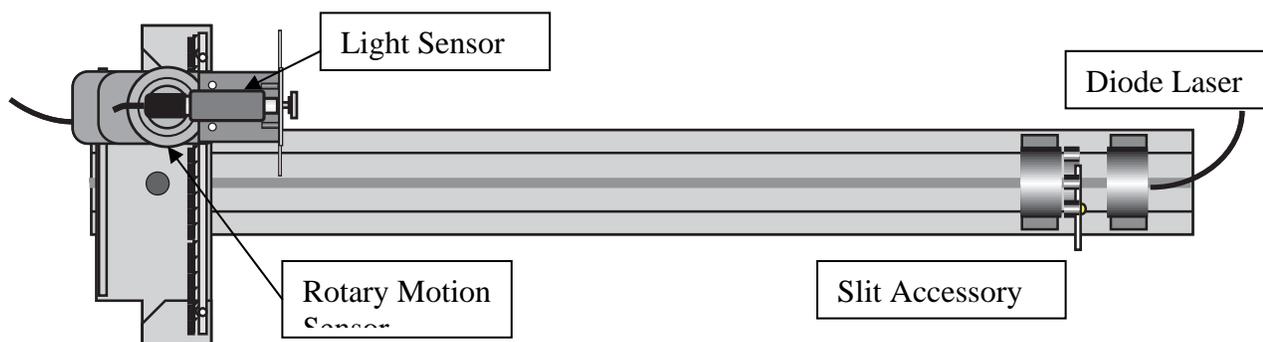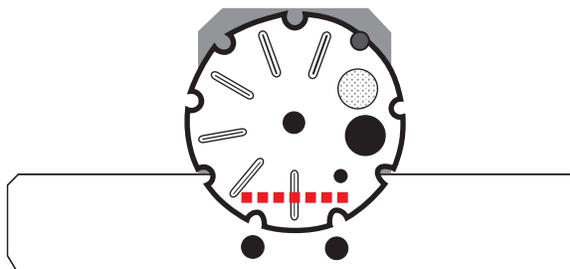
9.   Record the slit width "a" and slit spacing "d" of the double-slit pattern you use in the Lab
      Report section.

10.   Rotate the Aperture Disk on the front of the Aperture Bracket until the narrowest slit is in
      front of the Light Sensor opening.

Preparing to Record Data

•   Before recording any data for later analysis, you should experiment with the Rotary
      Motion Sensor and Light Sensor setup.

•   Move the Rotary Motion Sensor/Light Sensor along the rack until the maximum at one
      edge of the diffraction pattern is next to the slit in front of the Light Sensor.

•   Begin recording data.

•   Slowly and smoothly, move the Rotary Motion Sensor/Light Sensor so that the maxima of
      the diffraction pattern move across the slit on the Aperture Disk.

•   When the entire interference pattern has been measured, stop recording data. 'Run #1' will
      appear in the Data List.

•   Rescale the Graph to fit the data. Examine the plot of light intensity versus position..

•   Erase your data. Select Run #1 in the Data List and press the 'Delete key on the keyboard.

PART IIIA: Data Recording – Double-Slit Diffraction Pattern

•   Move the Rotary Motion Sensor/Light Sensor along the rack until the maximum at one
      edge of the diffraction pattern is next to the slit in front of the Light Sensor.

1.   Begin recording data.

2.   Slowly and smoothly, move the Rotary Motion Sensor/Light Sensor so that the maxima of the diffraction pattern move across the slit on the Aperture Disk.

3.   When the entire diffraction pattern has been measured, stop recording data.

PART IB: Computer Setup – Single-Slit Diffraction Pattern

• Use the same computer setup as in Part A.

PART IIB: Sensor Calibration & Equipment Setup – Single-Slit Diffraction Pattern

1. Replace the MULTIPLE SLIT SET with the SINGLE SLIT SET on the Slit Accessory Holder.

2. Record the slit width "a" of the single-slit pattern you use in the Lab Report section.

3. Re-align the laser beam with one of the single slits on the SINGLE SLIT SET. Adjust the positions of the laser and the Rotary Motion Sensor/Light Sensorif necessary so that the diffraction pattern is at the same height for the double-slit.

PART IIIB: Data Recording – Single-Slit Diffraction Pattern

1. Repeat the procedure for collecting data as in Part A.

• Run #2 will appear in the Data List in the Experiment Setup window.

2. Turn off the laser.

Analyzing the Data

1. Rescale the Graph to fit the data.

2. Examine the shape of the plots of light intensity versus position for both the double-slit and the single-slit patterns.

• In *ScienceWorkshop*, the Graph will display the most recent run of data. Use the 'Add Plot

   Menu' to create a second plot on the Graph. Click the 'Add Plot Menu' button ([icon])
   and select 'Analog A, Intensity' from the Add Plot Menu.

• Both plots will show the most recent run (Run #2) of data. Use the 'DATA Menu' in the top plot of the Graph to display Run #1.

   Click the 'DATA Menu' button ([DATA]) in the top plot of the
   Graph. Select 'No Data' to clear Run #2. Click the DATA Menu button again and select Run #1. **Result**: The top plot will display Run #1 and the bottom plot will display Run #2.
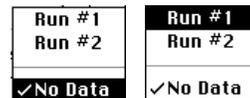
Lab Report - Activity P58: Diffraction Patterns

What Do You Think?

The wave nature of light can be investigated by studying diffraction patterns. What is diffraction and just how can the observance of diffraction patterns be used to verify the wave nature of light?

Data

	Slit Width (a)	Slit Spacing (d)
Part A – Double-slit		
Part B – Single-Slit		

Question

1. How does the plot of light intensity versus position for the double-slit diffraction pattern compare to the plot of light intensity versus position for the single-slit diffraction pattern?

Name _____   Class _____   Date _____