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 Motion and Matter 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 41). 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.
DISCIPLINARY CORE IDEAS

A Framework for K–12 Science Education has four core ideas in physical sciences.

PS1: Matter and its interactions
PS2: Motion and stability: Forces and interactions
PS3: Energy
PS4: Waves and their applications in technologies for information transfer

The questions and descriptions of the core ideas in the text on these pages are taken from the NRC Framework for the grades 3–5 grade band and the NGSS performance expectations for grade 3. The module focuses on core ideas for force and matter interactions, conservation of matter, and engineering design.

Physical Sciences

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? [Each force acts on one particular object and has both a strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object’s speed or direction of motion. The patterns of an object’s motion in various situations can be observed and measured; when past motion exhibits a regular pattern, future motion can be predicted from it.]

- PS2.B: Types of interactions
  What underlying forces explain the variety of interactions observed? [Objects in contact exert forces on each other (friction, elastic pushes and pulls.) 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 two magnets, on their orientation relative to each other. The gravitational force of Earth acting on an object near Earth’s surface pulls that object toward the planet’s center.]

The following NGSS Grade 3 Performance Expectations for PS2 are derived from the Framework disciplinary core ideas above.

- 3-PS2-1: Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object. [Clarification Statement: Examples could include an unbalanced force on one side of a ball can make it start moving; and balanced forces pushing on a box from both sides will not produce any motion at all.] [Assessment Boundary: Assessment is limited to one variable at a time: number, size, or direction of forces. Assessment does not include quantitative force size, only qualitative and relative. Assessment is limited to gravity being addressed as a force that pulls objects down.]
Introduction to Performance Expectations

- 3-PS2-2: Make observations and/or measurements of an object's motion to provide evidence that a pattern can be used to predict future motion. [Clarification Statement: Examples of motion with a predictable pattern could include a child swinging in a swing, a ball rolling back and forth in a bowl, and two children on a see-saw.] [Assessment Boundary: Assessment does not include technical terms such as period and frequency.]

- 3-PS2-3: Ask questions to determine cause and effect relationships of electric or magnetic interactions between two objects not in contact with each other. [Clarification Statement: Examples of an electric force could include the force on hair from an electrically charged balloon and the electrical forces between a charged rod and pieces of paper; examples of a magnetic force could include the force between two permanent magnets, the force between an electromagnet and steel paper clips, and the force exerted by one magnet versus the force exerted by two magnets. Examples of cause and effect relationships could include how the distance between objects affects strength of the force and how the orientation of magnets affects the direction of the magnetic force.] [Assessment Boundary: Assessment is limited to forces produced by objects that can be manipulated by students, and electrical interactions are limited to static electricity.]

- 3-PS2-4: Define a simple design problem that can be solved by applying scientific ideas about magnets. [Clarification Statement: Examples of problems could include constructing a latch to keep a door shut and creating a device to keep two moving objects from touching each other.]

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

- PS1.A: Structures and properties of matter
  
  *How do particles combine to form the variety of matter one observes?*
  
  [Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means (e.g., by weighing or by its effects on other objects). For example, a model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon; the effects of air on larger particles or objects (e.g., leaves in wind, dust suspended in air); and the appearance of visible scale water droplets in condensation, fog, and, by extension, also in clouds or the contrails of a jet.]

**REFERENCES**


**NOTE**

Only one of these core ideas, PS2, is represented in the NGSS performance expectations for grade 3. The Motion and Matter Module includes one investigation involving PS1: Matter and its interactions. This was done intentionally to bridge student learning experiences with PS1 between grades 2 and 5 and to provide opportunities for grade 3 students to effectively use metric measurement tools to collect data to develop evidence.
MOTION AND MATTER — Framework and NGSS

DISCIPLINARY CORE IDEAS

A Framework for K–12 Science Education has two core ideas in engineering, technology, and applications of science.

ETS1: Engineering design

ETS2: Links among engineering, technology, science, and society

Only one of these core ideas, ETS1, is represented in the NGSS performance expectations for grade 3.

The questions and descriptions of the core ideas in the text on these pages are taken from the NRC Framework for the grades 3–5 grade band to keep the core ideas in a rich and useful context.

The performance expectations related to each core idea are taken from the NGSS for grade 3–5.

• PS1.B: Chemical reactions
How do substances combine or change (react) to make new substances? How does one characterize and explain these reactions and make predictions about them? [When two or more different substances are mixed, a new substance with different properties may be formed; such occurrences depend on the substances and the temperature. No matter what reaction or change in properties occurs, the total weight of the substances does not change. (Boundary: Mass and weight are not distinguished at this grade level.]

