INTRODUCTION

The Energy and Electromagnetism Module consists of five sequential investigations, each designed to introduce or reinforce concepts in physical science dealing with energy and change. Students experience electricity and magnetism as related effects and learn useful applications of electromagnetism in everyday life. In this module, students will

- Ask questions that can be answered about electricity and magnetism.
- Plan and conduct investigations about electromagnetism; record and organize data using appropriate tools for the task.
- Analyze observations; build reasonable explanations; discuss and justify the merits of explanations.
- Conduct an experiment to determine how the force of attraction between two magnets changes with the distance between the magnets.
- Conduct an experiment to determine how the number of winds in an electromagnet coil affects the strength of the magnetism.
- Design and build a model telegraph system.
- Use tools and techniques to make observations and build explanations about light.
## Overview

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<th>Module Summary</th>
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| **Inv. 1: Energy and Circuits** | Students investigate electric current and circuits, the pathways through which electricity flows. They work with a variety of components—D-cells, solar cells, light bulbs, motors, switches, wires—and explore conductors and insulators. They observe energy transfer that results in heat, light, sound, and motion. Students are introduced to sources of energy and components that store energy for later use. | What is needed to light a bulb?  
What does energy do in a circuit with a motor?  
What is needed to make a complete pathway for current to flow in a circuit?  
What do we observe that provides evidence that energy is present? |
| **Inv. 2: Series and Parallel** | Students 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. D-cells and solar cells are used as energy sources. Students also learn about alternative energy sources. | How can you get two bulbs to light at the same time?  
How can you light two bulbs brightly with one D-cell?  
Which design is better for manufacturing long strings of lights—series or parallel?  
How can you make a motor run faster using solar cells? |
| **Inv. 3: The Force of Magnetism** | Students investigate the properties of magnets and their interaction with materials and each other. 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. Students go outdoors to find objects in the environment that are attracted to magnets. | What materials stick 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 when the distance between them changes?  
What do magnets interact with in the outdoor environment? |
### Content
- An electric circuit is a complete pathway through which electric current flows from a source of electric energy to components.
- Electricity transfers energy that can produce heat, light, sound, and motion. Electricity can be produced from a variety of sources.
- A solar cell is a technology that transfers energy from the Sun into electricity.
- Conductors are materials through which electric current can flow; all metals are conductors.
- Energy is present whenever there are moving objects, sound, light, or heat.
- Energy can be generated by using fossil fuels or renewable sources.

### Reading
- **Science Resources Book**
  - "Edison Sees the Light"
  - "Electricity"
  - "Energy"

### Assessment
- **Embedded Assessment**
  - Science notebook entry
  - Response sheet
  - Scientific practices
- **Benchmark Assessment**
  - Survey
  - Investigation 1 I-Check

### Content
- In series circuits, there is a single pathway from the energy source to the components; in parallel circuits each component has its own direct pathway to the energy source.
- Two bulbs can be lit dimly using a series circuit, one in which both bulbs are in a single pathway with the D-cell. Two bulbs can be lit brightly using parallel circuitry, one in which each bulb has direct access to the energy source.
- 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
- **Science Resources Book**
  - "Series and Parallel Circuits"
  - "Alternative Sources of Electricity"
  - "Ms. Osgood's Class Report"

### Assessment
- **Embedded Assessment**
  - Science notebook entries
  - Response sheet
  - Scientific practices
- **Benchmark Assessment**
  - Survey
  - Investigation 2 I-Check

### Content
- Magnets interact with each other and with some materials, and stick to objects that contain iron.
- Magnets have two poles. Like poles of magnets repel each other, and opposite poles attract.
- Magnetism can be induced in iron.
- Magnets are surrounded by an invisible magnetic field, which acts through space and through most materials.
- The magnetic force acting between magnets declines as the distance between them increases.
- Earth has a magnetic field.

### Reading
- **Science Resources Book**
  - "When Magnet Meets Magnet"
  - "Magnificent Magnetic Models"
  - "Make a Magnetic Compass"

### Assessment
- **Embedded Assessment**
  - Science notebook entries
  - Response sheet
  - Scientific practices
- **Benchmark Assessment**
  - Survey
  - Investigation 3 I-Check
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| **Inv. 4: Electromagnets** | 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? |
| 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 build a simple telegraph system and communicate using a click code. | |
| **Inv. 5: Light Insight** | How does light travel?  
What happens when light strikes an object? |
| Students use mirrors to reflect light and learn that light travels in straight lines. They are introduced to blocked light (shadows), to light absorption, and to white light as a mixture of all colors of light. They investigate firsthand and through simulations how the appearance of an object is affected by the color of light striking it. | |
### Content

- 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.
- The amount of electric current flowing in an electromagnet circuit affects the strength of the magnetism in the core (more current = more magnetism).
- A telegraph system is an electromagnet-based technology used for long-distance communication.

- Light travels in a straight line 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.
- The apparent color of an object is the result of the light it radiates or reflects.
- The apparent color of an object is affected by the color of light striking it.

### Reading

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

- **Media**
  - *All about Light*

### Assessment

- **Embedded Assessment**
  - Science notebook entry
  - Response sheet
  - Scientific practices

- **Benchmark Assessment**
  - *Investigation 4 I-Check*
FOSS CONCEPTUAL FRAMEWORK

In the last half decade, a significant amount of teaching and learning research has focused on learning progressions. The idea behind a learning progression is that core ideas in science are complex and wide-reaching, requiring years to develop fully—ideas such as the structure of matter or the relationship between the structure and function of organisms. From the age of awareness throughout life, matter and organisms are important to us. There are things students can and should understand about these core ideas in primary school years, and progressively more complex and sophisticated things they should know as they gain experience and develop cognitive abilities. When we as educators can determine those logical progressions, we can develop meaningful and effective curriculum for students.

