INTRODUCTION TO PERFORMANCE EXPECTATIONS

“The NGSS are standards or goals, that reflect what a student should know and be able to do; they do not dictate the manner or methods by which the standards are taught. . . . Curriculum and assessment must be developed in a way that builds students’ knowledge and ability toward the PEs [performance expectations]” (Next Generation Science Standards, 2013, page xiv).

This chapter shows how the NGSS Performance Expectations were bundled in the Materials and Motion Module to provide a coherent set of instructional materials for teaching and learning.

This chapter also provides details about how this FOSS module fits into the matrix of the FOSS Program (page 35). Each FOSS module K–5 and middle school course 6–8 has a functional role in the FOSS conceptual frameworks that were developed based on a decade of research on science education and the influence of A Framework for K–12 Science Education (2012) and Next Generation Science Standards (NGSS, 2013).

The FOSS curriculum provides a coherent vision of science teaching and learning in the three ways described by the NRC Framework. First, FOSS is designed around learning as a developmental progression, providing experiences that allow students to continually build on their initial notions and develop more complex science and engineering knowledge. Students develop functional understanding over time by building on foundational elements (intermediate knowledge). That progression is detailed in the conceptual frameworks.

Second, FOSS limits the number of core ideas, choosing depth of knowledge over broad shallow coverage. Those core ideas are addressed at multiple grade levels in ever greater complexity. FOSS investigations at each grade level focus on elements of core ideas that are teachable and learnable at that grade level.

Third, FOSS investigations integrate engagement with scientific ideas (content) and the practices of science and engineering by providing firsthand experiences.

Teach the module with the confidence that the developers have carefully considered the latest research and have integrated into each investigation the three dimensions of the Framework and NGSS, and have designed powerful connections to the Common Core State Standards for English Language Arts.

Contents

Introduction to Performance Expectations .................. 27
FOSS Conceptual Framework .................................. 34
Background for the Conceptual Framework in Materials and Motion .......... 36
Connections to NGSS by Investigation ......................... 46
Recommended FOSS Next Generation K–8 Scope and Sequence ............... 50

The NGSS Performance Expectations bundled in this module include

Physical Sciences
K-PS2-1
K-PS2-2
K-PS3-1
K-PS3-2

Earth and Space Sciences
K-ESS3-3

Engineering, Technology, and Applications of Science
K–2-ETS1-1
K–2-ETS1-2
K–2-ETS1-3
Disciplinary Core Ideas Addressed

The Materials and Motion Module connects with the NRC Framework for the grades K–2 grade band and the NGSS performance expectations for these grades. The module focuses on core ideas for physical science, earth science, and engineering design.

Physical Sciences

Framework core idea PS1: Matter and its interactions—How can one explain the structure, properties, and interactions of matter?

- PS1.A: Structure and properties of matter
  *How do particles combine to form the variety of matter one observes?*
  [Different kinds of matter exist (e.g., wood, metal, water), and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties, by its uses, and by whether it occurs naturally or is manufactured. Different properties are suited to different purposes. A great variety of objects can be built up from a small set of pieces. Objects or samples of a substance can be weighed, and their size can be described and measured.]

Framework core idea PS2: Motion and stability: Forces and interactions—How can one explain and predict interactions between objects and within systems of objects?

- PS2.A: Forces and motion
  *How can one predict an object’s continued motion, changes in motion, or stability?* [Objects pull or push each other when they collide or are connected. Pushes and pulls can have different strengths and directions. Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. An object sliding on a surface or sitting on a slope experiences a pull due to friction on the object due to the surface that opposes the object’s motion.]

- PS2.B: Types of interactions
  *What underlying forces explain the variety of interactions observed?* [When objects touch or collide, they push on one another and can change motion or shape.]
The following NGSS Grade K Performance Expectations for PS2 are derived from the Framework disciplinary core ideas above.

- **K-PS2-1**: Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object. [Clarification Statement: Examples of pushes or pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other.]

- **K-PS2-2**: Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull. [Clarification Statement: Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path, and knock down other objects. Examples of solutions could include tools such as a ramp to increase the speed of the object and a structure that would cause an object such as a marble or ball to turn.]

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

- **PS3.B**: Conservation of energy and energy transfer
  What is meant by conservation of energy? How is energy transferred between objects or systems? [Sunlight warms Earth’s surface.]

- **PS3.C**: Relationship between energy and forces
  How are forces related to energy? [A bigger push or pull makes things go faster. Faster speeds during a collision can cause a bigger change in shape of the colliding objects; secondary to K-PS2-1.]

The following NGSS kindergarten performance expectations for PS3 are derived from the Framework disciplinary core ideas above.

- **K-PS3-1**: Make observations to determine the effect of sunlight on Earth’s surface. [Clarification Statement: Examples of Earth’s surface could include sand, soil, rocks, and water.] [Assessment Boundary: Assessment of temperature is limited to relative measures such as warmer/cooler.]

- **K-PS3-2**: Use tools and materials to design and build a structure that will reduce the warming effect of sunlight on an area. [Clarification Statement: Examples of structures could include umbrellas, canopies, and tents that minimize the warming effect of the sun.]

**REFERENCES**


Earth and Space Sciences

Framework core idea ESS3: Earth and human activity—How do Earth’s surface processes and human activities affect each other?