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? [Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.]

• ETS1.B: Developing possible solutions
What is the process for developing potential design solutions? [Research on a problem should be carried out before beginning to design a solution. An often productive way to generate ideas is for people to work together to brainstorm, test, and refine possible solutions. Testing a solution involves investigating how well it performs under a range of likely conditions. Tests are often designed to identify failure points or difficulties, which suggest the elements of a design that need to be improved. At whatever stage, communication with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs.]

• ETS1.C: Optimizing the design solution
How can the various proposed design solutions be compared and improved? [Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints.]

Full Option Science System
Introduction to Performance Expectations

The following NGSS Grades 3–5 Performance Expectations for ETS1 are derived from the Framework disciplinary core ideas above.

- 3-5-ETS1-1: Define a simple design problem reflecting a need or a want that includes specified criteria for success and constraints on materials, time, or cost.
- 3-5-ETS1-2: Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- 3-5-ETS1-3: Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.

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

- ETS2.A: Interdependence of science, engineering, and technology
  What are the relationships among science, engineering, and technology? [Tools and instruments (e.g., rulers, balances, thermometers, graduated cylinders, telescopes, microscopes) are used in scientific exploration to gather data and help answer questions about the natural world. Engineering design can develop and improve such technologies. Scientific discoveries about the natural world can often lead to new and improved technologies, which are developed through the engineering design process. Knowledge of relevant scientific concepts and research findings is important in engineering.]

- ETS2.B: Influence of engineering, technology, and science on society and the natural world
  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? [Over time, people’s needs and wants change, as do their demands for new and improved technologies. Engineers improve existing technologies or develop new ones to increase their benefits, to decrease known risks, and to meet societal demands. When new technologies become available, they can bring about changes in the way people live and interact with one another.]

Note: There are no separate performance expectations described for core idea ETS2 (see volume 2, appendix J, for an explanation and elaboration).
Science and Engineering Practices Addressed

1. **Asking questions and defining problems**
   - Ask questions that can be investigated based on patterns such as cause-and-effect relationships.
   - Define a simple design problem that can be solved through the development of a new or improved object or tool.

2. **Developing and using models**
   - Develop models to describe phenomena.

3. **Planning and carrying out investigations**
   - Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence, using fair tests in which variables are controlled and the number of trials considered.
   - Make observations and/or measurements to produce data to serve as the basis for evidence for an explanation of a phenomenon or test a design solution.

4. **Analyzing and interpreting data**
   - Represent data in tables and various graphical displays to reveal patterns that indicate relationships.
   - Analyze and interpret data to make sense of phenomena using logical reasoning.
   - Analyze data to refine a problem statement or the design of a proposed object, tool, or process.
   - Use data to evaluate and refine design solutions.

5. **Using mathematics and computational thinking**
   - Organize simple data sets to reveal patterns that suggest relationships.
   - Describe, measure, estimate, and/or graph quantities (e.g., area, volume, weight, time) to address scientific and engineering questions and problems.

6. **Constructing explanations and designing solutions**
   - Use evidence (e.g., observations, patterns) to construct or support an explanation or design a solution to a problem.
   - Apply scientific ideas to solve design problems.
   - Generate and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.

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**SCIENCE AND ENGINEERING PRACTICES**

*A Framework for K–12 Science Education* (National Research Council, 2012) describes eight science and engineering practices as essential elements of a K–12 science and engineering curriculum. All eight practices are incorporated into the learning experiences in the Motion and Matter Module.

The learning progression for this dimension of the framework is addressed in *Next Generation Science Standards* (National Academies Press, 2013), volume 2, appendix F. Elements of the learning progression for practices recommended for grade 3 as described in the performance expectations appear in bullets below each practice.
7. **Engaging in argument from evidence**
   - Construct an argument with evidence, data, and/or a model.
   - Make a claim about the merit of a solution to a problem by citing relevant evidence about how it meets the criteria and constraints of the problem.

8. **Obtaining, evaluating, and communicating information**
   - Obtain and combine information from books and/or other reliable media to explain phenomena or solutions to a design problem.

**Crosscutting Concepts Addressed**

**Patterns**
- Similarities and differences in patterns can be used to sort and classify natural phenomena. Patterns of change can be used to make predictions.