FOSS has elaborated learning progressions for core ideas in science for kindergarten through grade 8. Developing a learning progression involves identifying successively more sophisticated ways of thinking about a core idea over multiple years. “If mastery of a core idea in a science discipline is the ultimate educational destination, then well-designed learning progressions provide a map of the routes that can be taken to reach that destination” (National Research Council, A Framework for K–12 Science Education, 2011).

The FOSS modules are organized into three domains: physical science, earth science, and life science. Each domain is divided into two strands, as shown in the table below for the FOSS Elementary Program. Each strand represents a core idea in science and has a conceptual framework.

- Physical Science: matter; energy and change
- Earth Science: dynamic atmosphere; rocks and landforms
- Life Science: structure and function; complex systems

The sequence in each strand relates to the core ideas described in the national framework. Modules at the bottom of the table form the foundation in the primary grades. The core ideas develop in complexity as you proceed up the columns.

Information about the FOSS learning progression appears in the conceptual framework (page 9), which shows the structure of scientific knowledge taught and assessed in this module, and the content sequence (pages 16-17), a graphic and narrative description that puts this single module into a K–8 strand progression.
In addition to the science content development, every module provides opportunities for students to engage in and understand the importance of scientific practices, and many modules explore issues related to engineering practices and the use of natural resources.

**Asking questions and defining problems**

- Ask questions about objects, organisms, systems, and events in the natural and human-made world (science).
- Ask questions to define and clarify a problem, determine criteria for solutions, and identify constraints (engineering).

**Planning and carrying out investigations**

- Plan and conduct investigations in the laboratory and in the field to gather appropriate data (describe procedures, determine observations to record, decide which variables to control) or to gather data essential for specifying and testing engineering designs.

**Analyzing and interpreting data**

- Use a range of media (numbers, words, tables, graphs, images, diagrams, equations) to represent and organize observations (data) in order to identify significant features and patterns.

**Developing and using models**

- Use models to help develop explanations, make predictions, and analyze existing systems, and recognize strengths and limitations of proposed solutions to problems.

**Using mathematics and computational thinking**

- Use mathematics and computation to represent physical variables and their relationships and to draw conclusions.

**Constructing explanations and designing solutions**

- Construct logical explanations of phenomena, or propose solutions that incorporate current understanding or a model that represents it and is consistent with available evidence.

**Engaging in argumentation from evidence**

- Defend explanations, develop evidence based on data, examine one’s own understanding in light of the evidence offered by others, and challenge peers while searching for explanations.

**Obtaining, evaluating, and communicating information**

- Communicate ideas and the results of inquiry—orally and in writing—with tables, diagrams, graphs, and equations—in collaboration with peers.

*Energy and Electromagnetism Module*
BACKGROUND FOR THE CONCEPTUAL FRAMEWORK
in Energy and Electromagnetism

Scientists have identified four forces that drive and control actions in the universe. From weakest to strongest, they are gravity, weak nuclear, electromagnetic, and strong nuclear. Gravity, the weakest of the four, acts to attract masses toward each other. The strong nuclear force, the strongest of the four, binds the atomic nucleus together. The weak nuclear force produces radioactivity in certain materials. The electromagnetic force does everything else. It is responsible for most of the phenomena that we describe as electricity, magnetism, light, and heat. It is the force that drives the complex process of life itself.

Early Awareness of Magnetism

Magnetism was first recognized as a property of a naturally occurring mineral that today is called lodestone. About 600 BCE (before the common era), Greek shepherds noted that bits of a certain kind of stone would stick to the iron tips of their staffs and the iron nails in their sandals, but nothing besides the novelty of the phenomenon was understood.

As early as 1000 CE, people knew that if pieces of lodestone were floated on corks placed in water, the stones always oriented north/south, and could be used as crude compasses. An account of suspended magnetic compasses was written in Chinese by Shen Kua in 1088. In 1269, French engineer Pierre de Maricourt discovered that the magnetism in lodestones can be detected and described as lines of force, and that the magnetic phenomenon has two different natures or poles. In 1600, William Gilbert tested magnetic phenomena extensively and found that the two ends of a magnet always behave differently. He called the two ends the north pole and the south pole. He also found that opposite poles attract and similar poles repel one another. His work explained the behavior of the lodestone compass. He speculated that the entire Earth was a magnet, complete with its own set of poles.

Early Awareness of Electricity

Electric phenomena were first investigated systematically by the Greeks several hundred years BCE. They found that rubbing a piece of amber with cloth gave amber the ability to attract small scraps of straw. What they discovered was static electricity, the electricity that makes your clothes cling, gives you fly-away hair, and zaps you when you grab the door handle after sliding across the car seat. The Greek word for amber was elektron.
During the 17th and 18th centuries, an understanding of electricity slowly developed. Gilbert found that a variety of rubbed surfaces could attract a variety of materials. The attracting force was so widespread, he thought, that it deserved to be named. Other careful investigators discovered that the electric force can move from one place to another through some substances, but not through others. The materials through which the charge can travel are conductors; the others are insulators. In 1752, Ben Franklin performed his famous kite experiment, proving to the world that he was one lucky fellow not to be electrocuted by such a daring act and that, as he suspected, lightning is electricity.

In 1800, a major discovery revolutionized the way we live. Alessandro Volta developed the first battery from silver and zinc disks in a saltwater environment. Volta’s battery produced a continuous flow of electricity rather than an electric surge that could be discharged only once. What followed was a scientific and technological revolution that changed forever the way we live.

