Lesson Title	Diffraction of Waves Demonstration
Length of Lesson	30 minutes
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Subject	Physics
Grade Level	11-12
State Standards	Physics: 4a and 4e
DOK Level	DOK 2
DOK Application	Identify patterns, Interpret, Cause/Effect, Make Observations.
National Standards	9-12: B (Physical Science)
Graduate Research Element	Beam forming as in Sonar and Radar with a phased array

Student Learning Goal:
The students will learn about diffraction of waves, and that light and sound are waves.

Physics: 4a. Describe and model the characteristics and properties of mechanical waves.

- Simple harmonic motion
- Relationships among wave characteristics such as velocity, period, frequency, amplitude, phase, and wavelength
- Energy of a wave in terms of amplitude and frequency.
- Standing waves and waves in specific media (e.g., stretched string, water surface, air, etc.)

4e. Investigate and draw conclusions about the characteristics and properties of electromagnetic waves.

National Science Education Standards of Content 9 – 12
B (Interactions of Energy and Matter): Waves, including sound and seismic waves, waves on water, and light waves, have energy and can transfer energy when they interact with matter.

Materials Needed (supplies, hand-outs, resources):
Diffraction grating, laser, computer speakers, and computer.

Lesson Performance Task/Assessment:
Students will witness a demonstration that light and sound are composed of waves. The teacher can require the students to demonstrate farther knowledge by estimating the wavelength of the laser or the properties of the diffraction grating, but the purpose of this is to show the students that light and sound are waves.

Lesson Relevance to Performance Task and Students:
The students will see that light and sound are waves.

Anticipatory Set/Capture Interest:
Ask the students "What do light and sound have in common?" "If light and sound are waves, how can we prove this?" "Can a beam of light or sound neutralize another beam of light or sound?"

Guided Practice:
The teacher should start by talking about slit experiments with waves. This can be shown to them using water, but it is probably easier to show the students a video or nice diagram. You can find them on the Internet relatively easily. You want to show that waves passing through the slits interact with each other and produce a multi-striped diffraction pattern, while particles produce 2-striped pattern. The question students should be asking is what pattern does light have.

The teacher should then demonstrate that light has the multi-striped pattern by shining a laser through a diffraction grating. This will break the single laser beam into multiple beams. The teacher should make sure the students understand that this pattern is caused diffraction. The teacher can then demonstrate diffraction in sound by setting two computer speakers 39 cm apart, and playing the sound files included with the lesson. The most interesting is the sound file where the two speakers are 90 degrees out of phase. In this one, an observer hardly hears the sound if standing directly in front of speakers, but if he or she moves to the side, it becomes louder. Unfortunately, the ears have a non-linear response to sound volume, so the listener has to be very observant. Also remember that the sound files produce a 440 Hz signal, which has a wavelength of about 78 cm, so the observer has to be standing a few wavelengths away from the speakers and move a few wavelengths from the centerline to observe the affect. If the teacher has access to a decibel meter, they can demonstrate quantitatively that the volume changes. It is also important to note that in any practical room, the sound will not completely disappear because it will be bouncing off walls and other objects such as desks.

Independent Practice:
There is no independent practice time for this lesson, but the teacher should incorporate time for the students to talk among themselves about the lesson.

If the teacher want, he or she can have the students use the diffraction gradients lasers to make measurements at lab stations, which they can use to infer the wavelength of the laser light.

Remediation and/or Enrichment:
Remediation: individual IEP; partner help throughout the lesson; the teacher can observe the students and intervene during the independent practice.

Check(s) for Understanding:

The teacher should use informal checks such as questions and discussions to check for understanding.

Some good questions for this are:

- Why does the sound get louder when you move from directly in front of the speakers?
- How do we compute wavelength?
- What does this imply about a stadium full of people yelling and making sound that is not in phase with each other?

Closure:
The teacher can close with some checks for understanding.

Possible Alternate Subject Integrations:
Math can be incorporated if the teacher wants to compute the wavelength of the laser.

Teacher Notes:
There are several sound files included with this lesson plan.
The number in the name of the file indicates how much out of phase the right channel is from the left.