Wave Properties and Information Transfer

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FOSS is a **K-8, modular, research-based, NGSS-aligned** curriculum developed at the Lawrence Hall of Science (UC Berkeley) with support from the National Science Foundation.
FOSS Next Generation is a research-based science curriculum designed to support the Next Generation Science Standards for grades K-8. Each course provides instructional sequences and pedagogical strategies to support three dimensional instruction.
## FOSS Middle School Recommended Scope and Sequence

<table>
<thead>
<tr>
<th>Grade</th>
<th>Integrated Middle Grades</th>
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<tbody>
<tr>
<td></td>
<td>Chemical Interactions</td>
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<td></td>
<td>Weather and Water</td>
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</tbody>
</table>

*Half-length courses  Physical Science content  Earth Science content  Life Science content  Engineering content
# FOSS Middle School Recommended Scope and Sequence

<table>
<thead>
<tr>
<th>Grade</th>
<th>Integrated Middle Grades</th>
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<tbody>
<tr>
<td>6–8</td>
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<tr>
<td></td>
<td>Heredity and Adaptation*</td>
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<td></td>
<td>Electromagnetic Force*</td>
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<td>Gravity and Kinetic Energy*</td>
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<td>Waves*</td>
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<td>Planetary Science</td>
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<td>Earth History</td>
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<td></td>
<td>Populations and Ecosystems</td>
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<td></td>
<td>Weather and Water</td>
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<td></td>
<td>Diversity of Life</td>
</tr>
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<td></td>
<td>Human Systems Interactions*</td>
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</tbody>
</table>

*Half-length courses
**Physical Science content**
**Earth Science content**
**Life Science content**
**Engineering content**
Features of FOSS Next Generation

- Notebooking embedded in curriculum
- Embedded assessment including three-dimensional performance assessments
- Benchmark assessments online
- Student Resource Book with embedded strategies to support Common Core ELA
- FOSSweb:
  - Online activities, simulations, videos
  - Digital Teacher Guide and eSRB
  - Modifiable teacher slides
  - Teacher prep videos

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Instructional Support

Teacher Resources online at www.fossweb.com

Chapters on sense-making discussions, Common Core integration, and more
Storyline of Course

Investigation 1: Make Waves
Investigation 2: Wave Energy
Investigation 3: Light Waves
Investigation 4: Communication Waves
NGSS Performance Expectations in Investigations 3 and 4

MS-PS4-2: Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials.

MS-PS4-3: Integrate qualitative scientific and technical information to support the claim that digitized signals (sent as wave pulses) are a more reliable way to encode and transmit information.
Inv 3: Light Waves recap (pgs. 3–15 in sample notebook)

Starting on page 3, leaf through a sample of what students will have experienced so far in this investigation.
Inv 3: Light Waves recap

Light Waves travel in rays, can travel in a vacuum

| Reflection | Angle of incidence | Angle of reflection |

Lasers have intense light that can be dangerous. Follow these safety guidelines:

1. Never look into a laser.
2. Never point a laser toward another person or animal.
3. Keep the laser beam horizontal to the ground, above the beam.
4. Turn off the laser when not in use.

Signature
FOSSweb
Heredity and Adaptation
Next Generation
Resources by Investigation

Investigation 1: The History of Life

Students are introduced to the big question that drives the course: How can we explain the diversity of life that exists on Earth? They take a tour of the fossil record, looking for evidence of the existence, diversity, and transitions in life-forms throughout Earth’s history.

Investigation 1, Part 1: The Fossil Record
Investigation 1, Part 2: Transitions

Investigation 2: Heredity

Investigation 3: Evolution
Investigation 3: Wave Interactions

Students explore properties of light waves. They start by using mirrors to explore reflection. Students use spectroscopes to analyze spectra of visible light and learn more about the electromagnetic spectrum. They use filters to change the spectrum of a light source and to learn about color. Finally, they determine how refraction changes the path of light rays as they travel between media.

Investigation 3, Part 1: Mirrors

Students develop a model of waves to explain properties of electromagnetic radiation. They use lasers and mirrors to explore properties of light-wave reflection.

