INTRODUCTION

The **Energy Module** provides first-hand experiences in physical science dealing with energy and change. Students investigate electricity and magnetism as related effects and engage in engineering design while learning useful applications of electromagnetism in everyday life. They explore energy transfer through waves, repeating patterns of motion, that result in sound and motion.

The five investigations focus on the concepts that energy is present whenever there is motion, electric current, sound, light, or heat, and that energy can transfer from one place to another. Students conduct controlled experiments by incrementally changing variables to determine how to make an electromagnet stronger and how the amount of energy transfer changes when balls of different masses hit a stationary object. Students interpret data from graphs to build explanations from evidence and make predictions of future events. They develop models to represent how energy moves from place to place in electric circuits and in waves. Students gain experiences that will contribute to the understanding of crosscutting concepts of patterns; cause and effect; systems and system models; and energy and matter.

The **NGSS Performance Expectations addressed in this module include:**

**Physical Sciences**
- 3-PS2-3
- 3-PS2-4
- 4-PS3-1
- 4-PS3-2
- 4-PS3-3
- 4-PS3-4
- 4-PS4-1
- 4-PS4-2
- 4-PS4-3

**Engineering, Technology, and Applications of Science**
- 3–5-ETS1-1
- 3–5-ETS1-2
- 3–5-ETS1-3

**NOTE**
The three modules for grade 4 in FOSS Next Generation are

**Energy**
- Soils, Rocks, and Landforms
- Environments
## Module Summary

Students investigate electric current and circuits, the pathways through which electricity flows. They work with a variety of components—D-cells, lightbulbs, motors, switches, and wires—and explore conductors and insulators. They explore series and parallel circuits and compare the functioning of the components in each circuit. They formulate and justify their predictions, based on their observations of electricity transferring energy to produce light and motion.

### Focus Questions

- What is needed to light a bulb?
- What is needed to make a complete pathway for current to flow in a circuit?
- How can you light two bulbs brightly with one D-cell?
- Which design is better for manufacturing long strings of lights—series or parallel?

## Inv. 1: Energy and Circuits

Students investigate the properties of magnets and their interactions with materials and each other. Students go outdoors to find objects in the environment that are attracted to magnets. They conduct an investigation to determine if like or opposite poles of a magnet attract. They construct a simple compass and use it to detect magnetic effects. They also discover that magnetism can be induced in a piece of iron. They investigate the strength of the force of attraction between two magnets by graphing data to look for patterns of interaction.

### Focus Questions

- What materials sticks to magnets?
- What happens when two or more magnets interact?
- What happens when a piece of iron comes close to or touches a permanent magnet?
- What happens to the force of attraction between two magnets as the distance between them changes?
**Module Matrix**

<table>
<thead>
<tr>
<th>Content Related to Disciplinary Core Ideas</th>
<th>Reading/Technology</th>
<th>Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Energy is evident whenever there is motion, electric current, sound, light, or heat. Energy can transfer from place to place.</td>
<td><strong>Science Resources Book</strong>&lt;br&gt;“Edison Sees the Light”&lt;br&gt;“Energy Sources”&lt;br&gt;“Series and Parallel Circuits”&lt;br&gt;“Science Practices”&lt;br&gt;“Engineering Practices”&lt;br&gt;“Thinking Like an Engineer”&lt;br&gt;“Engineering a Solar Lighting System”</td>
<td><strong>Embedded Assessment</strong>&lt;br&gt;Science notebook entries&lt;br&gt;Response sheet&lt;br&gt;Performance assessments</td>
</tr>
<tr>
<td>• An electric circuit is a system that includes a complete pathway through which electric current flows from an energy source to its components.</td>
<td><strong>Online Activities</strong>&lt;br&gt;“Lighting a Bulb”&lt;br&gt;“Flow of Electricity”&lt;br&gt;“Tutorial: Simple Circuits”&lt;br&gt;“Tutorial: Conductors and Insulators”&lt;br&gt;“Turn on the Switch”&lt;br&gt;“Conductor Detector”&lt;br&gt;“D-cell Orientation”</td>
<td><strong>Benchmark Assessment</strong>&lt;br&gt;Survey&lt;br&gt;Investigation 1 I-Check</td>
</tr>
<tr>
<td>• Conductors are materials through which electric current can flow; all metals are conductors.</td>
<td></td>
<td><strong>NGSS Performance Expectations</strong>&lt;br&gt;4-PS3-2&lt;br&gt;4-PS3-4&lt;br&gt;3–5-ETS1-1&lt;br&gt;3–5-ETS1-2&lt;br&gt;3–5-ETS1-3</td>
</tr>
<tr>
<td>• In a series circuit, there is a single pathway from the energy source to the components; in a parallel circuit, each component has its own direct pathway to the energy source.</td>
<td></td>
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<tr>
<td>• The energy of two energy sources (D-cells or solar cells) adds when they are wired in series, delivering more power than a single source. Two cells in parallel have the same power as a single cell.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Magnets interact with each other and with some materials.</td>
<td><strong>Science Resources Book</strong>&lt;br&gt;“When Magnet Meets Magnet”&lt;br&gt;“Magnificent Magnetic Models”&lt;br&gt;“Make a Magnetic Compass”</td>
<td><strong>Embedded Assessment</strong>&lt;br&gt;Science notebook entry&lt;br&gt;Response sheet&lt;br&gt;Performance assessment</td>
</tr>
<tr>
<td>• Magnets stick to (attract) objects that contain iron. Iron is the only common metal that sticks to magnets.</td>
<td><strong>Video</strong>&lt;br&gt;All about Magnets</td>
<td><strong>Benchmark Assessment</strong>&lt;br&gt;Investigation 2 I-Check</td>
</tr>
<tr>
<td>• All magnets have two poles, a north pole at one end (side) and a south pole at the other end (side). Like poles of magnets repel each other, and opposite poles attract.</td>
<td><strong>Online Activities</strong>&lt;br&gt;“What Sticks and What Conducts?”&lt;br&gt;“Tutorial: Magnetic Poles”&lt;br&gt;“Magnetic Poles”&lt;br&gt;“Magnetic Poles Quiz”</td>
<td><strong>NGSS Performance Expectations</strong>&lt;br&gt;3-PS2-3&lt;br&gt;4-PS3-4</td>
</tr>
<tr>
<td>• Magnets are surrounded by an invisible magnetic field, which acts through space and through most materials.</td>
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<td></td>
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<tr>
<td>• When an iron object enters a magnetic field, the field induces magnetism in the iron object, and the object becomes a temporary magnet.</td>
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<td></td>
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<tr>
<td>• The magnetic force acting between magnets declines as the distance between them increases.</td>
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<td></td>
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<tr>
<td>• Earth has a magnetic field.</td>
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</tbody>
</table>
## Module Summary

