

Diffraction Unit, Lesson 1: Bending Light

What Is Diffraction?

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Grade Level	9th – Secondary Grade
Subject	Science
Course	Chemistry, Physics

Essential Question

What is diffraction? How does light bend when it passes through an object?

Summary

Students will learn that light is formed by waves and can change direction through diffraction. They will use pencils to build a spectroscope and make observations as to the color and size of light. Students will research wave diffraction and use what they learned to build and test a spectroscope.

Snapshot

Engage

Students watch a phenomenon and describe diffraction.

Explore

Students explore how light can bend around edges through a pencil investigation.

Explain

Students complete an I Think/We Think chart, along with questions they still have, while watching a video on wave diffraction. Working in pairs, students choose 1–2 questions to add to the Driving Question Board.

Extend

Students research how to design and build a spectroscope, as well as one of the questions from the Driving Question Board.

Evaluate

Students test and revise their spectroscope.

Standards

ACT College and Career Readiness Standards - Science (6-12)

SIN502: Predict the results of an additional trial or measurement in an experiment
EMI201: Find basic information in a model (conceptual)
EMI503: Identify the strengths and weaknesses of models

Next Generation Science Standards (Grades 9, 10, 11, 12)

HS-PS4-3: Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

Oklahoma Academic Standards (Chemistry)

CH.PS4.3 : Develop an argument for how scientific evidence supports the explanation that electromagnetic radiation can be described either by the wave model or the particle model, and in some situations one model is more useful than the other.

Oklahoma Academic Standards (Chemistry)

PH.PS4.3 : Develop an argument for how scientific evidence supports the explanation that electromagnetic radiation can be described either by the wave model or the particle model, and in some situations one model is more useful than the other.

Attachments

- I Think, We Think—What Is Diffraction - Spanish.docx
- I Think, We Think—What Is Diffraction - Spanish.pdf
- I Think, We Think—What Is Diffraction.docx
- I Think, We Think—What Is Diffraction.pdf
- Lesson Slides—What Is Diffraction.pptx
- Light Can Bend Around Edges!—What Is Diffraction - Spanish.docx
- Light Can Bend Around Edges!—What Is Diffraction - Spanish.pdf
- Light Can Bend Around Edges!—What Is Diffraction.docx
- Light Can Bend Around Edges!—What Is Diffraction.pdf
- Optional Engage Activity—What Is Diffraction.docx
- Optional Engage Activity—What Is Diffraction.pdf
- Spectroscope Engineering—What Is Diffraction - Spanish.docx
- Spectroscope Engineering—What Is Diffraction - Spanish.pdf
- Spectroscope Engineering—What Is Diffraction.docx
- Spectroscope Engineering—What Is Diffraction.pdf

Materials

- Lesson Slides (attached)
- I Think/We Think handout (attached; one per student)
- Light Can Bend Around Edges! handout (attached; one per student)
- Spectroscope Engineering handout (attached; one per pair of students)
- Optional Engage Activity handout (attached; for teacher use)
- Student laptops or tablets for research (one per pair of students)
- Clean, new pencils with erasers (two per student)
- Transparent tape (one piece per student)
- Flashlight: Mini Maglite (one per student or group of students)
- Optional: Pieces of cloth, a feather, plastic diffraction grating, metal screen, a human hair (one per student)
- CDs or diffraction grating (one per pair of students)

- Cereal boxes, paper towel tubes, or anything similar for the body of the spectroscope (one per pair of students)
- Exacto knife (one per pair of students)
- Tape for building spectroscopes (amount varies)
- Any other materials needed/desired for building spectroscopes

Engage

Teacher's Note: Lesson Preparation

The activities in this lesson are ideally suited to be completed in a science notebook, but handouts are provided as an alternative.

Introduce the lesson using **slide 2** of the attached **Lesson Slides**.

Display **slide 3** to share the essential questions and **slide 4** to go over the lesson's learning objectives to the extent you feel necessary.

Move to **slide 5**. Share the Using Phenomena to Drive Science Instruction strategy with students and preview the questions ahead of time.

Move to **slide 6** to share the "Homemade Kaleidoscope" video from Sick Science (stop the video at 0:57).