**Unification of Magnetism and Electricity**

At the beginning of the 19th century, magnetism and electricity were believed to be completely separate phenomena. This idea changed in 1820, when Hans Christian Oersted discovered that a wire carrying a current deflects a compass needle. The wire acts like a magnet. A decade later, an English physicist named Michael Faraday figured that, if electricity could produce magnetism, magnetism might create electricity. In 1831, he demonstrated that a magnet passing through a coil of wire produced a surge of electricity in the wire. Faraday’s work unified magnetism and electricity as a single force. Moving magnets and coils are the basis of modern generators. Massive coils, driven by steam or falling water, rotate in huge magnetic fields to produce electricity for home and industry.
Since Faraday’s time, the chronicles of electric and magnetic discoveries show advance after advance, from electric motors, generators, and lights to communication devices such as the telegraph, telephone, radio, and television. In the 1940s, some scientists experimented with a poorly conductive crystalline substance called silicon. They discovered that, when traces of impurities are in the material, it conducts electricity in interesting ways. A crystal can act like a switch or a one-way valve, allowing electricity to flow in only one direction, and can perform other interesting functions. These silicon materials came to be known as semiconductors.

The most famous semiconductor, the transistor, evolved into integrated circuits, which are scores or even millions of transistors and other electronic components compressed into a tiny wafer, or chip, of silicon embedded in hard plastic. Chips allow incredible miniaturization of circuitry. We can now listen to a radio that rides comfortably in our ear, watch television on our wrist, store file cabinets full of paper on a flash drive that fits in our hand, and carry a powerful computer from place to place in a briefcase or pocket. Amazing, and you can rest assured that further miniaturization of electric circuitry is to come.

**How Electricity Works**

Electric current is the movement of charge. The charge carriers are usually electrons, those subatomic particles that buzz around the nucleus of every atom. Electrons are negatively charged. Inside the nucleus of an atom are protons and neutrons. Protons are positively charged, and neutrons have no charge. Under normal conditions the number of electrons (–) is equal to the number of protons (+), so the net charge of the atom is neutral.

But atoms are often not neutral. During actions as simple as rubbing a rubber rod with a piece of wool, electrons can be “stolen.” In this case, electrons leave the atoms in the wool and attach to atoms in the rubber. Thus the wool ends up with more protons than electrons and the rubber with more electrons than protons. This separation of charge results in a positive electric charge for the wool and a negative electric charge for the rubber. We call the separation, static charge.

Conditions of imbalance are unstable. Electrons tend to move instantaneously to areas of positive electric charge until balance is achieved. If the number of moving electrons is great, we might see them move as a spark. When you slide across the car seat and then touch the door handle, you feel a momentary shock as the electric charges equalize, and then nothing. Electricity that moves in this way is static discharge.
Portable radios (sound), car horns (sound), flashlights (light), and all other familiar electric devices (toasters, hair dryers) use a different form of electricity: current electricity in a circuit. The simplest source of electric current is the dry cell—a battery. Inside are carefully selected chemicals. The chemicals have a predisposition to react with one another, a process that involves the transfer of charge. The battery is designed so that the chemicals can’t interact directly. To react they must pass electrons from the electron-donor chemical to the electron-receiver chemical through an external pathway. So a battery is an engineered container of chemicals with a potential to drive electrons from one terminal (electrode) to the other when a conductive pathway is provided.

If a continuous pathway connects one electrode to the other and is made of material with loosely associated electrons, the battery will push charge (electrons) through the material. The resulting movement of electrons is electric current. Materials through which electrons move are conductors. The outermost electrons in all metals form a kind of electron sea surrounding the nuclei, making metals good conductors. If the electrons are tightly attached to the nucleus, or dedicated to forming strong bonds between nuclei, they cannot be induced to move from one atom to the next. No electricity will flow. Such materials are insulators. Rock, wood, plastic, glass, cloth, and paper are all insulators.

The electromotive force is the push that moves the electrons on their way. It is measured in volts. If electricity acted like water, voltage would be the amount of pressure pushing the water through the pipe. The number of electrons actually moving along is current. It is measured in amperes. Following the water analogy, amperage is the amount of water (number of water molecules) in motion. The pathway (pipe) is a circuit. If the pathway allows the electricity to flow, it is a closed circuit; if no electricity can flow, it is an open circuit.

**How Magnetism Works**

Moving charges generate electric current, so those electrons whizzing around every atom’s nucleus are generating a localized electric current. Because electric currents produce magnetic fields, every atom in the universe has its own little magnetic field.

In most materials, the electrons spin in different directions, effectively cancelling the magnetic fields created around each atom. In a few materials, such as iron, cobalt, and nickel, atoms form magnetic domains that act like little magnets inside the larger structure of the material. In a steel nail, the domains are distributed randomly and have no magnetic effect. If the magnetic domains can be reoriented so that they align in the same direction, the nail will become a magnet.
Magnets can be made in several ways. A very strong magnetic field will reorient some of the magnetic domains in a piece of steel. The stronger the field, the stronger the magnet produced. Also, if a piece of steel is oriented north/south and you strike it a mighty blow, the magnetic domains will be thrown into a momentary state of chaos, and as they settle down, Earth’s magnetic field will influence their orientation. A magnet can be made with a nail and a hammer in this manner.

Temporary magnets can be made by wrapping coils of insulated wire around a piece of steel and running a current through the wire. The magnetic field created by the current reorients a large number of the magnetic domains while the current is flowing, thus creating an electromagnet. When the current is interrupted, the domains return to their random orientations, and the piece of steel loses its magnetism.