Students learn how to use electricity to make an electromagnet. They explore the variables that influence the strength of the magnetism produced by their electromagnets. Students use all the concepts they have learned to engineer a simple telegraph system and communicate using a click code.

## Focus Questions

- How can you turn a steel rivet into a magnet that turns on and off?
- How does the number of winds of wire around a core affect the strength of the magnetism?
- How can you reinvent the telegraph using your knowledge of energy and electromagnetism?

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## Energy - Overview

| Students observe energy transfer that results in heat, light, sound, and motion and they are introduced to sources of energy and components that store energy. They conduct structured investigations with steel balls and ramps to discover how the variable of starting position on the ramp affects the speed of the rolling ball. Using controlled experiments, students test the variables of mass and release position to find out how these variables affect energy transfer. |
| What do we observe that provides evidence that energy is present? |
| How does the starting position affect the speed of a ball rolling down a ramp? |
| What happens when objects collide? |

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**Inv. 3: Electromagnets**

**Inv. 4: Energy Transfer**
### Content Related to Disciplinary Core Ideas

- A magnetic field surrounds a wire through which electric current is flowing.
- The magnetic field produced by a current-carrying wire can induce magnetism in a piece of iron or steel.
- An electromagnet is made by sending electric current through an insulated wire wrapped around an iron core.
- The number of winds of wire in an electromagnet coil affects the strength of the magnetism induced in the core (more winds = more magnetism).
- The amount of electric current flowing in an electromagnet circuit affects the strength of the magnetism in the core (more current = stronger magnetism).
- A telegraph system is an electromagnet-based technology used for long-distance communication.

- Energy is evident whenever there is motion, electric current, sound, light, or heat. Energy can be transferred from place to place.
- Objects in motion have energy. The faster a given object is moving, the more kinetic energy it has.
- When objects collide, energy can transfer from one object to another, thereby changing their motion. Kinetic energy is energy of motion; potential energy is energy of position. For identical objects at rest, the objects at higher heights have more potential energy than the objects at lower heights.

### Reading/Technology

- **Science Resources Book**
  - "Electricity Creates Magnetism"
  - "Using Magnetic Fields"
  - "Electromagnets Everywhere"
  - "Morse Gets Clicking"

- **Online Activities**
  - "Kitchen Magnets"
  - "Tutorial: Electromagnets"
  - "Virtual Electromagnet"

### Assessment

- **Embedded Assessment**
  - Response sheet
  - Performance assessment
  - Science notebook entry

- **Benchmark Assessment**
  - Investigation 3 I-Check

- **NGSS Performance Expectations**
  - 3-PS2-3
  - 3-PS2-4
  - 4-PS3-2
  - 4-PS3-4
  - 4-PS4-3
  - 3–5-ETS1-3

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**Energy Module—FOSS Next Generation**
**Module Summary**

Students experience waves through firsthand experiences using ropes, demonstrations with waves in water, spring toys, and a sound generator. They also use videos, animations, and readings to gather information. Through these experiences, students learn that waves are repeating patterns of motion that transfer energy from place to place. They analyze compression waves (sound waves) to learn the general properties of waves—amplitude, wavelength, and frequency.

Students use mirrors to experience reflecting light. They start by using mirrors outdoors to see objects behind them and to reflect a bright image of the Sun onto walls. In the classroom, they determine that a mirror can be used to reflect light. Students then use flashlights, mirrors, and water to observe light in numerous ways, reinforcing the idea that light can reflect and refract. Students build a conceptual model about how light travels.

Students design series and parallel solar cell circuits and observe the effect on the speed of a motor. They observe that cells in series make the motor run faster, but cells in parallel do not deliver additional power to the motor. They read about alternative energy sources.

**Focus Questions**

- How are waves involved in energy transfer?
- How does light travel?
- How can you make a motor run faster using solar cells?
## Content Related to Disciplinary Core Ideas

- Waves are a repeating pattern of motion that transfer energy from place to place. Some electromagnetic waves can be detected by humans (light); others can be detected by designed technologies (radio waves, cell phones).
- There are sound waves, light waves, radio waves, microwaves, and ocean waves.
- Waves have properties—amplitude, wave length, and frequency.
- Light travels in straight lines and can reflect (bounce) off surfaces.
- Light can refract (change direction) when it passes from one transparent material into another.
- Matter can absorb light.
- An object is seen only when light from that object enters and is detected by an eye.
- White light is a mixture of all colors (wavelengths) of visible light.
- Solar cells are designed technologies to transfer visible light into electricity.
- The energy of two energy sources (D-cells or solar cells) adds when they are wired in series, delivering more power than a single source.
- Two cells in parallel have the same power as a single cell.