- Investigation 3 - Teacher Prep Video
- Focus Question 3.1
- Teaching Slides 3.1 (Modifiable PPT)
- Teaching Slides 3.1 (PDF)
- Teacher Master J
- Teacher Master K
- Teacher Master L
- Embedded Assessment Notes
Teacher Prep Videos
Inv 3: Light Waves recap

Filters and Color

Spectroscopes reveal electromagnetic spectrum

p. 7–15 in the notebook
1. What is the difference between mechanical waves and electromagnetic waves?
2. What media have we seen electromagnetic waves travel through?
Test Water

• Observe a phenomenon: pencil in cup of water
Focus question

• What happens to light waves at the interface of different media?

Turn to p. 16 in the notebook

Jot down a few ideas.

The focus question connects to the phenomenon being investigated.
Prepare for experimentation

- Review p. 5 in the notebook – students’ earlier experimentation using laser, mirror, and protractor

- How can we design an experiment to collect refraction data?

The angle of incidence equals the angle of reflection.
REFRACTION TEST INSTRUCTIONS

Materials for each group:

- Refraction cup half full of water
- Laser
- Protractor
- Milk
- White paper folded into screen

Procedure

1. **Setup protractor.** Put the refraction cup on the protractor sheet with the flat side along the dotted line of the protractor. The laser beam enters the flat side of the cup. Place the screen on the opposite side of the cup to help see where the beam exits the cup.

2. **Add water.** Add water and a drop of milk so you can see a laser beam in it.

3. **Setup 1.** Aim the laser at the center point of the protractor sheet at a $10^\circ$ angle of incidence toward the flat side of the cup. Record the angle of refraction in your notebook sheet and calculate the difference between the angle of incidence and refraction. Repeat with other angles to complete the data table for Setup 1 on the notebook sheet.

4. **Setup 2.** Rotate the refraction dish so the laser beam is entering through the curved side. Complete the data table for Setup 2 on the notebook sheet.

<table>
<thead>
<tr>
<th>Angle of incidence</th>
<th>Setup 1 (beam entering flat side)</th>
<th>Setup 2 (beam entering curved side)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Angle of refraction ($)</td>
<td>Difference (angle of incidence – angle of refraction)</td>
</tr>
<tr>
<td>10°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20°</td>
<td></td>
<td></td>
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<tr>
<td>30°</td>
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<tr>
<td>40°</td>
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<tr>
<td>70°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80°</td>
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</tbody>
</table>

At what angle in which setup is there no longer a refracted beam? __________

Conclusions

**Setup 1.** The ______ the angle of incidence, the ______ the difference between angle of incidence and refraction.

**Setup 2.** The ______ the angle of incidence, the ______ the difference between angle of incidence and refraction until ______°. Then there was no refracted beam, but there was total internal reflection.
Prepare for experimentation

Setup 1

Refraction beam

Incoming laser beam

Reflected beam

p. 17 in the notebook

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Step 5
Prepare for experimentation

Setup 2

Incoming laser beam  Refracted beam  Reflected beam

p. 17 in the notebook
Sample data

At what angle/in which setup is there no longer a refracted beam?  

Conclusions

Setup 1. The ______ the angle of incidence, the ______ the difference between angle of incidence and refraction.

Setup 2: The ______ the angle of incidence, the ______ the difference between angle of incidence and refraction until ______ °. Then there was no refracted beam, but there was total internal reflection.
7. **Assess progress: performance assessment**

As students set up their tests, listen to the group discussions and observe how students work together to assess students’ three-dimensional learning. Note student progress on the *Performance Assessment Checklist*.