Magnets might pose a hazard in the classroom—not to you and your students, but to any old-fashioned videotapes or other magnetic storage technologies, including credit cards. (CDs and DVDs are optical technologies, not magnetic technologies, so they are not affected by magnets.) The brown magnetic tape and the black part of magnetic storage cards have carefully oriented domains of magnetism. When they interact with an electronic circuit, little pulses of electricity are generated that carry specific messages. If you bring a magnet close to one of these magnetic-storage devices, you can destroy the encoded message by reorienting the little domains of magnetism.

Primary Source of Energy

We live 150 million kilometers from a star that radiates energy continuously. The energy streams out in lots of discrete forms, but the most important form for us here on Earth is electromagnetic radiation. Electromagnetic radiation is delivered in a spectrum of specific wavelengths, from radio waves on the long-wavelength, low-energy end of the spectrum to the X-rays and gamma rays at the short-wavelength, high-energy end. In the middle of the spectrum is visible light. Most of the Sun’s energy that reaches Earth’s surface is in the visible and near-visible wavelengths.

Four things can happen to light that falls on materials on Earth (including the atmosphere, water, and organisms): It can pass through unchanged (transmit), pass through but be redirected (refract), bounce off (reflect), or soak in (absorb). When energy is absorbed, the object that absorbed it has more energy. When sunlight falls on the land or sea and is absorbed, it usually changes into heat. Earth maintains a habitable temperature in a potentially inhospitable universe in part because of its “just-right” proximity to a star, bathed in neither too much nor too little energy.
One of the defining characteristics of Earth is that it is liberally covered with plants and other organisms, such as algae, that absorb solar energy. The absorbed energy is not transformed into heat, but rather into chemical bonds. This complex biochemical process is photosynthesis. The energy of the chemical bonds of carbohydrates, fats, and proteins provides the energy that drives the process of life. The energy can be released as needed to run the metabolic processes, such as growth, movement, sensory response, brain function, reproduction, and the millions of other essential operations that together define life.

**Stored Energy**

The energy locked in the bodies of organisms can be used by humans for other purposes. Plants, particularly trees, contain a lot of stored energy. That energy produces heat when the plant material burns. Materials that contain stored energy that can produce heat are called fuels. Other examples are fossil fuels, such as coal, petroleum, and natural gas.

**Energy Transmission**

Energy is a property, or perhaps a condition, of matter. Atoms and electrons are always in motion, and motion has energy. When matter absorbs energy, the matter usually heats up. Hot matter has more energy than cold matter. Energy is always moving. The net flow of energy is always from a place of higher energy to a place of lower energy. Two ways that energy gets from one place to another are by radiation and conduction. Radiation is how energy travels through space. Light, heat, X-rays, radio waves, and their ilk transfer by radiation. Conduction transfers energy by contact between molecules—physical contact, such as your hand touching a hot stove and getting burned.

Energy travels through water as waves. A pebble tossed into a pond creates a disturbance when its contact transfers kinetic energy from the pebble to the water. Waves emanate outward from the source. Eventually little waves “crash” on the shore of the pond, transferring the energy of the wave to the sand and rocks.

Ocean waves develop when energy transfers from wind to water. The energy of waves moves across the ocean until the waves crash on the shore. But the source of the energy, the wind, is itself a product of solar energy. So, in a very real way, ocean waves are just one more manifestation of solar energy.
Energy in electric currents can produce light, heat, sound, and magnetism. The magnetic energy can produce motion in an electric motor. The electric motor is one of the technological icons of Western culture, as so many of the advances in labor saving, convenience, recreation, manufacturing, construction, and so on are enabled or assisted by movement powered by electric motors.

**Light**

Light is an electromagnetic radiation. The primary source of light is a radiant object. The most familiar radiant object is the Sun, but lamp filaments, flames, flashes of electricity, and fireflies are also primary sources of light. These objects make light.

Light starts from a vibrating charge, like an electron. The vibration creates waves of energy that stream out in all directions. They are called electromagnetic waves. The size of the wave depends on the rate of vibration of the source charge. Rapidly vibrating charges have lots of energy, and the high-frequency waves they produce have lots of energy, too.

All electromagnetic waves, regardless of their frequency, travel at the speed of light (299,792 kilometers per second or 186,000 miles per second) in straight lines until they hit something. The different frequencies of light waves, called wavelengths, are organized into the electromagnetic spectrum. The longest wavelengths are the low-energy radio frequencies. A single radio wave can be a meter or more in length. At the other end of the spectrum are the high-energy X-rays and gamma rays, with tiny wavelengths that are billionths of a centimeter. Right in the center of the spectrum is a narrow slice of wavelengths known as visible light. The wavelengths of visible light range from 0.00004 cm (violet) to 0.00007 cm (red). It is this small range of wavelengths that we humans exploit for vision. We cannot see longer wavelengths (infrared and longer) or shorter wavelengths (ultraviolet and shorter), although we can feel infrared radiation as heat and sense the effects of ultraviolet radiation when we are careless and get a painful sunburn.
Vision

The human eye has evolved photosensors (modified neurons called rods and cones) that turn visible light into electric pulses, which are processed in the brain to effect what we know as vision. Vision is a direct response to light interacting with photoreceptors.

Light can come from a primary source (radiant object) or a secondary source (an object that reflects light). Reflected light is a little different from what we usually consider a reflection, like that from a window or mirror. Reflected light hits an object and is not absorbed, but bounces off in a new direction. Trees, books, people, oranges, shoes, and every other nonluminous object we see—all reflect light.