• ESS3.A: Natural resources
  How do humans depend on Earth’s resources? [Living things need water, air, and resources from the land, and they try to live in places that have the things they need. Humans use natural resources for everything they do: for example, they use soil and water to grow food, wood to burn to provide heat or to build shelters, and materials such as iron or copper extracted from Earth to make cooking pans.]

• ESS3.C: Human impacts on Earth systems
  How do humans change the planet? [Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things—for example, by reducing trash through reuse and recycling.]

The following NGSS kindergarten performance expectations for ESS3 are derived from the Framework disciplinary core ideas above.

• K-ESS3-3: Communicate solutions that will reduce the impact of humans on the land, water, air, and/or other living things in the local environment. [Clarification Statement: Examples of human impact on the land could include cutting trees to produce paper and using resources to produce bottles. Examples of solutions could include reusing paper and recycling cans and bottles.]

Engineering, Technology, and Applications of Science

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

• ETS1.A: Defining and delimiting an engineering problem
  What is a design for? What are the criteria and constraints of a successful solution? [A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions. Asking questions, making observations, and gathering information are helpful in thinking about problems. Before beginning to design a solution, it is important to clearly understand the problem.]
• ETS1.B: Developing possible solutions
  *What is the process for developing potential design solutions?* [Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem’s solutions to other people. To design something complicated, one may need to break the problem into parts and attend to each part separately but must then bring the parts together to test the overall plan.]

• ETS1.C: Optimizing the design solution
  *How can the various proposed design solutions be compared and improved?* [Because there is always more than one possible solution to a problem, it is useful to compare designs, test them, and discuss their strengths and weaknesses.]

The following NGSS grades K–2 performance expectations for ETS1 are derived from the Framework disciplinary core ideas above.

• **K-2-ETS1-1:** Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.

• **K-2-ETS1-2:** Develop a simple sketch, drawing, or physical model to illustrate how the shape of an object helps it function as needed to solve a given problem.

• **K-2-ETS1-3:** Analyze data from tests of two objects designed to solve the same problem to compare the strengths and weaknesses of how each performs.
Science and Engineering Practices Addressed

1. **Asking questions and defining problems**
   - Ask questions based on observations to find more information about the natural and/or designed world(s).
   - Define a simple problem that can be solved through the development of a new or improved object or tool.

2. **Developing and using models**
   - Develop a simple model based on evidence to represent a proposed object or tool.

3. **Planning and carrying out investigations**
   - With guidance, plan and conduct an investigation with peers.
   - Make observations and/or measurements to collect data that can be used to make comparisons.
   - Make predictions based on prior experiences.

4. **Analyzing and interpreting data**
   - Record information (observations, thoughts, and ideas).
   - Use and share pictures, drawings, and/or writings of observations.
   - Use observations (firsthand or from media) to describe patterns in the natural world in order to answer scientific questions.

5. **Using mathematics and computational thinking**
   - Use counting and numbers to identify and describe patterns in the natural and designed world(s).
   - Describe, measure, and/or compare attributes of different objects and display the data using simple graphs.

6. **Constructing explanations and designing solutions**
   - Make observations (firsthand or from media) to construct an evidence-based account for natural phenomena.
   - Use tools and/or materials to design and/or build a device that solves a specific problem or a solution to a specific problem.

7. **Engaging in argument from evidence**
   - Construct an argument with evidence to support a claim.

8. **Obtaining, evaluating, and communicating information**
   - Read grade-appropriate texts and/or use media to obtain scientific information to determine patterns in the natural world.
   - Communicate information or solutions with others in oral and/or written forms using models or drawings that provide detail about scientific ideas.
Crosscutting Concepts Addressed

Patterns
• Patterns in the natural and human-designed world can be observed, used to describe phenomena, and used as evidence.

Cause and effect
• Events have causes that generate observable patterns.
• Simple tests can be designed to gather evidence to support or refute student ideas about causes.

Scale, proportion, and quantity
• Relative scales allow objects and events to be compared and described (e.g., bigger and smaller; hotter and colder; faster and slower).

Systems and system models
• Objects and organisms can be described in terms of their parts.
• Systems in the natural and designed world have parts that work together.

Energy and matter
• Objects may break into smaller pieces, be put together into larger pieces, or change shapes.

Structure and function
• The shape and stability of structures of natural and designed objects are related to their function(s).

Connections: Understandings about the Nature of Science

Scientific knowledge is based on empirical evidence.
• Scientists look for patterns and order when making observations about the world.

Connections: Science, Technology, Society, and the Environment

Influence of engineering, technology, and science on society and the natural world.
• Every human-made product is designed by applying some knowledge of the natural world and is built by using natural materials.

CROSSCUTTING CONCEPTS

A Framework for K–12 Science Education describes seven crosscutting concepts as essential elements of a K–12 science and engineering curriculum. The crosscutting concepts listed here are those recommended for kindergarten in the NGSS, and are incorporated into the learning opportunities in the Materials and Motion Module.

The learning progression for this dimension of the framework is addressed in volume 2, appendix G, in the NGSS. Elements of the learning progression for crosscutting concepts recommended for kindergarten, as described in the performance expectations, appear after bullets below each concept.

See volume 2, appendix H and appendix J, in the NGSS, for more on these connections.