## Reading/Technology

- **Science Resources Book**
  - “Waves”
  - “More about Sound”
  - “Light Interactions”
  - “Throw a Little Light on Sight”
  - “More Light on the Subject”
  - “Alternative Sources of Electricity”
  - “Ms. Osgood’s Class Report”

- **Videos**
  - *Sound Energy*
  - *Waves*
  - *Real World Science: Sound*
  - *All about Waves*
  - *All about Light*
  - *Wave*

- **Online Activities**
  - “Reflecting Light”
  - “Colored Light”

## Assessment

- **Embedded Assessment**
  - Science notebook entry
  - Response sheet
  - Performance assessment

- **Benchmark Assessment**
  - Posttest

- **NGSS Performance Expectations**
  - 4-PS3-4
  - 4-PS4-1
  - 4-PS4-2
  - 3–5-ETS1-1
  - 3–5-ETS1-2
  - 3–5-ETS1-3
FOSS COMPONENTS

Teacher Toolkit for Each Module

The FOSS Next Generation Program has three modules for grade 4—Energy, Environments, and Soils, Rocks, and Landforms.

Each module comes with a Teacher Toolkit for that module. The Teacher Toolkit is the most important part of the FOSS Program. It is here that all the wisdom and experience contributed by hundreds of educators has been assembled. Everything we know about the content of the module, how to teach the subject, and the resources that will assist the effort are presented here. Each toolkit has three parts.

Investigations Guide. This spiral-bound document contains these chapters.

• Overview
• Framework and NGSS
• Materials
• Technology
• Investigations (five in this module)
• Assessment

Investigation 2—The Force of Magnetism

Materials for Steps 1A–1C
• (Available to students for at least one class period)

10. Distribute additional spacers
Call for volunteers and select at least five students.

a. Ask students how many spacers they used in the investigation.

b. To record data on the graph, have students find the number on the graph and work with the class to plot the first few data points.

c. Guide students through setting up the graph. Project the blank magnetic force—Graph.

d. Distribute copies of notebook sheet 18, FOSS Energy and Electromagnetism Module—Notebook Master.

11. Assess progress—performance assessment

Students use mathematical representations to explain their models.

What to Look For

• Students control the movement in logical sequence, recording observations, developing and testing explanations, and communicating information.

• Students suggest possible hypotheses to answer the question and look for patterns among data (Using mathematics and computational thinking skills).

• Students determine the distance relationship between magnets, the stronger the force, the greater the number of washers needed to separate the magnets.

• Students compact how data and graphs with other groups to make predictions about the relationship. (Observe, measure, and communicate information.)

12. Graph the data

When the data have been recorded, the number of washers needed to separate the magnets. Have students look for patterns among data (Using mathematics and computational thinking skills).

13. Make predictions using the graph

Ask students to take the data and come up with a prediction for the data that will allow them to separate the magnets.

14. Test the prediction

Ask students to use the model to separate the magnets. Students should be able to separate the magnets with the number of washers needed to separate the magnets. Have students look for patterns among data (Using mathematics and computational thinking skills).

15. Discuss

Encourage students to discuss the results of the investigation and then use the model to separate the magnets. Students should be able to separate the magnets with the number of washers needed to separate the magnets.

FOSS Science Resources book. One copy of the student book of readings is included in the Teacher Toolkit.
**Teacher Resources.** These chapters can be downloaded from FOSSweb and are also in the bound *Teacher Resources* book.

- FOSS Program Goals
- Science Notebooks in Grades 3–5
- Science-Centered Language Development
- FOSS and Common Core ELA—Grade 4
- FOSS and Common Core Math—Grade 4
- Taking FOSS Outdoors
- Science Notebook Masters
- Teacher Masters
- Assessment Masters

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**Equipment Kit for Each Module or Grade Level**

The FOSS Program provides the materials needed for the investigations, including metric measuring tools, in sturdy, front-opening drawer-and-sleeve cabinets. Inside, you will find high-quality materials packaged for a class of 32 students. Consumable materials are supplied for three uses before you need to resupply. Teachers may be asked to supply small quantities of common classroom items.

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**Lighting Bulbs**

Write a prediction for each circuit in the small box. If you think it will light, write "yes." If you think it won't light, write "no."

a.  
b.  
c.  
d.  
e.  
f.  

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**Energy Module—FOSS Next Generation**
**Energy – Overview**

### FOSS Science Resources Books

FOSS Science Resources: *Energy* is a book of original readings developed to accompany this module. The readings are referred to as articles in *Investigations Guide*. Students read the articles in the book as they progress through the module. The articles cover specific concepts, usually after the concepts have been introduced in the active investigation.

The articles in *Science Resources* and the discussion questions provided in *Investigations Guide* help students make connections to the science concepts introduced and explored during the active investigations. Concept development is most effective when students are allowed to experience organisms, objects, and phenomena firsthand before engaging the concepts in text. The text and illustrations help make connections between what students experience concretely and the ideas that explain their observations.

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**A Better Lightbulb**

Think about Thomas Edison (1847–1931) working on the lightbulb. The filament burnt out too quickly. His team developed a plan to solve this problem. They made hundreds of different prototypes and tested them. Think about the criteria for a solution to this problem: How do you make an inexpensive lightbulb that lasts a long time and uses little energy? Edison and his team found a good solution. Ever since, engineers have been designing light sources that meet new criteria.

What would the criteria be for a portable lighting system used in places without electricity? What would the constraints be?