Light coming from the Sun is a mixture of frequencies of light. The flood of light includes red, yellow, green, blue, orange, and every other color of light mixed together. The net result is white light. When white light falls on an orange, the orange absorbs wavelengths of light selectively, and reflects the rest. The orange reflects only orange light, so that is what enters our eye. And the orange looks . . . orange! Leaves of trees reflect only green light, stop signs absorb everything but red, and so on. That’s what happens when white light falls on an object.

What happens when only selected wavelengths of light fall on an object such as a ripe orange? The orange absorbs all colors of light except orange. If you shine a blue light on the orange, the fruit absorbs the blue light and reflects nothing. The orange appears black.
# Energy and Change Content Sequence

This table shows the five FOSS modules and courses that address the content sequence “energy and change” for grades K–8. Running through the sequence are two progressions—1) motion and stability: forces and interactions, and 2) energy transfer and conservation. The supporting elements in each module (somewhat abbreviated) are listed. The elements for the *Energy and Electromagnetism Module* are expanded to show how they fit into the sequence.

## Energy and Electromagnetism Module

- A circuit is a pathway through which electric current (energy) can transfer to produce light and other effects.
- Voltage (electromotive force) is the push that moves electric current through a circuit.
- Resistance is a property of materials that impedes the flow of electric current.
- There is a relationship (Ohm’s law) between resistance, voltage, and electric current in a circuit.
- Energy can be moved from place to place by electric currents.
- Current (electric energy) is the amount of charge moving past a point in a conductor in a unit of time.
- The sum of the voltage drops in a circuit is equal to the voltage available at the source.
- Voltage drop is proportional to resistance.
- Resistances in series add; resistances in parallel add inversely.

## Force and Motion

- A net force is the sum of the forces acting on a mass; a net force applied to a mass results in acceleration of the mass.
- Gravity is a force pulling two masses toward each other; the strength of the force depends on the objects’ masses.
- The heavier the object, the greater the force needed to achieve the same change in motion.
- When two objects interact, each one exerts a force on the other, causing energy transfer between them.
- Friction increases energy transfer to the surrounding environment by heating or accelerating the interacting materials.

## Motion, Force, and Models

- Any change of motion requires a force.
- Gravity is a pulling force that acts between all masses.
- Patterns of motion can be observed; when there are regular patterns of motion, future patterns can be predicted.

## Energy and Electromagnetism

- Objects can be balanced in many ways; counterweights can balance an object.
- Pushing or pulling on an object can change the speed or direction of its motion (rolling, rotation, vibration) and can start or stop it.
- Magnetic force acts at a distance to make objects move by pushing or pulling.

## Balance and Motion

- A bigger push or pull makes things go faster.
- Sound comes from vibrating objects.
- Larger objects vibrate slowly and produce low-pitched sounds; smaller objects vibrate quickly and produce high-pitched sounds.
### Motion and Stability: Forces and Interactions

- Magnets interact with each other and with materials that contain iron.
- Like poles of magnets repel each other; opposite poles attract. The magnetic force declines as the distance between the magnets increases.
- Conductors are materials through which electric current can flow; all metals are conductors.

### Energy Transfer and Conservation

- Energy is present whenever there is motion, electric current, sound, light, or heat.
- Electricity (electric current) transfers energy that can produce heat, light, sound, and motion. Electricity can be produced from a variety of sources.
- A circuit is a system that includes a complete pathway through which electric current flows from a source of energy to its components.
- Energy can be generated by burning fossil fuels or harnessing renewable energy sources such as solar, wind, hydroelectric, and geothermal.
The Energy and Electromagnetism Module aligns with the NRC Framework. The module addresses these 3–5 grade band endpoints described for core ideas from the national framework for physical science and for engineering, technology and the application of science.

**Physical Sciences**

**Core idea PS2: Motion and stability: Forces and interactions—How can we explain and predict interactions between objects and within systems?**

- **PS2.B:** What underlying forces explain the variety of interactions observed? [Electric, magnetic, and gravitational forces between a pair of objects do not require that the objects be in contact—for example, magnets push or pull at a distance. The sizes of the forces in each situation depend on the properties of the objects and their distances apart, and for forces between magnets, on their orientation relative to each other.]

**Core idea PS3: Energy—How is energy transferred and conserved?**

- **PS3.A:** What is energy? [Energy can be moved from place to place by moving objects or through sound, light, or electric currents. (Boundary: At this grade level, no attempt is made to give a precise or complete definition of energy.)]

- **PS3.B:** What is meant by conservation of energy? How is energy transferred between objects or systems? [Energy is present whenever there are moving objects, sound, light, or heat. Light also transfers energy from place to place. For example, energy radiated from the Sun is transferred to Earth by light. When this light is absorbed, it warms Earth’s land, air, and water and facilitates plant growth. Energy can also be transferred from place to place by electric currents, which can then be used locally to produce motion, sound, heat, or light. The currents may have been produced to begin with from the energy of motion (e.g., moving water driving a spinning turbine).]

- **PS3.C:** How are forces related to energy? [Magnets can exert forces on other magnets or on magnetizable materials, thereby transferring energy (e.g., in the form of motion) even when the objects are not touching.]

- **PS3.D:** How do food and fuel provide energy? If energy is conserved, why do people say it is produced or used? [The expression “produce energy” typically refers to the conversion of stored energy into a desired form for practical use—for example, the stored energy of water behind a dam is released so that it flows downhill and drives a turbine generator to produce electricity. Food and fuel also]
release energy when they are burned or digested. When machines or animals “use” energy, most often the energy ends up transferred to heat in the surrounding environment. The energy released by burning fuel or digested food was once energy from the Sun that was captured by plants. (Boundary: The fact that plants capture energy from sunlight is introduced at this level, but details of photosynthesis are not.)