For details on learning connections to Common Core State Standards for English Language Arts and Math, see the chapters FOSS and Common Core ELA—Grade K and FOSS and Common Core Math—Grade K in Teacher Resources.
FOSS CONCEPTUAL FRAMEWORK

In the last half decade, 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. . . . Because learning progressions extend over multiple years, they can prompt educators to consider how topics are presented at each grade level so that they build on prior understanding and can support increasingly sophisticated learning. (National Research Council, A Framework for K–12 Science Education, 2012, p. 26)

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 “FOSS Next Generation—K–8 Sequence.” Each strand represents a core idea in science and has a conceptual framework.

- Physical Science: matter; energy and change
- Earth and Space 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 NRC 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.

TEACHING NOTE

FOSS has conceptual structure at the module and strand levels. The concepts are carefully selected and organized in a sequence that makes sense to students when presented as intended.
Information about the FOSS learning progression appears in the conceptual framework (pages 39–40), which shows the structure of scientific knowledge taught and assessed in this module, and the content sequence (pages 42–45), a graphic and narrative description that puts this single module into a K–8 strand progression.

FOSS is a research-based curriculum designed around the core ideas described in the NRC Framework. The FOSS module sequence provides opportunities for students to develop understanding over time by building on foundational elements or intermediate knowledge leading to the understanding of core ideas. Students develop this understanding by engaging in appropriate science and engineering practices and exposure to crosscutting concepts. The FOSS conceptual frameworks therefore are more detailed and finer-grained than the set of goals described by the NGSS performance expectations (PEs). The following statement reinforces the difference between the standards as a blueprint for assessment and a curriculum, such as FOSS.

Some reviewers of both public drafts [of NGSS] requested that the standards specify the intermediate knowledge necessary for scaffolding toward eventual student outcomes. However, the NGSS are a set of goals. They are PEs for the end of instruction—not a curriculum. Many different methods and examples could be used to help support student understanding of the DCIs and science and engineering practices, and the writers did not want to prescribe any curriculum or constrain any instruction. It is therefore outside the scope of the standards to specify intermediate knowledge and instructional steps. (Next Generation Science Standards, 2013, volume 2, p. 342)
BACKGROUND FOR THE CONCEPTUAL FRAMEWORK
in Materials and Motion

This module integrates core ideas in physical science (matter and motion), Earth science, and engineering to provide rich learning opportunities for kindergarten students that relate to their interests and are teachable and learnable. We begin with a study of properties of materials and how those properties determine their use. This provides background information that students can apply in their engineering design projects. It is important for young learners to have experiences with concrete objects to build their repertoire of science and engineering practices working in small groups so they can better approach a study of motion with objects that don’t remain in one place.

Materials—Wood, Paper, and Fabric

For thousands of years, humans have used natural fibers from both plant and animal sources to produce useful materials. The short, tough fibers of cellulose found in the stems and branches of plants are useful for making familiar materials that are found all over the world. Cellulose fibers can be teased apart by brute force and made into a pulp. When the pulp is spread out in a uniform layer, pressed flat, and dried, the resulting material is paper.

The first paper mill in the United States was built just over 300 years ago. It used discarded cotton and linen rags exclusively to manufacture paper. In the 1860s, when the demand for paper outstripped the supply, new techniques were developed to manufacture paper from wood. At the turn of the 20th century, 60 percent of the paper made in the United States was derived from wood, with the rest coming from rags and recycled paper, and by 1930 nearly all paper came from virgin fiber sources. Since that time, people have been making advances in reusing paper fiber, but there is still lots of room for advancement.

Long fibers from animals (wool from sheep, angora goats, and alpacas; and silk from moths), or single fibers from plants (cotton seed pods, hemp stems, and flax stems), twisted together, make useful, strong, manageable materials called thread and yarn. Threads and yarns can be manufactured into some of the most varied and important materials on Earth. Known variously as fabric, cloth, material, and textile, these flexible, durable, attractive, and shapeable materials provide protection, warmth, identity, shelter, tools, and beauty.
**Wood.** The wide distribution of wood and its combination of properties make it an especially useful and versatile material. Because wood is most often obtained from trees, and trees come in thousands of different varieties around the world, there are thousands of different kinds of wood. Each kind of wood has observable properties such as color, grain pattern, and density (does it float or sink in water?). Some wood absorbs water, and other types of wood repel water. The properties of wood make it a useful natural resource for many purposes.

Wood production usually begins with the felling of a living tree rather than a dead one. Living trees are more abundant, the wood is in better condition, and they are easier to handle and less likely to split or break during harvest and transportation. Logs are hurried to the lumber mill and kept wet to prevent cracking and splitting before they are sawed.

Some kinds of wood are not from a single tree but are the products of modern technology—manufactured wood materials. Particleboard and plywood are examples of manufactured wood materials. Particleboard was invented to take advantage of abundant waste wood fiber. Over the years, the process of making this material has been refined to produce a wood product used in cabinetry and furniture as well as home construction. Plywood is made from large, thin sheets of wood glued together, with the grain of alternate layers running in perpendicular directions. This construction produces a tremendously strong, large surface wood product, much more suitable for walls and floors than is conventional lumber.