**Cause and effect**
- Cause-and-effect relationships are routinely identified and used to explain change.

**Scale, proportion, and quantity**
- Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume.

**Systems and system models**
- A system can be described in terms of its components and their interactions.

**Energy and matter**
- Matter flows and cycles can be tracked in terms of the weight of the substances before and after a process occurs. The total weight of the substances does not change. This is what is meant by conservation of matter. Matter is transported into, out of, and within systems.

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**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 grade 3 in the NGSS and are incorporated into the learning opportunities in the **Motion and Matter 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 grade 3, as described in the performance expectations, appear after bullets below each concept.
Connections: Understandings about the Nature of Science

**Scientific investigations use a variety of methods.**
- Scientific methods are determined by questions.
- Scientific investigations use a variety of methods, tools, and techniques.

**Scientific knowledge is based on empirical evidence.**
- Science findings are based on recognizing patterns.
- Science investigations use a variety of methods, tools, and techniques.

**Science is a human endeavor.**
- Men and women from all cultures and backgrounds choose careers as scientists and engineers.
- Most scientists and engineers work in teams.
- Science affects everyday life.
- Creativity and imagination are important to science.

**Scientific knowledge assumes an order and consistency in natural systems.**
- Science assumes consistent patterns in natural systems.
Connections to Engineering, Technology, and Applications of Science

Interdependence of science, engineering, and technology.

- Science and technology support each other. Knowledge of relevant scientific concepts and research findings is important in engineering.
- Tools and instruments are used to answer scientific questions, while scientific discoveries lead to the development of new technologies.

Influence of science, engineering, and technology on society and the natural world.

- Engineers improve existing technologies or develop new ones. Over time, people’s needs and wants change, as do their demands for new and improved technologies. When new technologies become available, they can bring about changes in the way people live and interact with one another.
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.
Information about the FOSS learning progression appears in the conceptual framework (pages 42, 43, and 45), which shows the structure of scientific knowledge taught and assessed in this module, and the content sequence (pages 46–49), 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 Motion and Matter

There are three conceptual frameworks for the disciplinary core ideas in this module for grade 3. Two of the frameworks focus on physical science and one on engineering design.

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 young students, this means that things move (and stop) because they get pushed or pulled. A force is a push or a pull and they have direction and strength. Big pushes and pulls result in big movements; little pushes and pulls result in little movements.

Some forces are pretty obvious—pushing on the shaft of the top makes it spin; pushing a wheel-and-axle system across the table puts it in motion. Other forces are not so obvious. Systems rolling down a ramp seem to spring into motion all by themselves. Dropping a twirler causes it to spin in air.

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 opposes the force of gravity and prevents any further movement. Holding something, resting on the floor of 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. Twirlers go down, cups roll down, carts roll down, and things fall down because of gravity.

Electromagnetism is the most pervasive of all forces, accounting for the obvious phenomena of electricity and magnetism, but it also gives matter shape and strength, and makes it possible for you and me to run, eat, feel, think, and grow. Understanding the electromagnetic force is a lifelong undertaking.

Students start by exploring magnets and sharing what they observe. One thing magnets do is push. They also pull. Pushes and pulls are forces, so magnets have a detectable force field surrounding them. And the force can act at a distance; magnets don’t have to touch to affect one another.

**Matter**

The **Motion and Matter Module** includes one investigation focusing on disciplinary core idea PS1: Matter and its interactions. This was done intentionally to bridge student learning experiences with PS1 between grades 2 and 5 and to provide opportunities for grade 3 students to effectively use metric measurement tools to collect data to develop evidence. The use of metric measurement tools will become increasingly important in higher grades, and grade 3 is the best time to give students opportunities to develop an understanding of the tools and practice how to use them effectively.

Everything that we know of in the universe is either matter or energy. Matter is the stuff from which tangible objects like people, pencils, mountains, and the ocean are made. Energy is the glue and drive that holds things together and moves them around.

Common matter on Earth exists in three states—solid, liquid, and gas. Many substances can exist in all three states, depending on the temperature. Heat energy can change a substance from one state to another. A common example we are all familiar with is water. When solid water...
(ice) is heated, it melts, changing from solid to liquid. When liquid water is heated, it evaporates, changing from liquid to gas (water vapor). The addition of heat energy changes the relationship between the water particles, which changes the state (also referred to as phase change). The amount of heat energy required to cause a change of state for materials varies greatly.

When two or more kinds of matter are combined, the result is a mixture. Simple mixtures include sand and water, oil and vinegar, nuts and bolts, coleslaw, rocky-road ice cream, and trail mix. Mixtures can be made with any combination of gases, liquids, and solids. The components of a mixture are not changed by mixing with other materials. The resulting mass of a mixture is the sum of the masses of the components.