**What to Look For**

- Students conduct the investigation and collect data, then look for patterns in the data. (*Planning and carrying out investigations; analyzing and interpreting data; PS4.A: Wave properties; patterns.)*

- Students witness a discrepant event when they cannot find an angle of refraction, and ask questions about what may be causing this anomaly in the data. (*Asking questions; analyzing and interpreting data; PS4.B: Electromagnetic radiation; patterns.)*

- Students share ideas with each other about what may be causing the anomalous data when they cannot find an angle of refraction. (*Obtaining, evaluating, and communicating information; PS4.A: Wave properties; PS4.B: Electromagnetic radiation.)*

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**SCIENCE AND ENGINEERING PRACTICES**

- Asking questions
- Planning and carrying out investigations
- Analyzing and interpreting data
- Obtaining, evaluating, and communicating information

**DISCIPLINARY CORE IDEAS**

- PS4.A: Wave properties
- PS4.B: Electromagnetic radiation

**CROSSCUTTING CONCEPTS**

- Patterns
Draw conclusions

• Setup 1: The _____ the angle of incidence, the _____ the difference between angle of incidence and refraction.

• Setup 2: The _____ the angle of incidence, the _____ the difference between angle of incidence and refraction until _____.
Draw conclusions

When the light is refracted so much that it will not exit the medium (the water in the dish), that is called **total internal reflection**.
Review vocabulary

Spend a few minutes reviewing the vocabulary for this part. Update the vocabulary index and table of contents in your notebook.

- interface
- refraction
- total internal reflection

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Step 10
Answer the focus question

• What happens to light waves at the interface between different media?

p. 16 in the notebook
Revisit Part 1 focus question

• What happens when light waves interact with matter?

p. 3 in the notebook

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Step 12
Homework

“Refraction” online activity

What happens to light when it passes from one transparent material to another, such as from air into glass?
Homework

Read “Seismic Waves” on page 54 of FOSS Science Resources.

Seismic Waves

Nobody has been to the center of Earth, but scientists use evidence to make conclusions about what lies deep under the surface.

Measuring Earthquakes

If you live in an area with frequent earthquakes, you may have felt the ground shake. Earthquakes are sudden releases of energy that shake the ground. Scientists use various methods to measure and record these events, including instruments called seismographs.

Earth’s Layers

Geologists get clues about Earth’s interior by studying seismic waves. They have learned that Earth is made up of three main layers: the crust, the mantle, and the core.
FOSS Science Resources
Books and eBook online

Reading Strategies and ELA Connections in the Investigations Guide

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• When a laser beam is shined into a transparent medium at certain angles of incidence, there is total internal reflection and the light waves can travel from one end of the tube to another.
Why would it be important to have total internal reflection through a fiber-optic cable?
Focus question

- What are some design constraints in fiber-optic communications?
Optical-Fiber Testing

Procedure

1. Group member A: Coil the optical fiber so it forms one large loop. Use the twist tie to secure the loop.

2. Group member B: Hold the foam block flat on the table, so that the fiber stays horizontal on the table in one position.

3. Group member C: Keep the laser flat on the table, pointed straight into the end of the optical fiber (near the foam block). Roll the laser as needed to adjust its height until the beam reaching the other end of the optical fiber is as bright as possible. Once it is in position, hold the laser so it cannot move.

4. Group member D: Keep the other end of the fiber pointing toward a hand or paper to show the laser beam coming out of the fiber.

5. Group member A: Slowly slide the optical fiber through the twist tie, making the loop smaller and smaller until the beam leaving the other end of the fiber is significantly dimmer, indicating loss of total internal reflection. The loop may begin to glow at this point because of light refracting from the optical fiber.

6. Group member D: Measure the diameter of the optical-fiber loop when the beam dims and total internal reflection is lost.

SAFETY NOTE: Never point a laser directly into someone’s eyes.

NOTE: Do not bend the cable or tighten the loop any more after losing total internal reflection.

Results

Diameter of the loop at loss of total internal reflection: ____________
Test the structural limitations of the optical fiber.

Consider analog and digital data, along with implications for communications technology.
13. Assess progress: notebook entry
After students complete their responses to the focus question, have them hand in their notebooks open to that page. Collect a sample of notebooks from each class, and assess students’ progress using Embedded Assessment Notes.

What to Look For

- Students describe that light can be refracted out of a material or reflected within a material (total internal reflection).
- Students explain that the amount of bending of the fiber-optic cable can affect whether light will get all the way through it.
12. Revisit the focus question
   Ask students to return to the focus question. Have students respond to the focus question with any information they learned about total internal reflection.