**Paper.** Paper is most often associated with some form of communication—paper as a medium for recording words or images: newspapers, books, letters, advertising flyers, drawings, photographs, and so forth. Paper was developed originally as a lightweight, reasonably durable, flat surface for painting and writing. Even the most cursory glance around today's environment will affirm that the original purpose has been fulfilled at a level certainly undreamed of by the pioneer papermakers.

The craft of papermaking is about 2,000 years old. Paper is an example of a nonnative, or manufactured, material. People used native materials, such as stone, metal, wood, leather, and bone, long before they used manufactured materials, because manufactured materials require an accumulation of knowledge and the application of technology to produce them. The technology for paper production has advanced so that today's paper mills make a huge variety of papers, ranging from delicate facial tissue to strong, durable kraft paper for shopping bags to heavy cardboard and tar paper for industrial use.
Paper falls into the category of renewable resources: the raw material to make paper is constantly being made in nature. If you need a new sheet of paper, you cut down a tree, reduce it to chips, smash and churn the bits into pulp, and make it into paper. If you need a new tree to make the next sheet of paper, you plant it, and nature in time delivers the tree. The false notion of a limitless or endless renewable supply of trees gave rise to the behavior of using paper once and tossing it out.

The forest resource is finite. The typical American uses 260 kilograms (kg) of paper each year, and to supply the Sunday paper to an eager public requires a virtual forest of trees—a whopping 500,000 trees each week. The next generations will have to be better educated than their parents, and their children better educated yet, about the value of fibers and the most effective ways to conserve them. Paper will be categorized with several other materials, as not only renewable but also reusable.

**Fabric.** Fabric is also a manufactured material. The weaving of fabric is an ancient enterprise, dating back perhaps 5,000 years. Natural fibers—probably hair from sheep and goats—were twisted into yarns and woven into a durable cloth, using a frame called a loom. The basic process of weaving threads together in two directions has not changed conceptually; it has just become more efficient and refined. A length of modern fabric might be 1 meter (m) or so wide and 100 m long. When it is wrapped around a piece of cardboard, ready for shipping to the fabric vendor, it is called a bolt of fabric. The long piece of fabric has threads that run the entire length of the bolt, 100 m or longer. These threads are the warp of the fabric.

The threads that run across the fabric are shorter, and they are woven over, under, over, under the threads of the warp. These are the weft of the fabric. It is extremely tedious to actually sinuate the weft over and under each thread of the warp, and long ago looms were invented that streamlined the process. If a weaver uses colored threads in the warp, the fabric produced can have interesting colors woven into it. If the weaver varies the number and arrangements of threads, intricate patterns can be woven into the fabric.

When only a few fabrics were available, each had a fairly well-defined set of applications. Wool made tough, weather-resistant, warm cloth, and linen made fine, lightweight, attractive frocks and trim items. Cotton made utilitarian items, and silk was used for regal finery. With the invention of synthetic fibers, the constellation of fabrics has expanded. Textile production is one of the most important industries worldwide and a wonderful subject for scientific investigation by primary students.
Engineering Design

Science is a discovery activity, a process for producing new knowledge. Scientific knowledge advances when scientists observe objects and events, think about how their observations relate to what is known, test their ideas in logical ways, and generate explanations that integrate the new information into understanding of the natural world. Thus the scientific enterprise is both what we know (content knowledge) and how we come to know it (practices). Scientists engage in a set of practices as they do their work, and these are the same practices that students use in their science investigations.

Engineers apply that understanding of the natural world to solve real-world problems. Engineering is the systematic approach to finding solutions to problems identified by people in societies. The fields of science and engineering are mutually supportive, and scientists and engineers collaborate in their work. Often, acquiring scientific data requires designing and producing new technologies—tools, instruments, machines, and processes—to perform specific functions. The practices that engineers use are very similar to science practices but also involve defining problems and designing solutions.

The process of engineering design, while it involves engineering practices, is considered a separate set of disciplinary core ideas in the Framework and in the NGSS. There are three basic ideas of engineering design: defining the problem, developing possible solutions, and comparing solutions to improve the design.

**Defining the problem** involves asking questions and making observations to obtain information about designing a specific object or tool. In this module, students investigate how kinds of wood float in water. Problem: To make a wood raft that holds the most passengers. Students conduct tests to gather the necessary information to make a decision about the materials and design for making a raft to hold the most passengers.

**Developing possible solutions** involves making decisions about the most appropriate materials available (wood, paper, fabric) and thoughtfully planning a design for a structure to reduce the warming effect of the Sun on Earth’s surface. Students communicate their solutions with drawings and words.
Comparing different solutions and improving a design involves testing several designs to see how well each one meets the challenge criteria. Kindergartners are not expected to conduct tests with controlled variables, but they should be able to determine if an object or tool, such as a structure to provide shade for a cup of water, meets the challenge satisfactorily, and if not, how it might be improved. Identifying the differences between design solutions is important. Students need to know that “failure” is not only OK, but expected in engineering design. Having something fail drives you to improve the system and make progress. Collaboration is an important aspect of engineering design; learning from the successes and failures of other design groups can be very productive.

**Force and Motion**

Newton’s first law of motion states that objects at rest stay at rest, and objects in motion stay in uniform motion unless they are acted on by a net force. For primary students, this means that things move (and stop) because they get pushed or pulled. A force is a push or a pull, and in an investigation where everything is in motion, there are lots of pushes and pulls going on. Big pushes and pulls result in big movements; little pushes and pulls result in little movements.