It is important to be able to concentrate energy so that it is available for use where and when it is needed. For example, batteries are physically transportable energy storage devices, whereas electricity generated by power plants is transferred from place to place through distribution systems.

Core idea PS4: Waves and their applications in technologies for information transfer—How are waves used to transfer energy and information?

- PS4.B: What is light? How can one explain the varied effects that involve light? What other forms of electromagnetic radiation are there? [An object can be seen when light reflected from its surface enters the eyes; the color people see depends on the color of the available light sources as well as the properties of the surface. The stress is on understanding that light traveling from the object to the eye determines what is seen.]

- PS4.C: How are instruments that transmit and detect waves used to extend human senses? [High-tech devices, such as computers or cell phones, can receive and decode information—convert it from digitized form to voice—and vice versa.]

Engineering, Technology, and Applications of Science

Core idea ETS1: Engineering design—How do engineers solve problems?

- ETS1.A: What is a design for? What are the criteria and constraints of a successful solution? [Different proposals for solutions can be compared on the basis of how well each one meets criteria.]

Core idea ETS2: Links among engineering, technology, science, and society—How are engineering, technology, science, and society interconnected?

- ETS2.B: How do science, engineering, and the technologies that result from them affect the ways in which people live? How do they affect the natural world? [Every human-made product is designed by applying some knowledge of the natural world and is built by using materials derived from the natural world.]
FOSS COMPONENTS

Teacher Toolkit

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
• Materials
• Investigations (five in this module)

Teacher Resources. This three-ring binder contains these chapters.

• FOSS Introduction
• Assessment
• Science Notebooks in Grades 3–6
• Science-Centered Language Development
• Taking FOSS Outdoors
• FOSSweb and Technology
• Science Notebook Masters
• Teacher Masters
• Assessment Masters

The chapters contained in the Teacher Resources and the Spanish duplication masters can also be found on FOSSweb (www.FOSSweb.com) and on CDs included in the Teacher Toolkit.

FOSS Science Resources book. One copy of the student book of readings is included in the Teacher Toolkit.

Equipment Kit

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 two uses before you need to resupply. Teachers may be asked to supply small quantities of common classroom items.
FOSS Science Resources Books

FOSS Science Resources: Energy and Electromagnetism is a book of original readings developed to accompany this module. The readings are referred to as articles in the Investigations Guide. Students read the articles in the book as they progress through the module. The articles cover a specific concept usually after that concept has been introduced in an active investigation.

The articles in Science Resources and the discussion questions provided in the 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.

FOSSweb and Technology

The FOSS website opens new horizons for educators, students, and families, in the classroom or at home. Each module has an interactive site where students and families can find instructional activities, interactive simulations and virtual investigations, and other additional resources. FOSSweb provides resources for materials management, general teaching tools for FOSS, purchasing links, contact information for the FOSS Project, 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 Development

The Lawrence Hall of Science and Delta Education are committed to supporting science educators with unrivaled teacher support, high-quality implementation, and continuous staff-development opportunities and resources. FOSS has a strong network of consultants who have rich and experienced backgrounds in diverse educational settings using FOSS. Find out about professional-development opportunities on FOSSweb.
FOSS INSTRUCTIONAL DESIGN

Each FOSS investigation follows a similar design to provide multiple exposures to science concepts. The design includes these pedagogies.

- Active investigation, including outdoor experiences
- Recording in science notebooks to answer the focus question
- Reading in FOSS Science Resources
- Assessment to monitor progress and motivate student reflection on learning

In practice, these components are seamlessly integrated into a continuum 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.

FOSS Investigation Organization

Modules are subdivided into investigations (five in this module). Investigations are further subdivided into two 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.

Investigation-specific scientific background information for the teacher is presented in each investigation chapter. The content discussion is divided into sections, each of which relates directly to one of the focus questions. This section ends with information about teaching and learning and a conceptual-flow diagram for the content.

The Getting Ready and Guiding the Investigation sections have several features that are flagged or presented 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.

Teaching notes 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. It supports your work teaching students at all levels, from management to inquiry. 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.
The **safety** icon alerts you to a potential safety issue. It could relate to the use of a chemical substance, such as salt, requiring safety goggles, or the possibility of a student allergic reaction when students use latex, legumes, or wheat.

The small-group **discussion** icon asks you to pause while students discuss data or construct explanations in their groups. Often a Reporter shares the group’s conclusions with the class.

The **new-word** icon alerts you to a new vocabulary word or phrase that should be introduced thoughtfully. The new vocabulary should also be entered onto the word wall (or pocket chart). A complete list of the scientific vocabulary used in each investigation appears in the sidebar on the last page of the Background for the Teacher section.

The **vocabulary** icon indicates where students should review recently introduced vocabulary, often just before they will be answering the focus question or preparing for benchmark assessment.

The **recording** icon points out where students should make a science-notebook entry. Students record on prepared notebook sheets or, increasingly, on pages in their science notebooks.

The **reading** icon signals when the class should read a specific article in the FOSS Science Resources book, preferably during a reading period.

The **assessment** icon appears when there is an opportunity to assess student progress by using embedded or benchmark assessments. Some of the embedded-assessment methods for grades 3–6 include observation of students engaged in scientific practices, review of a notebook entry, and response sheets.