Embedded video
https://youtube.com/watch?v=Qfbsog3Cqac

Go to **slide 7** to use the following questions to help guide a whole class discussion:

- What is happening to the light inside the tube?
- Why do these phenomena happen?
- What is causing the colors to appear?
- Do the colors always occur in the same order?

Optional Engage Activity

With an overhead projector, have students record observations about the color and shape of the light at each step in the attached **Optional Engage Activity** handout.

Explore

Display **slides 8**, and share that light bends when it passes around an edge or through a slit. This bending is called diffraction. You can easily demonstrate diffraction using a candle or a small bright flashlight bulb and a slit made with two pencils. The diffraction pattern—the pattern of dark and light created when light bends around an edge or edges—shows that light has wavelike properties.

Move to **slide 9** and pass out the attached **Light Can Bend Around Edges!** handout. Have students gather all the material they need to complete this pencil activity from Exploratorium.

Teacher's Note: Pencil Activity

- Do not substitute a flashlight for this activity other than a mini Maglite.
- If the slit is too big, in addition to squeezing the pencils together, students can also move the pencils higher and look closer to the middle of the pencils where the slit is smaller.

Move to **slide 10** and walk students through properly assembling their materials.

Move to **slide 11** and have students explore how light can bend around edges while completing the questions on the handout.

Possible Student Response to Question 3

The blobs of light grow larger and spread apart, moving away from the central light source and becoming easier to see.

Once students are wrapping up their observations, share with them that the black bands between the blobs of light show that a wave is associated with the light. The light waves that go through the slit spread out, overlap, and add together, producing the diffraction pattern you see. Where the crest of one wave overlaps with the crest of another wave, the two waves combine to make a bigger wave, and you see a bright blob of light. Where the trough of one wave overlaps with the crest of another wave, the waves cancel each other out, and you see a dark band.

The angle at which the light bends is proportional to the wavelength of the light. Red light, for instance, has a longer wavelength than blue light, so it bends more than blue light does. This different amount of bending gives the blobs their colored edges: blue on the inside, red on the outside.

The narrower the slit, the more the light spreads out. In fact, the angle between two adjacent dark bands in the diffraction pattern is inversely proportional to the width of the slit.

Thin objects, such as a strand of hair, also diffract light. Light that passes around the hair spreads out, overlaps, and produces a diffraction pattern. Cloth and feathers, which are both made up of many smaller, thinner parts, produce complicated diffraction patterns.

Move to **slide 12** and briefly review the difference between reflection, refraction, and diffraction.

Optional Modification for Distance Learning

This activity has been made accessible for distance learners; you may choose to have students complete the activity portions of this lesson using the linked Nearpod presentation. In order to use this, you will need to create a free account in Nearpod.

Explain

Teacher's Note: Driving Question Board

You may wish to have a piece of chart paper set up ahead of time, labeled for your Driving Question Board, if you do not have a dedicated place on your board or in your classroom for this.

Move to **slide 13**, share the I Think/We Think strategy with students, and pass out the attached **I Think/We Think** handout.

Move to **slide 14** and have students watch the "Wave Diffraction" video. Have students fill out the first two columns of the handout while watching.

Embedded video
https://youtube.com/watch?v=1bHipDSHVG4

- In the column labeled "I Think," record your observations.
- In the column labeled "Questions," record any questions you have during the video.

Move to **slide 15**. Have students work with a partner and discuss the following:

- Observations they both made during the video.
- Write a one-sentence summary of their discussion and add it to the column labeled "We Think."
- Select 1–2 questions that they both still have to share with the class.

Once all groups have finished, move to **slide 16**. Share the Driving Question Board strategy with students. Based on what they discussed with their partner, ask them to share some questions that can be added to the Driving Question Board. These questions will be used in the next part of the lesson.

Extend

Teacher's Note: Diffraction Grating Materials

Diffraction grating needs to be: 500 lines/mm, single axis

Where to buy grating:

- Flinn: https://www.flinnsci.com/flinn-c-spectra-6-x-12-sheet/ap1714/
- Carolina: https://www.carolina.com/physical-science-light-and-optics/diffraction-grating-film/755227.pr
- Amazon: https://www.amazon.com/Lines-Diffraction-Grating-Single-Linear/dp/B08Z6ZFF66/

Move to **slide 17** and tell students that their mission is to design, build, and refine a spectroscope to observe light spectra. Preview what they will be doing during this time:

- Select one question from the Driving Question Board that they would like to research.
- Watch the videos to learn more about how to create a spectroscope.
- Design and build a spectroscope using diffraction materials.
- Then, they will show off the spectroscope to other groups in a Gallery Walk.