   ▶ What are some design constraints in fiber-optic communications?

13. Assess progress: notebook entry
   After students complete their responses to the focus question, have them hand in their notebooks open to that page. Collect a sample of notebooks from each class, and assess students’ progress using Embedded Assessment Notes.

   **What to Look For**
   - Students describe that light can be refracted out of a material or reflected within a material (total internal reflection).
   - Students explain that the amount of bending of the fiber-optic cable can affect whether light will get all the way through it.

   **EL NOTE**
   For students who need scaffolding, give them a few minutes to discuss what they learned about communicating with fiber-optic cables with a partner before writing. You can also provide sentence frames.
NGSS Three Dimensions

- Asking questions
- Planning and carrying out investigations
- Analyzing and interpreting data
- Obtaining, evaluating, and communicating information

PS4.A: Wave properties
PS4.B: Electromagnetic radiation

Patterns Cause and Effect

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**Investigation 3: Light Waves**

Part 4: Refraction

As students work with Setup 2, they may be perplexed when they cannot find an angle of refraction (around 50 degrees). As you circulate among groups, encourage students to discuss what may be causing this. Suggest that if they cannot find a refracted beam, they will be able to answer the question below the data table.

**7. Assess progress: performance assessment**

As students set up their tests, note their progress on Performance Assessment Checklist.

**What to Look For**

- Students conduct the investigation and collect data, then look for patterns in the data. (Planning and carrying out investigations; Analyzing and interpreting data; Patterns.)
- Students witness a disruptive event when they cannot find an angle of refraction, and ask questions about what may be causing this anomaly in the data. (Analyzing and interpreting data; Asking questions; Patterns.)
- Students share ideas with each other about what may be causing the anomalous data when they cannot find an angle of refraction. (Obtaining, evaluating, and communicating information.)

**8. Extend the investigation with homework**

Students can extend their classroom investigation by using the online activity “Refraction.” Students should perform 10–15 tests, record their data in a data table that they design, and write a concluding statement that summarizes their findings.

**9. Draw conclusions**

Have students take a few minutes to compare notes about their findings in Session 1. Call on students to share observations and inferences in a class discussion. Encourage them to cite patterns they notice in their data and the cause-and-effect statements they made based on those patterns. If needed, guide the discussion with these questions and prompts.

- What pattern did you notice happening to the laser light beam at the higher angles of incidence? [It bends more at greater angles.]

Draw students’ attention to the conclusion section of notebook sheet 20, and ask for students to determine the relationship between incidence and refraction.

**Crosscutting Concepts**

- Patterns
- Cause and effect

**Science and Engineering Practices**

- Asking questions
- Planning and carrying out investigations
- Analyzing and interpreting data
- Obtaining, evaluating, and communicating information

**EL Note**

Add “refraction” to the diagram on the word wall.
Connections to the Framework

Specific connections to the K-12 Framework **Disciplinary Core Ideas**, **Scientific and Engineering Practices**, and **Crosscutting Concepts** can be found in multiple locations:

- Overview Chapter
- Framework Chapter
- Online at [www.FOSSweb.com](http://www.FOSSweb.com)
Benchmark Assessment

- Entry-Level-Survey
- I-Checks
- Posttest
- FOSSMap and Online Assessment
FOSS Next Generation

- FOSS supports three dimensional instruction, and provides detailed pedagogical support for notebooking, assessment, literacy, and engineering.
- FOSS courses build concepts through a course and across grades with a conceptual framework for grades K-8.
- FOSS integrates scientific knowledge with the practices of science and engineering.

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What do you get?

- Investigations Guide
- Materials for 5 classes
- FOSSweb – Digital Resources
- Student Books with ELA and ELL support
- Teaching Slides (editable)
- Teacher Prep Videos

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Next Steps

• Want to learn more?
  – Visit the Delta booth on the exhibit floor to ask about pilots and sample materials
  – Log on to FOSSweb to explore the courses using your temporary access code
  – Check out FOSSConnect, our online newsletter, at www.deltaeducation.com/FOSSconnect
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