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**Engineering a Solar Lighting System**

In 2008, Dr. Laura Stachel was in northern Nigeria. There she observed emergency care at a state hospital. She realized that lack of reliable electricity was a huge problem. Because of frequent blackouts, midwives and doctors struggled to diagnose and treat women with pregnancy problems. Emergency surgeries were interrupted. Dr. Stachel worked with her husband, Hal Aronson, a solar energy educator in Berkeley, California, to solve the problem. They created a solar system to provide electricity for important parts of the hospital. Other health workers in the area began to ask for solar lighting for their clinics, too. Mr. Aronson and Dr. Stachel formed a nonprofit company, We Care Solar. Mr. Aronson designed the We Care Solar Suitcase. This solar system is easy to move, easy to install, durable, and inexpensive to maintain.

Mr. Aronson sat down with FOSS to talk about how he engineered this device.

Q: Can you describe the problem that you set out to solve?

A: The primary problem is the lack of good-quality light, or any light at all. Good-quality light is needed to properly treat sick people. For example, doctors need to see where a mother is bleeding to be able to stop the bleeding.
Technology

The FOSS website opens new horizons for educators, students, and families, in the classroom or at home. Each module has digital resources for students and families—interactive simulations, virtual investigations, and online activities. For teachers, FOSSweb provides resources for materials management, general teaching tools for FOSS, purchasing links, contact information for the FOSS Program, and technical support. You do not need an account to view this general FOSS Program information. In addition to the general information, FOSSweb provides digital access to PDF versions of the Teacher Resources component of the Teacher Toolkit and digital-only resources that supplement the print and kit materials.

Additional resources are available to support FOSS teachers. With an educator account, you can customize your homepage, set up easy access to the digital components of the modules you teach, and create class pages for your students with access to tutorials and online assessments.

Ongoing Professional Learning

The Lawrence Hall of Science and Delta Education strive to develop long-term partnerships with districts and teachers through thoughtful planning, effective implementation, and ongoing teacher support. FOSS has a strong network of consultants who have rich and experienced backgrounds in diverse educational settings using FOSS.
FOSS INSTRUCTIONAL DESIGN

FOSS is designed around active investigations that provide engagement with science concepts and science and engineering practices. Surrounding and supporting those firsthand investigations are a wide range of experiences that help build student understanding of core science concepts and deepen scientific habits of mind.

The Elements of Active Investigation

- Taking FOSS Outdoors
- Using Formative Assessment
- Integrating Science Notebooks
- Engaging in Science–Centered Language Development
- Accessing Technology
- Reading FOSS Science Resources Books
Each FOSS investigation follows a similar design to provide multiple exposures to science concepts. The design includes these pedagogies.

- Active investigation, firsthand experiences with objects, organisms, and materials in the natural and designed worlds
- Recording in science notebooks to answer the focus question
- Reading in *FOSS Science Resources* books
- Online activities to review or extend the investigation
- Outdoor experiences to collect data from the local environment or apply knowledge
- Assessment to monitor progress and motivate student learning

In practice, these components are seamlessly integrated into a curriculum designed to maximize every student’s opportunity to learn. An instructional sequence may move from one pedagogy to another and back again to ensure adequate coverage of a concept.

A **learning cycle** is an instructional model based on a constructivist perspective that calls on students to be actively involved in their own learning. The model systematically describes both teacher and learner behaviors in a systematic approach to science instruction.

The most recent model is a series of five phases of intellectual involvement known as the 5Es: Engage, Explore, Explain, Elaborate, and Evaluate. The body of foundational knowledge that informs contemporary learning-cycle thinking has been incorporated seamlessly and invisibly into the FOSS curriculum design.
Active Investigation

Active investigation is a master pedagogy. Embedded within active learning are a number of pedagogical elements and practices that keep active investigation vigorous and productive. The enterprise of active investigation includes

- **context**: questioning and planning;
- **activity**: doing and observing;
- **data management**: recording, organizing, and processing;
- **analysis**: discussing and writing explanations.

**Context: questioning and planning.** Active investigation requires focus. The context of an inquiry can be established with a focus question or challenge from you or, in some cases, from students. (How can you get two bulbs to burn brightly?) At other times, students are asked to plan a method for investigation. This might start with a teacher demonstration or presentation. Then you challenge students to plan an investigation, such as to find out how the number of winds of wire around a core affect the strength of an electromagnet. In either case, the field available for thought and interaction is limited. This clarification of context and purpose results in a more productive investigation.

**Activity: doing and observing.** In the practice of science, scientists put things together and take things apart, observe systems and interactions, and conduct experiments. This is the core of science—active, firsthand experience with objects, organisms, materials, and systems in the natural world. In FOSS, students engage in the same processes. Students often conduct investigations in collaborative groups of four, with each student taking a role to contribute to the effort.

The active investigations in FOSS are cohesive, and build on each other to lead students to a comprehensive understanding of concepts. Through investigations and readings, students gather meaningful data.

**Data management: recording, organizing, and processing.** Data accrue from observation, both direct (through the senses) and indirect (mediated by instrumentation). Data are the raw material from which scientific knowledge and meaning are synthesized. During and after work with materials, students record data in their science notebooks. Data recording is the first of several kinds of student writing.

Students then organize data so they will be easier to think about. Tables allow efficient comparison. Organizing data in a sequence (time) or series (size) can reveal patterns. Students process some data into graphs, providing visual display of numerical data. They also organize data and process them in the science notebook.
Analysis: discussing and writing explanations. The most important part of an active investigation is extracting its meaning. This constructive process involves logic, discourse, and prior knowledge. Students share their explanations for phenomena, using evidence generated during the investigation to support their ideas. They conclude the active investigation by writing a summary of their learning as well as questions raised during the activity in their science notebooks.