Some forces are pretty obvious—blowing on a pinwheel makes it spin. Throwing or kicking a ball moves it across a field. Other forces are not so obvious. Balls rolling down a ramp seem to spring into motion all by themselves.

These phenomena occur as a result of the force of gravity. Students know the results of gravitational attraction: things fall, things roll downhill, liquids pour, and so on. These are all examples of movement, so there must be a force at work. But it is difficult to identify exactly what is exerting the pull or push to make these movements happen.

Gravity pulls everything toward the center of Earth. Things will move toward the center of Earth until they meet up with a force that

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**CONCEPTUAL FRAMEWORK**

**Physical Science, Energy and Change: Materials and Motion**

**Motion and Stability: Forces and Interactions**

**Concept A** The motion of an object is determined by the sum of the forces (pushes and pulls) acting on it.
- Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it.
- Pushes and pulls can have different strengths and directions.

**Concept B** All interactions between objects arise from a few types of forces, primarily gravity and electromagnetism.
- Gravity pulls things down.

**Energy Transfer and Conservation**

**Concept A** Energy is a quantitative property (condition) of a system that depends on the motion and interactions of matter within the system.
- A bigger push or pull makes things go faster.

**Concept B** The total change of energy in any system is always equal to the total energy transferred into or out of the system. When two objects interact, each one exerts a force on the other, and these forces can transfer energy.
- When objects touch or collide, they push on one another and can change motion.

**Concept C** Radiant energy travels through air and space from the Sun to Earth.
- The Sun warms Earth’s surface.
- Shade is where sunlight is blocked.
opposes the force of gravity and prevents any further movement.  
Holding something, resting on the floor or Earth’s surface, hanging  
from a string, and gluing something to a wall represent the application  
of force equal to, but opposite in direction to, the force of gravity.  

Realizing that gravity is the force that makes everything go down is  
an appropriate place to start.  Balls, marbles, and cans roll downhill and  
things fall down because of gravity.  Take advantage of any opportunities  
to introduce this fundamental notion into the investigation on motion.  

**Energy from the Sun**

One significant energy source provides heat to Earth—the Sun.  The  
amount of solar radiation transferred to Earth’s land, air, and water  
depends on a number of variables, including the time of day (no transfer  
to Earth at night), time of year, degree of cloud cover, nature of the  
surface on which the solar radiation falls, and efficiency of transfer from  
land and water to air.  

Solar energy comes to Earth in the form of radiation waves.  Different  
wavelengths have different amounts of energy.  The bulk of the radiation  
coming to Earth’s surface from the Sun is in the range of wavelengths  
we recognize as visible light and the wavelengths just outside that range.  
Wavelengths just longer than we can see are infrared, and wavelengths  
just shorter than we can see are ultraviolet.  

On a clear day, visible light passes through the atmosphere virtually  
unimpeded, to fall on the land and sea.  Visible light is absorbed by  
land and water, warming Earth’s surface.  Warm land and water transfer  
energy to the atmosphere in the form of infrared radiation.  This process  
is called reradiation.  

Infrared radiation is absorbed by water vapor in the atmosphere.  
The water molecules acquire thermal energy (warm up).  Thermal  
energy from warm water molecules transfer to the other air molecules  
(primarily nitrogen and oxygen) when they collide with them.  The  
atmosphere is heated indirectly by energy from the Sun as a result of  
countless collisions between molecules in the air.  

For primary students, it is sufficient to point out that they are warm  
when they stand in the sunshine.  Extend this warming experience to  
befall all things on which the Sun shines, including the land, air, and  
water.
### Energy and Change Content Sequence

This table shows most of the 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.

<table>
<thead>
<tr>
<th>Module or course</th>
<th>Motion and stability: Forces and interactions</th>
<th>Energy transfer and conservation</th>
</tr>
</thead>
</table>
| **Gravity and Kinetic Energy (middle school)** | - An object in motion will stay in motion (or an object at rest will stay at rest) unless acted on by an external force.  
- The greater the mass of the object, the greater the force needed to achieve a change in motion.  
- A moving object can have constant speed or acceleration. A falling object increases speed with a constant acceleration because of gravity.  
- For a pair of objects, the force exerted by one on the second is equal in strength to the force that the second exerts on the first, but in opposite directions. | - Kinetic energy is energy of motion; potential energy is dependent on the position of an object within a system.  
- Kinetic energy is proportional to the mass of a moving object. Increasing the speed of an object increases its kinetic energy by the same factor squared.  
- When objects collide, energy can transfer from one object to another, thereby changing their motion. |
| **Electromagnetic Force (middle school)** | - A force is a push or a pull. Net force is the sum of all the forces acting on a mass.  
- The magnitude of magnetic force between two interacting magnetic fields decreases as the distance between increases.  
- Magnets are surrounded by an invisible magnetic field. Magnetic materials may become temporary magnets when they interact with magnetic fields.  
- The magnetic field produced by a current-carrying wire can induce magnetism in a piece of iron—an electromagnet. | - Kinetic energy is energy of motion; potential energy is dependent on the position of an object within a system.  
- Changing the position of an object in an electric or magnetic field changes the potential energy.  
- Energy sources can be categorized as renewable or nonrenewable.  
- Energy cannot be created or destroyed, only transferred; energy use can be described as a sequence of energy transfers |
| **Energy (grade 4)** | - 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.  
- Any change of motion requires a force.  
- Gravity is a pulling force that acts between all masses. | - 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.  
- 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.  
- The faster an object is moving, the more energy it has.  
- Motion of one object can transfer to motion of other objects in a collision; a larger force causes a larger change.  
- Kinetic energy is energy of motion; potential energy is energy of position.  
- Waves are a repeating pattern of motion that transfer energy.  
- An object is seen when light from an object enters and is detected by the eye. |
| **Motion and Matter (grade 3)** | - Magnetic forces between a pair of objects do not require that the objects be in contact. The strength of the force depends on the properties of the objects and their distance apart.  
- How magnets interact depends on their orientation (sometimes they attract and sometimes they repel).  
- Gravity is the force that pulls masses toward the center of Earth.  
- Any change of motion requires a force. Each force has a strength and direction.  
- Patterns of motion can be observed; when there are regular patterns of motion, future motions can be predicted. | |
| **Materials and Motion (grade K)** | | |
The supporting elements in each module (somewhat abbreviated) are listed. The elements for the Materials and Motion Module are expanded to show how they fit into the sequence.