The **outdoor** icon signals when to move the science learning experience into the schoolyard. It also helps you plan for selecting and preparing an outdoor site for a student activity.

The **engineering** icon indicates opportunities for addressing engineering practices—applying and using scientific knowledge. These opportunities include developing a solution to a problem, constructing and evaluating models, and using systems thinking.

The **EL note** in the sidebar provides a specific strategy to use to assist English learners in developing science concepts. A discussion of strategies is in the Science-Centered Language Development chapter.

To help with pacing, you will see icons for **breakpoints**. Some breakpoints are essential, and others are optional.
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. (What is needed to light a bulb?) 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 what materials can complete a circuit. 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 and the readings to lead students to a comprehensive understanding of concepts. Through the investigations, 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 existing knowledge. Students share their explanations for phenomena, using evidence generated during the investigation to support their ideas. They conclude the active investigation by writing in their science notebooks a summary of their learning as well as questions raised during the activity.

**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 elements of the assessment system.

You will find the duplication masters for grades 1–6 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.

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**Energy and Electromagnetism Module**

<table>
<thead>
<tr>
<th>10-9-15</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is needed to light a bulb?</td>
</tr>
<tr>
<td><strong>FQ answer:</strong> There needs to be a complete pathway and an energy source. The components have to be connected at the right contact points. The current needs a way into the bulb and a different way out.</td>
</tr>
</tbody>
</table>
Reading in FOSS Science Resources

The FOSS Science Resources books emphasize expository articles and biographical sketches. FOSS suggests that the reading be completed during language-arts time. 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.

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 generally diagnostic. Summative assessment looks at the learning after instruction is completed, and it measures achievement.

Formative assessment in FOSS, called embedded assessment, occurs on a daily basis. You observe action during class or review notebooks after class. 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 a specific item on an I-Check with the class provides another opportunity 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. Within the instructional sequence, you will see the heading What to Look For in red letters. Under that, you will see bullet points telling you specifically what students should know and be able to communicate.
17. Assess progress: notebook entry

Have students hand in their notebooks open to the page on which they answered the focus question. Review students’ notebooks after class and check to see how they communicate their understanding of a basic circuit.

Record your notes on a copy of Embedded Assessment Notes.

What to Look For

- Students write that there must be a source of energy (D-cell) for the bulb to light.
- Students write that the energy (electricity) needs a complete pathway (circuit) through all the components to move or transfer energy.
- Students write that each component in the circuit needs to be connected with two different contact points.

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. They identify the depth to which students understand science concepts and principles and the extent to which they can apply that understanding. Since the output from the benchmark assessments is descriptive and complex, it can be used for formative as well as summative assessment.

Completely incorporating the assessment system into your teaching practice involves realigning your perception of the interplay between good teaching and good learning, and usually leads to a considerably different social order in the classroom with redefined student-student and teacher-student relationships.
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 might 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 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 the Teacher Resources.

FOSS is very enthusiastic about this dimension of the program and looks forward to hearing about your experience using the schoolyard as a logical extension of your classroom.
Science-Centered Language Development

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. We identify best practices in language-arts instruction that support science learning and examine how learning science content and engaging in scientific practices support 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 and strategies support conceptual development and scientific practices. For example, the skills and strategies used for enhancing reading comprehension, writing expository text, and exercising oral discourse are applied when students are recording their observations, making sense of science content, and communicating their ideas. Students’ use of language improves when they discuss (speak and listen, as in the Wrap-Up/Warm-Up activities), write, and read about the concepts explored in each investigation.

There are many ways to integrate language into science investigations. 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. The last section covers language-development strategies that are specifically for English learners.
FOSSWEB AND TECHNOLOGY

FOSS is committed to providing a rich, accessible technology experience for all FOSS users. FOSSweb is the Internet access to FOSS digital resources. It provides enrichment for students and support for teachers, administrators, and families who are actively involved in implementing and enjoying FOSS materials. Here are brief descriptions of selected resources to help you get started with FOSS technology.

Technology to Engage Students at School and at Home

Multimedia activities. The multimedia simulations and activities were designed to support students’ learning. They include virtual investigations and student tutorials that you can use to support students who have difficulties with the materials or who have been absent.

FOSS Science Resources. The student reading book is available as an audio book on FOSSweb, accessible at school or at home. In addition, as premium content, FOSS Science Resources is available as an eBook. The eBook supports a range of font sizes and can be projected for guided reading with the whole class as needed.

Home/school connection. Each module includes a letter to families, providing an overview of the goals and objectives of the module. Most investigations have a home/school activity providing science experiences to connect the classroom experiences with students’ lives outside of school. These connections are available in print in the Teacher Resources binder and on FOSSweb.

Student media library. A variety of media enhance students’ learning. Formats include photos, videos, an audio version of each student book, and frequently asked science questions. These resources are also available to students when they log in with a student account.

Recommended books and websites. FOSS has reviewed print books and digital resources that are appropriate for students and prepared a list of these media resources.

Class pages. Teachers with a FOSSweb account can easily set up class pages with notes and assignments for each class. Students and families can then access this class information online.
Technology to Support Teachers

**Teacher-preparation video.** The video presents information to help you prepare for a module, including detailed investigation information, equipment setup and use, safety, and what students do and learn through each part of the investigation.

**Science-notebook masters and teacher masters.** All notebook masters and teacher masters used in the modules are available digitally on FOSSweb for downloading and for projection during class. These sheets are available in English and Spanish.

**Assessment masters.** The benchmark assessment masters for grades 1–6 (I-Checks) are available in English and Spanish.

**Focus questions.** The focus questions for each investigation are formatted for classroom projection and for printing onto labels that students can glue into their science notebooks.