Science Notebooks

Research and best practice have led FOSS to place more emphasis on the student science notebook. Keeping a notebook helps students organize their observations and data, process their data, and maintain a record of their learning for future reference. The process of writing about their science experiences and communicating their thinking is a powerful learning device for students. The science-notebook entries stand as credible and useful expressions of learning. The artifacts in the notebooks form one of the core exhibitions of the assessment system.

You will find the duplication masters for grades 1–5 presented in notebook format. They are reduced in size (two copies to a standard sheet) for placement (glue or tape) into a bound composition book. Full-size duplication masters are also available on FOSSweb. Student work is entered partly in spaces provided on the notebook sheets and partly on adjacent blank sheets in the composition book. Look to the chapter in Teacher Resources called Science Notebooks in Grades 3–5 for more details on how to use notebooks with FOSS.
Reading in FOSS Science Resources

The FOSS Science Resources books are primarily devoted to expository articles and biographical sketches. FOSS suggests that the reading be completed during language-arts time to connect to the Common Core State Standards for ELA. When language-arts skills and methods are embedded in content material that relates to the authentic experience students have had during the FOSS active learning sessions, students are interested, and they get more meaning from the text material.

Recommended strategies to engage students in reading, writing, speaking, and listening around the articles in the FOSS Science Resources books are included in the flow of Guiding the Investigation. In addition, a library of resources is described in the Science-Centered Language Development chapter in Teacher Resources.

The chapter FOSS and the Common Core ELA in Teacher Resources shows how FOSS provides opportunities to develop and exercise the Common Core ELA practices through science. A detailed table identifies these opportunities in the three FOSS modules for the fourth grade.

Engaging in Online Activities through FOSSweb

The simulations and online activities on FOSSweb are designed to support students’ learning at specific times during instruction. Digital resources include streaming videos that can be viewed by the class or small groups. Resources may also include virtual investigations and tutorials that students can use to review the active investigations and to support students who need more time with the concepts or who have been absent and missed the active investigations.

The Technology chapter provides details about the online activities for students and the tools and resources for teachers to support and enrich instruction. There are many ways for students to engage with the digital resources—in class as individuals, in small groups, or as a whole class, and at home with family and friends.

Full Option Science System
Assessing Progress

The FOSS assessment system includes both formative and summative assessments. Formative assessment monitors learning during the process of instruction. It measures progress, provides information about learning, and is predominantly diagnostic. Summative assessment looks at the learning after instruction is completed, and it measures achievement.

Formative assessment in FOSS, called embedded assessment, is an integral part of instruction, and occurs on a daily basis. You observe action during class in a performance assessment or review notebooks after class. Performance assessments look at students’ engagement in science and engineering practices or their recognition of crosscutting concepts, and are indicated with the second assessment icon. Embedded assessment provides continuous monitoring of students’ learning and helps you make decisions about whether to review, extend, or move on to the next idea to be covered.

Benchmark assessments are short summative assessments given after each investigation. These I-Checks are actually hybrid tools: they provide summative information about students’ achievement, and because they occur soon after teaching each investigation, they can be used diagnostically as well. Reviewing specific items on an I-Check with the class provides additional opportunities for students to clarify their thinking.

The embedded assessments are based on authentic work produced by students during the course of participating in the FOSS activities. Students do their science, and you look at their notebook entries. Bullet points in Guiding the Investigation tell you specifically what students should know and be able to communicate.

If student work is incorrect or incomplete, you know that there has been a breakdown in the learning/communicating process. The assessment system then provides a menu of next-step strategies to resolve the situation. Embedded assessment is assessment for learning, not assessment of learning.

Assessment of learning is the domain of the benchmark assessments. Benchmark assessments are delivered at the beginning of the module (survey) and at the end of the module (posttest), and after each investigation (I-Checks). The benchmark tools are carefully crafted and thoroughly tested assessments composed of valid and reliable items. The assessment items do not simply identify whether or not a student knows a piece of science content, but identify the depth to which students understand science concepts and principles and the extent to which they can apply that understanding.

TECHNOLOGY COMPONENTS OF THE FOSS ASSESSMENT SYSTEM

FOSSmap for teachers and online assessment for students are the technology components of the FOSS assessment system. Students in grades 3–5 can take assessments online. FOSSmap provides the tools for you to review those assessments online so you can determine next steps for the class or differentiated instruction for individual students based on assessment performance. See the Assessment chapter for more information on these technology components.
Taking FOSS Outdoors

FOSS throws open the classroom door and proclaims the entire school campus to be the science classroom. The true value of science knowledge is its usefulness in the real world and not just in the classroom. Taking regular excursions into the immediate outdoor environment has many benefits. First of all, it provides opportunities for students to apply things they learned in the classroom to novel situations. When students are able to transfer knowledge of scientific principles to natural systems, they experience a sense of accomplishment.

In addition to transfer and application, students can learn things outdoors that they are not able to learn indoors. The most important object of inquiry outdoors is the outdoors itself. To today’s youth, the outdoors is something to pass through as quickly as possible to get to the next human–managed place. For many, engagement with the outdoors and natural systems must be intentional, at least at first. With repeated visits to familiar outdoor learning environments, students may first develop comfort in the outdoors, and then a desire to embrace and understand natural systems.

The last part of most investigations is an outdoor experience. Venturing out will require courage the first time or two you mount an outdoor expedition. It will confuse students as they struggle to find the right behavior that is a compromise between classroom rigor and diligence and the freedom of recreation. With persistence, you will reap rewards. You will be pleased to see students’ comportment develop into proper field-study habits, and you might be amazed by the transformation of students with behavior issues in the classroom who become your insightful observers and leaders in the schoolyard environment.

