# Diffraction Demystified

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**Date Created:** March, 2003/Updated September, 2016

**Subject:** Physics

**Grade Level:** High School Physics students

**Standards:** Next Generation Science Standards ([www.nextgenscience.org](http://www.nextgenscience.org))

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
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<tbody>
<tr>
<td>HS-PS4-1</td>
<td>Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media</td>
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<tr>
<td>HS-PS4-5</td>
<td>Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy</td>
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**Schedule:** Two to three 45-minute class periods

**CCMR Lending Library Connected Activities:** Light Waves
**Objectives:**

Learn about principles of light and light waves. Discover how diffraction and interference of light waves can be used to measure the dimensions of very small objects.

<table>
<thead>
<tr>
<th>Vocabulary:</th>
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<tr>
<td>Diffraction</td>
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<tr>
<td>Frequency</td>
</tr>
<tr>
<td>Wavelength</td>
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<tr>
<td>X-Ray</td>
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**Students Will:**

- Examine diffraction patterns from a range of objects using a laser pointer.
- Work with the diffraction from metal meshes to gain quantitative confirmation of the wave nature of light.
- Measure the track spacing on CDs and DVDs using the wave model of light.
- Measure the width of their hair.
- Apply their experience of light diffraction to electron and X-ray diffraction images of matter.
- Review and discuss concepts learned throughout the activity.

<table>
<thead>
<tr>
<th>Materials:</th>
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</thead>
</table>
| **For Wire Mesh Station (4-6 students)**
  
  ___ 2 Laser pointers
  ___ 2 Laser Stands (Wooden block w/rubber band)
  ___ 2 Clothespins (for holding wire mesh)
  ___ 2 Projection screen (Cardboard & Wood Block)
  ___ 2 Magnifying lenses
  ___ Mesh samples (coarse and fine)

| **For CD/DVD Station (4-6 students)**
  
  ___ 2 Laser pointers
  ___ 2 Laser Stands (Wooden block w/rubber band)
  ___ 2 CD/DVD Holder (Wooden block)
  ___ 2 CD’s
  ___ 2 DVD’s
  ___ Empty Diffraction Slide (for hair mounts)

| **For Hair Station (4-6 students)**
  
  ___ 2 Laser pointers
  ___ 2 Laser Stands (Wooden block w/rubber band)
  ___ 2 Clothespins (for holding wire mesh)
  ___ 2 Projection screen (Cardboard & Wood Block)
  ___ 2 Hair Mount Slides

| **For Teacher Demos**
  
  ___ Prism
  ___ Diffraction glasses
  ___ Magnifying lens

**Teacher Will Need to Provide**

- Metersticks & Rulers
- Adjustable slit
- White paper
- Chalk

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**Safety**

Students should use extreme caution when operating the laser pointer. The laser beam should never be pointed at any one’s eyes.
Science Content for the Teacher:

Pre-Teaching Concepts:

- Light is a wave.
- Wavelength of light is small.
- Spectrum of light is due to wavelength of light.
- Some exposure to milli, micro and nanometers.
- Ideally, students have seen water, sound or other physical waves diffract.
- Students must think through the difference between projection and diffraction.

What is LASER Light? Laser light is monochromatic, collimated, and coherent.

- Monochromatic- All the light waves are of the same frequency.
  It looks like one color.
  It does not spread out after passing through a prism.

- Collimated- All the light waves are parallel.
  Show the spot does not spread out.
  Use chalk powder to show the light path.
  Talk about bouncing lasers off the Moon.

- Coherent- All the light waves are in phase.
  Use a magnifying lens to spread out the laser beam into a broad spot on the screen. There are black and bright patches all across the spot. This is called “speckle” and only occurs for lasers and other types of coherent light.

Materials needed:
Prism, Chalk dust, and a magnifying lens.

Reciprocal Nature of Size and Angle –

Pass laser light through an adjustable slit. As the slit narrows the diffraction pattern grows in size. Small objects diffract widely. Large objects diffract a smaller amount.

Materials needed:
Adjustable slit

For more info, refer to Teacher Activity Guide and Introduction to Diffraction: Teacher Supplement

Preparation:

1. Photocopy print materials (Activity Sheets 1-3) for each student pair or group.
2. Set up stations for each activity.

**Classroom Procedure:**

*Engage (Time: 15 mins)*  
Discuss the basic concepts of light outlined in ‘Science Content’ with the students. Demonstrate the ‘Pre-Teaching Concepts’ and discuss the terminology. When performing the demonstrations, ask students to try to explain the phenomena they are witnessing before giving them the answer.

*Explore (Time: 60 mins)*  
Divide students into groups of two or three to complete the three activities.

1) *Wire Mesh Activity*  
2) *CD/DVD Activity,*  
3) *Hair Thickness Activity*

When they have completed the activities, groups can work on the “Further Questions.”

*Explain (Time: 20 mins)*  
Have the class come together for a discussion of what they learned. Discuss the lab questions as well as any points the students are still unclear about. Answers provided in *Teacher Activity Guide.*

**Assessment:**

The following rubric can be used to assess students during each part of the activity. The term “expectations” here refers to the content, process and attitudinal goals for this activity. Evidence for understanding may be in the form of oral as well as written communication, both with the teacher as well as observed communication with other students. Specifics are listed in the table below.
1= exceeds expectations  
2= meets expectations consistently  
3= meets expectations occasionally  
4= not meeting expectations

<table>
<thead>
<tr>
<th>Engage</th>
<th>Explore</th>
<th>Explain</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Shows leadership in the discussion and offers creative ideas reflecting a good understanding of the physics behind light waves.</td>
<td>Completes work accurately while providing an explanation for what is observed. Works very well with partner.</td>
</tr>
<tr>
<td>2</td>
<td>Participates in the brainstorm and shows an understanding of the physics related to light waves.</td>
<td>Completes work accurately and works cooperatively with partner.</td>
</tr>
<tr>
<td>3</td>
<td>Contributes to the brainstorm, but shows little understanding of light waves.</td>
<td>Works cooperatively with partner, but makes some mistakes with the procedure.</td>
</tr>
<tr>
<td>4</td>
<td>Does not participate in brainstorm. Shows no understanding of light waves.</td>
<td>Has trouble working with partner. Does little to complete the procedure.</td>
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