**NOTE**

See the Assessment chapter at the end of this *Investigations Guide* for more details on how the FOSS embedded assessment opportunities align to the conceptual frameworks and the learning progressions. In addition, the Assessment chapter describes specific connections between the FOSS assessments and the NGSS performance expectations.

The NGSS Performance Expectations addressed in this module include:

**Physical Sciences**
- K-PS2-1
- K-PS2-2
- K-PS3-1
- K-PS3-2

**Earth and Space Sciences**
- K-ESS3-3

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

See pages 28–31 in this chapter for more details on the kindergarten NGSS Performance Expectations.
Matter Content Sequence

This table shows the five FOSS modules and courses that address the content sequence “matter” for grades K–8. Running through the sequence are the two progressions—matter has structure, and matter interacts. The supporting elements in each module (somewhat abbreviated) are listed. The elements for the **Materials and Motion Module** are expanded to show how they fit into the sequence.

<table>
<thead>
<tr>
<th>Module or course</th>
<th>Matter has structure</th>
<th>Matter interacts</th>
</tr>
</thead>
</table>
| **Chemical Interactions (middle school)** | • Matter is made of atoms.  
• Substances are defined by chemical formulas.  
• Elements are defined by unique atoms.  
• The properties of matter are determined by the kinds and behaviors of its atoms.  
• Atomic theory explains the conservation of matter. | • During chemical reactions, particles in reactants rearrange to form new products.  
• Energy transfer to/from the particles in a substance can result in phase change.  
• During dissolving, one substance is reduced to particles (solute), which are distributed uniformly throughout the particles of the other substance (solvent). |
| **Mixtures and Solutions (grade 5)** | • Solid matter can break into pieces too small to see.  
• Mass is conserved (not created or lost) during changes.  
• Properties can be used to identify substances (e.g., solubility).  
• Relative density can be used to seriate solutions of different concentrations. | • A mixture is two or more intermingled substances.  
• Dissolving occurs when one substance disappears in a second substance.  
• A chemical reaction occurs when substances mix and new products result.  
• Melting is an interaction between one substance and heat. |
| **Motion and Matter (grade 3)** | • Measurement can be used to confirm that the mass of the whole is equal to the mass of its parts. | • A mixture is two or more intermingled substances.  
• A solution results when a solid material dissolves in a liquid.  
• Mass is conserved when objects or materials are mixed.  
• During chemical reactions, starting materials change into new materials. |
| **Solids and Liquids (grade 2)** | • Common matter is known to us as solid, liquid, and gas.  
• Solid matter has definite shape.  
• Liquid matter has definite volume but flows to fill a container to a level.  
• Gas matter has neither definite shape nor definite volume and expands to fill containers.  
• Intrinsic properties of matter can be used to organize objects (e.g., color, shape, etc.). | • Solids have properties that determine how they can be used for construction.  
• Liquids have properties that determine their behavior when agitated or tipped.  
• Solids interact with water in various ways: float, sink, dissolve, swell, change.  
• Liquids interact with water in various ways: layer, mix, change color.  
• Substances change state (e.g., melt or freeze) when heated or cooled.  
• Some changes to matter due to heating are reversible and some are irreversible. |
| **Materials and Motion (grade K)** | | |

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**Matter Content Sequence**

This table shows the five FOSS modules and courses that address the content sequence “matter” for grades K–8. Running through the sequence are the two progressions—matter has structure, and matter interacts. The supporting elements in each module (somewhat abbreviated) are listed. The elements for the **Materials and Motion Module** are expanded to show how they fit into the sequence.
MATERIALS AND MOTION

- Framework and NGSS

MATTER HAS STRUCTURE

- Wood, paper, and fabric are examples of solid materials.
- Solid objects are made of solid materials.
- Solid objects have properties.

MATTER INTERACTS

- Wood, paper, and fabric can be changed by sanding, coloring, tearing, and so forth.
- Common materials can be changed into new materials (papermaking, weaving, etc.).