Teaching outdoors is the same as teaching indoors—except for the space. You need to manage the same four core elements of classroom teaching: time, space, materials, and students. Because of the different space, new management procedures are required. Students can get farther away. Materials have to be transported. The space has to be defined and honored. Time has to be budgeted for getting to, moving around in, and returning from the outdoor study site. All these and more issues and solutions are discussed in the Taking FOSS Outdoors chapter in Teacher Resources.
Science-Centered Language Development and Common Core State Standards for ELA

The FOSS active investigations, science notebooks, FOSS Science Resources articles, and formative assessments provide rich contexts in which students develop and exercise thinking and communication. These elements are essential for effective instruction in both science and language arts—students experience the natural world in real and authentic ways and use language to inquire, process information, and communicate their thinking about scientific phenomena. FOSS refers to this development of language process and skills within the context of science as science-centered language development.

In the Science-Centered Language Development chapter in Teacher Resources, we explore the intersection of science and language and the implications for effective science teaching and language development. Language plays two crucial roles in science learning: (1) it facilitates the communication of conceptual and procedural knowledge, questions, and propositions, and (2) it mediates thinking—a process necessary for understanding. For students, language development is intimately involved in their learning about the natural world. Science provides a real and engaging context for developing literacy and language-arts skills identified in contemporary standards for English language arts.

The most effective integration depends on the type of investigation, the experience of students, the language skills and needs of students, and the language objectives that you deem important at the time. The Science-Centered Language Development chapter is a library of resources and strategies for you to use. The chapter describes how literacy strategies are integrated purposefully into the FOSS investigations, gives suggestions for additional literacy strategies that both enhance students’ learning in science and develop or exercise English-language literacy skills, and develops science vocabulary with scaffolding strategies for supporting all learners. We identify effective practices in language-arts instruction that support science learning and examine how learning science content and engaging in science and engineering practices support language development.

Specific methods to make connections to the Common Core State Standards for English Language Arts are included in the flow of Guiding the Investigation. These recommended methods are linked to the CCSS ELA through ELA Connection notes. In addition, the FOSS and the Common Core ELA chapter in Teacher Resources summarizes all of the connections to each standard at the given grade level.
DIFFERENTIATED INSTRUCTION

The roots of FOSS extend back to the mid-1970s and the Science Activities for the Visually Impaired and Science Enrichment for Learners with Physical Handicaps projects (SAVI/SELPH). As those special-education science programs expanded into fully integrated settings in the 1980s, hands-on science proved to be a powerful medium for bringing all students together. The subject matter is universally interesting, and the joy and satisfaction of discovery are shared by everyone. Active science by itself provides part of the solution to full inclusion and provides many opportunities at one time for differentiated instruction.

Many years later, FOSS began a collaboration with educators and researchers at the Center for Applied Special Technology (CAST), where principles of Universal Design for Learning (UDL) had been developed and applied. FOSS continues to learn from our colleagues about ways to use new media and technologies to improve instruction. Here are the UDL principles.

Principle 1. Provide multiple means of representation. Give learners various ways to acquire information and knowledge.


The FOSS Program has been designed to maximize the science-learning opportunities for students with special needs and students from culturally and linguistically diverse origins. FOSS is rooted in a 30-year tradition of multisensory science education and informed by recent research on UDL. Procedures found effective with students with special needs and students who are learning English are incorporated into the materials and strategies used with all students.

FOSS instruction allows students to express their understanding through a variety of modalities. Each student has multiple opportunities to demonstrate his or her strengths and needs. The challenge is then to provide appropriate follow-up experiences for each student. For some students, appropriate experience might mean more time with the active investigations or online activities. For other students, it might mean more experience building explanations of the science concepts orally or in writing or drawing. For some students, it might mean making vocabulary more explicit through new concrete experiences or
Differentiated Instruction

through reading to students. For some students, it may be scaffolding their thinking through graphic organizers. For other students, it might be designing individual projects or small-group investigations. For some students, it might be more opportunities for experiencing science outside the classroom in more natural, outdoor environments.

The next-step strategies used during the self-assessment sessions after I-Checks provide many opportunities for differentiated instruction. For more on next-step strategies, see the Assessment chapter.

There are additional strategies for providing differentiated instruction. The FOSS Program provides tools and strategies so that you know what students are thinking throughout the module. Based on that knowledge, read through the extension activities for experiences that might be appropriate for students who need additional practice with the basic concepts as well as those ready for more advanced projects. Interdisciplinary extensions are listed at the end of each investigation. Use these ideas to meet the individual needs and interests of your students. In addition, online activities including tutorials and virtual investigations are effective tools to provide differentiated instruction.

English Learners

The FOSS multisensory program provides a rich laboratory for language development for English learners. The program uses a variety of techniques to make science concepts clear and concrete, including modeling, visuals, and active investigations in small groups at centers. Key vocabulary is usually developed within an activity context with frequent opportunities for interaction and discussion between teacher and student and among students. This provides practice and application of the new vocabulary. Instruction is guided and scaffolded through carefully designed lesson plans, and students are supported throughout. The learning is active and engaging for all students, including English learners.

Science vocabulary is introduced in authentic contexts while students engage in active learning. Strategies for helping all students read, write, speak, and listen are described in the Science-Centered Language Development chapter. There is a section on science-vocabulary development with scaffolding strategies for supporting English learners. These strategies are essential for English learners, and they are good teaching strategies for all learners.
FOSS INVESTIGATION ORGANIZATION

Modules are subdivided into investigations (five in this module). Investigations are further subdivided into three to five parts. Each part of each investigation is driven by a focus question. The focus question, usually presented as the part begins, signals the challenge to be met, mystery to be solved, or principle to be uncovered. The focus question guides students’ actions and thinking and makes the learning goal of each part explicit for teachers. Each part concludes with students recording an answer to the focus question in their notebooks.