Move to **slide 18** and pass out the attached **Spectroscope Engineering** handout. Explain to students that, as they watch the videos that explain the science behind spectroscopy, they need to keep track of their research and notes on the handout.

Move to **slide 19**. Play the "What's Going On: CD Spectroscope" video and have students take notes on the handout.

Embedded video
https://youtube.com/watch?v=UnH3nsk-Ibs

Move to **slide 20**. Remind students:

- Their mission is to design, build, and refine a spectroscope using diffraction material to observe light spectra.
- They will need to watch at least two of the provided videos on the Spectroscope Engineering handout and possibly find some of their own for inspiration.

Move to **slide 21** and have student pairs share what they learned from their research on their Driving Question Board question.

Teacher's Note: Setting Up for Students to Build Their Spectroscope

Slide 22 is blank for you to insert class specific instructions and materials you have for them to use.

Teacher's Note: Safety Tips

If using CDs, allow the CD to stick out of the box. Breaking the CD may cause a safety hazard.

Remind students to exercise caution when using the Exacto knives.

Teacher's Note: Student Considerations

Glasses with a spectroscope: (CD rather than diffraction grating would be better); students may need to take off their glasses.

Color blindness with a spectroscope: still see bands in the places, but not the colors. Lights will be spread out but the colors will be different.

Move to **slide 22** and remind students that they need to create a spectroscope that meets the following criteria:

- A slit
- A part to diffract
- A place to look through

When ready, have students gather their materials and start building.

Move to **slide 23** and share the Gallery Walk strategy with students. As they walk around the room to view the spectroscopes built by their peers, ask them to take time to notice at least two similarities and at least two differences. Remind students to be prepared to share with the class.

After the Gallery Walk, take some time for students to discuss what they discovered while viewing other students' spectroscopes.

Optional Spectroscope-Building Activity

If you would like students to create their own spectroscopes, you may provide students with this Mini Spectroscope PDF (from the "Making Your Foldable Paper Cellphone Spectrometer" video in the Spectroscope Engineering handout).

Embedded video

https://youtube.com/watch?v=hZkVYuw4pJ4

Evaluate

Teacher's Note: Weather and Safety Tips

Plan according to the weather, as students work outside during this section of the lesson. Do not have students look directly at the sun; instead, they should direct their spectroscope toward clouds.

Teacher's Note: Setting Up for Students to Test Their Spectroscope

Slide 24 is blank for you to insert the instructions you would like students to follow for the testing phase of this investigation.

Move to **slide 24** and have students revisit the Spectroscope Engineering handout. Have students complete the **Build and Test Your Spectroscope** section of the handout as they are outside looking at light and clouds. This activity should take 10–15 minutes depending on your class.

Guide students in a class discussion about what they observed, what they might change, and what worked well while using their spectroscopes.

Possible discussion questions:

- Identify at least one refinement to your spectroscope. *How did you modify your design after you started building to improve performance?* Explain how the refinement improved the performance.
- If you were asked to build another spectroscope, name at least two things that worked well and you would do again.
- If you were asked to build another spectroscope, name at least two things you would do differently.

Teacher's Note: Setting Up for Students to Refine and Reflect on Their Spectroscope

Slide 25 is blank for you to insert directions on how you would like students to refine their spectroscopes.

Move to **slide 25** and have students complete the **Refine and Reflection** questions on the Spectroscope Engineering handout.

Move to **slide 26**. Remind students of the essential questions from the start of the unit. Have students answer the essential questions:

- What is diffraction?
- How does light bend when it passes through an object?

Resources

AfterschoolUniverse. (2011). Afterschool universe: Paper towel tube spectroscope [Video]. YouTube. https://www.youtube.com/watch?v=IvwW-S0j7gg&t=164s

Bozeman Science. (2015). Wave diffraction [Video]. YouTube. https://www.youtube.com/watch?v=1bHipDSHVG4&t=2s

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K20 Center. (n.d.). Using Phenomena to Drive Science Instruction. Strategies. https://learn.k20center.ou.edu/strategy/108

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