NOTE

The FOSS learning progression for matter starts at kindergarten and is implemented at grades 2, 3, 5, and middle school. The FOSS curriculum provides foundational experiences in kindergarten that will prepare students to continue their progression in grade 2 and address the performance expectations at that grade level. The matter learning progression is also foundational for addressing the Earth Science Standards on natural resources and human impact on the Earth at kindergarten.
## CONNECTIONS TO NGSS BY INVESTIGATION

<table>
<thead>
<tr>
<th>Science and Engineering Practices</th>
<th>Connections to Common Core State Standards for ELA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asking questions and defining problems</td>
<td>RI 1: Ask and answer questions about key details.</td>
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<tr>
<td>Developing and using models</td>
<td>RI 2: Identify main topic and retell key details.</td>
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<tr>
<td>Planning and carrying out investigations</td>
<td>RI 3: Describe the connection between two ideas.</td>
</tr>
<tr>
<td>Analyzing and interpreting data</td>
<td>RI 5: Identify the front cover, back cover, and title page of a book.</td>
</tr>
<tr>
<td>Using mathematics and computational thinking</td>
<td>RI 7: Describe the relationship between illustrations and the text.</td>
</tr>
<tr>
<td>Constructing explanations and designing solutions</td>
<td>RI 8: Identify the reasons an author gives to support points.</td>
</tr>
<tr>
<td>Engaging in argument from evidence</td>
<td>RI 10: Actively engage in group reading activities with purpose and understanding.</td>
</tr>
<tr>
<td>Obtaining, evaluating, and communicating information</td>
<td>W 5: Strengthen writing.</td>
</tr>
<tr>
<td></td>
<td>W 7: Participate in shared research and writing projects.</td>
</tr>
<tr>
<td></td>
<td>W 8: Recall information from experiences to answer a question.</td>
</tr>
<tr>
<td></td>
<td>SL 1: Participate in collaborative conversations.</td>
</tr>
<tr>
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<td>SL 2: Ask and answer questions about key details and request clarification.</td>
</tr>
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<td></td>
<td>SL 4: Describe with details.</td>
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</tbody>
</table>

| Inv. 1: Getting to Know Wood       | arabic RI 1: Ask and answer questions about key details. |
|                                  | arabic RI 2: Identify main topic and retell key details. |
|                                  | arabic RI 3: Describe the connection between two ideas. |
|                                  | arabic RI 5: Identify the front cover, back cover, and title page of a book. |
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|                                  | arabic W 7: Participate in shared research and writing projects. |
|                                  | arabic W 8: Recall information from experiences to answer a question. |
|                                  | arabic SL 1: Participate in collaborative conversations. |
|                                  | arabic SL 2: Ask and answer questions about key details and request clarification. |
|                                  | arabic SL 4: Describe with details. |

| Inv. 2: Getting to Know Paper      | arabic RF 1: Demonstrate understanding of the organization and basic features of print. |
|                                  | arabic RF 2: Demonstrate understanding of spoken words, syllables, and sounds. |
|                                  | arabic RF 4: Read texts with purpose and understanding. |
|                                  | arabic RI 2: Identify main topic and retell key details. |
|                                  | arabic RI 4: Ask and answer questions about unknown words. |
|                                  | arabic RI 9: Identify similarities in and differences between two texts on the same topic. |
|                                  | arabic RI 10: Actively engage in group reading activities with purpose and understanding. |
|                                  | arabic W 5: Strengthen writing. |
|                                  | arabic SL 1: Participate in collaborative conversations. |
|                                  | arabic SL 2: Ask and answer questions about key details and request clarification. |
|                                  | arabic SL 4: Describe with details. |
|                                  | arabic SL 5: Add drawings or other visual displays to descriptions. |
|                                  | arabic SL 6: Speak audibly, and express clearly. |
|                                  | arabic L 4: Determine or clarify the meaning of unknown and multiple-meaning words and phrases. |
|                                  | arabic L 6: Use acquired words and phrases. |

**MATERIALS AND MOTION — Framework and NGSS**
## Connections to NGSS by Investigation

<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PS1.A: Structure and properties of matter</strong></td>
<td>Patterns</td>
</tr>
<tr>
<td>• Matter can be described and classified by its observable</td>
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</tr>
<tr>
<td>properties. Different properties are suited to different</td>
<td>Energy and matter</td>
</tr>
<tr>
<td>purposes. (foundational)</td>
<td>Structure and function</td>
</tr>
<tr>
<td><strong>ESS3.C: Human impacts on Earth systems</strong></td>
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<tr>
<td><strong>ETS1.B: Developing possible solutions</strong></td>
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<td>physical models. These representations are useful in</td>
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**Patterns**

Cause and effect

Energy and matter

Structure and function
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<td>W 8: Recall information from experiences to answer a question.</td>
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</table>

**Inv. 3: Getting to Know Fabric**

- Asking questions and defining problems
- Developing and using models
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

**RF 1:** Demonstrate understanding of the organization and basic features of print.
**RI 1:** Ask and answer questions about key details.
**RI 2:** Identify main topic and retell key details.
**RI 3:** Describe the connection between two ideas.
**RI 7:** Describe the relationship between illustrations and the text.
**RI 9:** Identify similarities in and differences between two texts on the same topic.
**RI 10:** Actively engage in group reading activities with purpose and understanding.
**W 8:** Recall information from experiences to answer a question.
**SL 1:** Participate in collaborative conversations.
**SL 2:** Ask and answer questions about key details and request clarification.
**SL 4:** Describe with details.
**SL 6:** Speak audibly, and express clearly.
**L 1:** Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.
**L 6:** Use acquired words and phrases.