The investigation is summarized for the teacher in the At-a-Glance chart at the beginning of each investigation.

Investigation-specific scientific background information for the teacher is presented in each investigation chapter organized by the focus questions.

The Teaching Children about section makes direct connections to the NGSS foundation boxes for the grade level—Disciplinary Core Ideas, Science and Engineering Practices, and Crosscutting Concepts. This information is later presented in color-coded sidebar notes to identify specific places in the flow of the investigation where connections to the three dimensions of science learning appear. The Teaching Children about section ends with information about teaching and learning and a conceptual-flow graphic of the content.

The Materials and Getting Ready sections provide scheduling information and detail exactly how to prepare the materials and resources for conducting the investigation.

Teaching notes and ELA Connections appear in blue boxes in the sidebars. These notes comprise a second voice in the curriculum—an educative element. The first (traditional) voice is the message you deliver to students. The second educative voice, shared as a teaching note, is designed to help you understand the science content and pedagogical rationale at work behind the instructional scene. ELA Connection boxes provide connections to the Common Core State Standards for English Language Arts.

The Getting Ready and Guiding the Investigation sections have several features that are flagged in the sidebars. These include several icons to remind you when a particular pedagogical method is suggested, as well as concise bits of information in several categories.
The safety icon alerts you to potential safety issues related to chemicals, allergic reactions, and the use of safety goggles.

The small-group discussion icon asks you to pause while students discuss data or construct explanations in their groups.

The new-word icon alerts you to a new vocabulary word or phrase that should be introduced thoughtfully.

The vocabulary icon indicates where students should review recently introduced vocabulary.

The recording icon points out where students should make a science-notebook entry.

The reading icon signals when the class should read a specific article in the FOSS Science Resources book.

The technology icon signals when the class should use a digital resource on FOSSweb.

The assessment icons appear when there is an opportunity to assess student progress by using embedded or benchmark assessments. Some are performance assessments—observations of science and engineering practices, indicated by a second icon which includes a beaker and ruler.

The outdoor icon signals when to move the science learning experience into the schoolyard.

The engineering icon indicates opportunities for an experience incorporating engineering practices.

The math icon indicates an opportunity to engage in numerical data analysis and mathematics practice.

The EL note provides a specific strategy to use to assist English learners in developing science concepts.

To help with pacing, you will see icons for breakpoints. Some breakpoints are essential, and others are optional.
MANAGING THE CLASSROOM

Working in Collaborative Groups

Collaboration is important in science. Scientists usually collaborate on research enterprises. Groups of researchers often contribute to the collection of data, the analysis of findings, and the preparation of the results for publication.

Collaboration is expected in the science classroom, too. Some tasks call for everyone to have the same experience, either taking turns or doing the same things simultaneously. At other times, group members may have different experiences that they later bring together.

Research has shown that students learn better and are more successful when they collaborate. Working together promotes student interest, participation, learning, and self-confidence. FOSS investigations use collaborative groups extensively.

No single model for collaborative learning is promoted by FOSS. We can suggest, however, a few general guidelines that have proven successful over the years.

For most activities in upper-elementary grades, collaborative groups of four in which students take turns assuming specific responsibilities work best. Groups can be identified completely randomly (first four names drawn from a hat constitute group 1), or you can assemble groups to ensure diversity. Thoughtfully constituted groups tend to work better.

Groups can be maintained for extended periods of time, or they can be reconfigured more frequently. Six to nine weeks seems about optimum, so students might stay together throughout an entire module.

Functional roles within groups can be determined by the members themselves, or they can be assigned in one of several ways. Each member in a collaborative group can be assigned a number or a color. Then you need only announce which color or number will perform a certain task for the group at a certain time. Compass points can also be used: the person seated on the east side of the table will be the Reporter for this investigation.

The functional roles used in the investigations follow. If you already use other names for functional roles in your class, use them in place of those in the investigations.

Getters are responsible for materials. One person from each group gets equipment from the materials station, and another person later returns the equipment.
Managing the Classroom

One person is the **Starter** for each task. This person makes sure that everyone gets a turn and that everyone has an opportunity to contribute ideas to the investigation.

The **Reporter** makes sure that everyone has recorded information on his or her science notebook sheets. This person reports group data to the class or transcribes it to the board or class chart.

Getting started with collaborative groups requires patience, but the rewards are great. Once collaborative groups are in place, you will be able to engage students more in meaningful conversations about science content. You are free to “cruise” the groups, to observe and listen to students as they work, and to interact with individuals and small groups as needed.

**Managing Materials**

The Materials section lists the items in the equipment kit and any teacher-supplied materials. It also describes things to do to prepare a new kit and how to check and prepare the kit for your classroom. Individual photos of each piece of FOSS equipment are available for printing from FOSSweb, and can help students and you identify each item.

The FOSS Program designers suggest using a central materials distribution system. You organize all the materials for an investigation at a single location called the materials station. As the investigation progresses, one member of each group gets materials as they are needed, and another returns the materials when the investigation is complete. You place the equipment and resources at the station, and students do the rest. Students can also be involved in cleaning and organizing the materials at the end of a session.

**When Students Are Absent**

When a student is absent for a session, give him or her a chance to spend some time with the materials at a center. Another student might act as a peer tutor. Allow the student to bring home a **FOSS Science Resources** book to read with a family member. Each article has a few review items that the student can respond to verbally or in writing.

Students who have been absent from certain investigations can access online activities through FOSSweb. Some of the activities may require students to record data and answer concluding questions in their science notebooks.
SAFETY IN THE CLASSROOM AND OUTDOORS

Following the procedures described in each investigation will make for a very safe experience in the classroom. You should also review your district safety guidelines and make sure that everything you do is consistent with those guidelines. Two posters are included in the kit: Science Safety for classroom use and Outdoor Safety for outdoor activities.