**Equipment photo cards.** The cards provide labeled photos of equipment supplied in each FOSS kit.

**Materials Safety Data Sheets (MSDS).** These sheets have information from materials manufacturers on handling and disposal of materials.

**Teacher Resources chapters.** FOSSweb provides PDF files of all chapters from the Teacher Resources binder.

- Assessment
- Science Notebooks
- Science-Centered Language Development
- Taking FOSS Outdoors
- FOSSweb and Technology

**Streaming video.** Some video clips are part of the instruction in the investigation, and others extend concepts presented in a module.

**Resources by investigation.** This digital listing provides online links to notebook sheets, assessment and teacher masters, and multimedia for each investigation of a module for projection in the classroom.

**Interactive whiteboard resources.** You can use these slide shows and other resources with an interactive whiteboard.

**Investigations eGuide.** The eGuide is the complete Investigations Guide component of the Teacher Toolkit in an electronic web-based format, allowing access from any Internet-enabled computer.

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**NOTE**

The Spanish masters are available only on FOSSweb and on one of the CDs provided in the Teacher Toolkit.
Module summary. The summary describes each investigation in a module, including major concepts developed.

Module updates. These are important updates related to the teacher materials, student equipment, and safety guidelines.

Module teaching notes. These notes include teaching suggestions and enhancements to the module, sent in by experienced FOSS users.

FOSSmap and online assessments. A computerized assessment program, called FOSSmap, provides a system for students to take assessments online, and for you to review those assessments online and to assign tutorial sessions for individual students based on assessment performance. You generate a password for students to access and take the assessments online.

Most assessment items are multiple-choice, multiple-answer, or short-answer questions, but for one or two questions, students must write sentences. These open-response questions can be answered either online or using paper and pencil.

After students have completed a benchmark assessment, FOSSmap automatically codes (scores) the multiple-choice, multiple-answer, and short-answer questions. You will need to check students’ responses for short-answer questions to make sure that the questions have been coded correctly. Students’ open-response questions are systematically displayed for coding. If students have taken any part of the test via paper and pencil, you will need to enter students’ answers on the computer for multiple-choice and multiple-answer questions (the computer automatically codes the answers), and to code the short-answer and open-response questions.

Once the codes are in the FOSSmap program, you can generate and display several reports.

The Code-Frequency Report is a bar graph showing how many students received each code. This graph makes it easy to see which items might need further instruction.

In the Class-by-Item Report, each item is presented in a text format that indicates a percentage and provides names of students who selected each answer. It also describes what a code means in terms of what students know or need to work on.

The Class-by-Level Report describes four levels of achievement. It lists class percentages and students who achieved each level.
The Class-Frequency Report has bar graphs indicating how many students achieved each level. The survey and posttest are shown on the same page for easy comparison. I-Checks appear on separate pages.

The Student-by-Item Report is available for each student. It provides information about the highest code possible, the code the student received, and a note describing what the student knows or what he or she needs to work on. This report also suggests online tutorials to assign to students who need additional help.

The Student Assessment Summary bar graph indicates the level achieved by individual students on all the assessments taken up to any point in the module. This graph makes it easy to compare achievement on the survey and posttest as well as on each I-Check.

**Tutorials.** You can assign online tutorials to individual students, based on how each student answers questions on the I-Checks and posttest. The Student-by-Item Report, generated by FOSSmap, indicates the tutorials specifically targeted to help individual students to refine their understandings. Tutorials are an excellent tool for differentiating instruction and are available to students at any time on FOSSweb.
UNIVERSAL DESIGN FOR LEARNING

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.

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.

**Principle 2.** Provide multiple means of action and expression. Offer students alternatives for demonstrating what they know.

**Principle 3.** Provide multiple means of engagement. Help learners get interested, be challenged, and stay motivated.

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.

**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 primary 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.

**Differentiated Instruction**

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. 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 through reading to students. For some students, it might 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.

There are several possible 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.
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.
**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.

**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.

There is a set of two or three virtual investigations for each FOSS module for grades 3–6. Students who have been absent from certain investigations can access these simulations online through FOSSweb. The virtual investigations require students to record data and answer concluding questions in their science notebooks. Sometimes the notebook sheet that was used in the classroom investigation is also used for the virtual investigation.
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.–6 p.m. EST).

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 taste 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 protect your eyes. Wear safety goggles when necessary.
7. Never mix any chemicals unless your teacher tells you to do so.
8. Report all spills, accidents, and injuries to your teacher.
9. Always wash your hands with soap and warm water after handling chemicals, plants, or animals.
10. Never touch your face, mouth, ears, eyes, or nose while working with chemicals, plants, or animals.
11. Always wash your hands with soap and warm water after handling chemicals, plants, or animals.
12. Act responsibly during all science activities.
SCHEDULING THE MODULE

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.

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 10 weeks be devoted to this module. Take your time, and explore the subject thoroughly.

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

During **Wrap-Up/Warm-Up (W)** sessions, students share notebook entries.

**Reading (R)** sessions involve reading FOSS Science Resources articles.

**I-Checks** are short summative assessments.

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<th>Week</th>
<th>Day 1</th>
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<td>A/W</td>
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<td>R</td>
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<td>A</td>
<td>R</td>
<td>Review</td>
<td>Posttest</td>
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## ENERGY AND ELECTROMAGNETISM — Overview

### FOSS K–8 SCOPE AND SEQUENCE

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<th>Grade</th>
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<th>Earth Science</th>
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<td>Electronics</td>
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<td>Weather and Water</td>
<td>Diversity of Life</td>
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