**Inv. 4: Getting Things to Move**

- Asking questions and defining problems
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations and designing solutions
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

**RF 1:** Demonstrate understanding of the organization and basic features of print.
**RI 1:** Ask and answer questions about key details.
**RI 2:** Identify main topic and retell key details.
**RI 3:** Describe the connection between two ideas.
**RI 7:** Describe the relationship between illustrations and the text.
**RI 9:** Identify similarities in and differences between two texts on the same topic.
**W 8:** Recall information from experiences to answer a question.
**SL 1:** Participate in collaborative conversations.
**SL 2:** Ask and answer questions about key details and request clarification.
**SL 4:** Describe with details.
**SL 6:** Speak audibly, and express clearly.
**L 1:** Demonstrate command of the conventions of standard English grammar and usage when writing or speaking.
**L 6:** Use acquired words and phrases.
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<td>Matter can be described and classified by its observable properties. Different properties are suited to different purposes. (foundational)</td>
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<table>
<thead>
<tr>
<th>PS3.B: Conservation of energy and energy transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunlight warms Earth’s surface. (K-PS3-1, K-PS3-2)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ESS3.A: Natural resources</th>
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<tbody>
<tr>
<td>Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do. (K-ESS3-3)</td>
</tr>
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</table>

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<th>ESS3.C: Human impacts on Earth systems</th>
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<thead>
<tr>
<th>PS2.A: Forces and motion</th>
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</thead>
<tbody>
<tr>
<td>Pushes and pulls can have different strengths and directions. (K-PS2-1, K-PS2-2)</td>
</tr>
<tr>
<td>Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it. (K-PS2-1, K-PS2-2)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PS2.B: Types of interactions</th>
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<tbody>
<tr>
<td>When objects touch or collide, they push on one another and can change motion. (K-PS2-1)</td>
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<thead>
<tr>
<th>PS3.C: Relationship between energy and forces</th>
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<tbody>
<tr>
<td>A bigger push or pull makes things speed up or slow down more quickly. (K-PS2-1)</td>
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<tr>
<th>ETS1.A: Defining and delimiting engineering problems</th>
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<td>A situation that people want to change or create can be approached as a problem to be solved through engineering. (K-2-ETS1-1)</td>
</tr>
<tr>
<td>Before beginning to design a solution, it is important to clearly understand the problem. (K-2-ETS1-1)</td>
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<td>Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem’s solutions to other people. (K-2-ETS1-2)</td>
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<table>
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<tr>
<th>ETS1.C: Optimizing the design solution</th>
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<tr>
<td>Because there is always more than one possible solution to a problem, it is useful to compare and test designs. (K-2-ETS1-3)</td>
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### Crosscutting Concepts

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<td>Structure and function</td>
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</tbody>
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<table>
<thead>
<tr>
<th>Systems and system models</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cause and effect</td>
</tr>
<tr>
<td>Scale, proportion, and quantity</td>
</tr>
</tbody>
</table>

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*Materials and Motion Module—FOSS Next Generation*
### RECOMMENDED FOSS NEXT GENERATION K–8

#### SCOPE AND SEQUENCE

<table>
<thead>
<tr>
<th>Grade</th>
<th>Integrated Middle Grades</th>
</tr>
</thead>
<tbody>
<tr>
<td>6–8</td>
<td><img src="image1" alt="Heredity and Adaptation*" /> <img src="image2" alt="Electromagnetic Force*" /> <img src="image3" alt="Gravity and Kinetic Energy*" /> <img src="image4" alt="Waves*" /> <img src="image5" alt="Planetary Science" /> <img src="image6" alt="Chemical Interactions" /> <img src="image7" alt="Earth History" /> <img src="image8" alt="Populations and Ecosystems" /> <img src="image9" alt="Weather and Water" /> <img src="image10" alt="Diversity of Life" /> <img src="image11" alt="Human Systems Interactions*" /></td>
</tr>
</tbody>
</table>

*Half-length courses

<table>
<thead>
<tr>
<th>Grade</th>
<th>Physical Science</th>
<th>Earth Science</th>
<th>Life Science</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Mixtures and Solutions</td>
<td>Earth and Sun</td>
<td>Living Systems</td>
</tr>
<tr>
<td>4</td>
<td>Energy</td>
<td>Soils, Rocks, and Landforms</td>
<td>Environments</td>
</tr>
<tr>
<td>3</td>
<td>Motion and Matter</td>
<td>Water and Climate</td>
<td>Structures of Life</td>
</tr>
<tr>
<td>2</td>
<td>Solids and Liquids</td>
<td>Pebbles, Sand, and Silt</td>
<td>Insects and Plants</td>
</tr>
<tr>
<td>1</td>
<td>Sound and Light</td>
<td>Air and Weather</td>
<td>Plants and Animals</td>
</tr>
<tr>
<td>K</td>
<td>Materials and Motion</td>
<td>Trees and Weather</td>
<td>Animals Two by Two</td>
</tr>
</tbody>
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