Look for the safety icon in the Getting Ready and Guiding the Investigation sections that will alert you to safety considerations throughout the module.

Materials Safety Data Sheets (MSDS) for materials used in the FOSS Program can be found on FOSSweb. If you have questions regarding any MSDS, call Delta Education at 1-800-258-1302 (Monday–Friday, 8 a.m.–5 p.m. ET).

Science Safety in the Classroom

General classroom safety rules to share with students are listed here.

1. Listen carefully to your teacher’s instructions. Follow all directions. Ask questions if you don’t know what to do.
2. Tell your teacher if you have any allergies.
3. Never put any materials in your mouth. Do not touch anything unless your teacher tells you to do so.
4. Never smell any unknown material. If your teacher tells you to smell something, wave your hand over the material to bring the smell toward your nose.
5. Do not touch your face, mouth, ears, eyes, or nose while working with chemicals, plants, or animals.
6. Always wash your hands with soap and warm water after handling chemicals, plants, or animals.
7. Always wash your hands with soap and warm water after handling chemicals, plants, or animals.
8. Never mix any chemicals unless your teacher tells you to do so.
9. Report all spills, accidents, and injuries to your teacher.
10. Treat animals with respect, caution, and consideration.
11. Clean up your work space after each investigation.
12. Act responsibly during all science activities.

Full Option Science System
SCHEDULING THE MODULE

Below is a suggested teaching schedule for the module. The investigations are numbered and should be taught in order, as the concepts build upon each other from investigation to investigation. We suggest that a minimum of nine weeks be devoted to this module.

Active-investigation (A) sessions include hands-on work with materials active thinking about experiences, small-group discussion, writing in science notebooks, and learning new vocabulary in context.

Reading (R) sessions involve reading FOSS Science Resources articles. Reading can be completed during language-arts time to make connections to Common Core State Standards for ELA (CCSS ELA).

During Wrap-Up/Warm-Up (W) sessions, students share notebook entries and engage in connections to CCSS ELA. These sessions can also be completed during language-arts time.

I-Checks are short summative assessments at the end of each investigation. Students have a short notebook review session the day before and a self-assessment of selected items the following day. (See the Assessment chapter for the next-step strategies for self-assessment.)

<table>
<thead>
<tr>
<th>Week</th>
<th>Day 1</th>
<th>Day 2</th>
<th>Day 3</th>
<th>Day 4</th>
<th>Day 5</th>
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<tr>
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<td>Survey</td>
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<tr>
<td>1</td>
<td>START Inv. 1 Part 1</td>
<td>A</td>
<td>R/W</td>
<td>START Inv. 1 Part 2</td>
<td>R/W</td>
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<tr>
<td>2</td>
<td>START Inv. 1 Part 3</td>
<td>A</td>
<td>A/R/W</td>
<td>A/R</td>
<td>Review</td>
</tr>
<tr>
<td>3</td>
<td>Self-assess</td>
<td>A/W</td>
<td>A</td>
<td>A</td>
<td>R/W</td>
</tr>
<tr>
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<td>START Inv. 2 Part 3</td>
<td>A</td>
<td>A/R</td>
<td>Review</td>
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</tr>
<tr>
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<td>Self-assess</td>
<td>A</td>
<td>A/R/W</td>
<td>A</td>
<td>R/W</td>
</tr>
<tr>
<td>6</td>
<td>START Inv. 3 Part 3</td>
<td>A</td>
<td>A</td>
<td>Review</td>
<td>I-Check 3</td>
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<tr>
<td>7</td>
<td>Self-assess</td>
<td>A</td>
<td>A</td>
<td>R/W</td>
<td>START Inv. 4 Part 2</td>
</tr>
<tr>
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<td>A/R/W</td>
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<td>A/R</td>
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<td>A</td>
<td>R/W</td>
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<td>A</td>
<td>R</td>
<td>R/W</td>
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<td>11</td>
<td>START Inv. 5 Part 3</td>
<td>A</td>
<td>A/R</td>
<td>Review</td>
<td>Posttest</td>
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</table>

NOTE
The Getting Ready section for each part of an investigation helps you prepare. It provides information on scheduling the activities and introduces the tools and techniques used in the activity. Be prepared—read the Getting Ready section thoroughly and review the teacher preparation video on FOSSweb.
FOSS CONTACTS

General FOSS Program Information
www.FOSSweb.com
www.DeltaEducation.com/FOSS

Developers at the Lawrence Hall of Science
foss@berkeley.edu

Customer Service at Delta Education
http://www.DeltaEducation.com/contact.aspx
Phone: 1-800-258-1302, 8:00 a.m.–5:00 p.m. ET

FOSSmap (Online component of FOSS assessment system)
http://fossmap.com/

FOSSweb account questions/help logging in
School Specialty Online Support
loginhelp@schoolspecialty.com
Phone: 1-800-513-2465, 8:30 a.m.–6:00 p.m. ET
5:30 a.m.–3:00 p.m. PT

FOSSweb Tech Support
support@fossweb.com

Professional development
http://www.FOSSweb.com/Professional-Development

Safety issues
www.DeltaEducation.com/MSDS.shtml
Phone: 1-800-258-1302, 8:00 a.m.–5:00 p.m. ET
For chemical emergencies, contact Chemtrec 24 hours per day.
Phone: 1-800-424-9300

Sales and Replacement Parts
www.DeltaEducation.com/BuyFOSS
Phone: 1-800-338-5270, 8:00 a.m.–5:00 p.m. ET