Sometimes when two (or more) materials are mixed, a different kind of mixture results. For example, when salt and water are mixed, the solid salt seems to disappear in the water. This process is called dissolving; we say that the salt dissolved in the water. This mixture is a solution.

When two solutions are mixed, another kind of change could take place—a chemical change. When this happens, the result is a chemical reaction. The starting substances (reactants) change into new substances (products).

**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 related 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 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 improving the design.

**Defining the problem** involves an understanding of criteria and constraints. In this investigation, the constraints on the design of the carts are the materials available and the time involved. The criteria are the distance the cart travels and the kind of tricks it can do.

**Developing possible solutions** involves comparing alternative solutions to see which solution best meets the criteria and constraints of the problem. Each group works collaboratively on several cart designs of their own, testing each design as they work.

**Improving the design** involves testing the prototype using fair tests, trying to control all variables, and changing only one variable at a time. 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. Students can engage in engineering practices without fully engaging in the iterative process of design.

In this module, there is one investigation in which students explore the disciplinary core ideas of engineering design in the context of motion. But students engage in engineering practices in other investigations without engaging in the full engineering design process. FOSS has a continuum of engagements in the engineering practices and process from short experiences to more in-depth experiences where students reflect on the core ideas about the design process.

**CONCEPTUAL FRAMEWORK**

**Engineering Design: Motion and Matter**

**Concept A**

Defining and delimiting engineering problems.

- Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account.

**Concept B**

Developing possible solutions.

- Research before designing, testing possible solutions, communicating with peers about possible solutions are all important parts of the design process. Tests are designed to identify inadequacies which will suggest design elements to improve.

**Concept C**

Optimizing the design solution.

- Different solutions need to be tested in order to determine which of them best achieves the most satisfactory solution to the problem, given the criteria and the constraints.

**NOTE**

See the Assessment chapter at the end of this *Investigations Guide* for more details on how the FOSS embedded and benchmark 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.
MOTION AND MATTER – Framework and NGSS

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—motion and stability: forces and interactions and energy transfer and conservation. The supporting elements in each module (somewhat abbreviated) are listed. The elements for the Motion and Matter Module dealing with motion are expanded to show how they fit into the sequence.

<table>
<thead>
<tr>
<th>Module or course</th>
<th>Motion and Stability: Forces and Interactions</th>
<th>Energy Transfer and Conservation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electromagnetic Force (middle school)</td>
<td>• A force is a push or a pull. Net force is the sum of all the forces acting on a mass.</td>
<td>• Kinetic energy is energy of motion; potential energy is dependent on the position of an object within a system.</td>
</tr>
<tr>
<td></td>
<td>• The magnitude of the magnetic force between two interacting magnetic fields decreases with distance.</td>
<td>• Changing the position of an object in an electric or magnetic field changes the potential energy.</td>
</tr>
<tr>
<td></td>
<td>• Magnets are surrounded by an invisible magnetic field. Magnetic materials may become temporary magnets when they interact with magnetic fields.</td>
<td>• Energy sources can be categorized as renewable or nonrenewable.</td>
</tr>
<tr>
<td></td>
<td>• The magnetic field produced by a current-carrying wire can induce magnetism.</td>
<td>• Energy cannot be created or destroyed, only transferred. Every energy use can be described as a sequence of energy transfers.</td>
</tr>
<tr>
<td>Gravity and Kinetic Energy (middle school)</td>
<td>• Gravity is an attractive force between two objects; a falling object increases speed with a constant acceleration due to gravity.</td>
<td>• Kinetic energy is energy of moving things; potential energy is energy dependent on the position of an object within a system.</td>
</tr>
<tr>
<td></td>
<td>• An object in motion will stay in motion (or an object at rest will stay at rest) unless acted on by an external force.</td>
<td>• Kinetic energy is transferred in a collision.</td>
</tr>
<tr>
<td></td>
<td>• For interacting objects, the force exerted by one is equal in strength to the force that the second object exerts in opposite direction.</td>
<td>• 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.</td>
</tr>
<tr>
<td>Energy (grade 4)</td>
<td>• Magnets interact with each other and with materials that contain iron.</td>
<td>• Energy can be generated by burning fossil fuels or harnessing renewable energy.</td>
</tr>
<tr>
<td></td>
<td>• Like poles of magnets repel each other; opposite poles attract. The magnetic force declines as the distance between the magnets increases.</td>
<td>• Electric current transfers energy that can produce heat, light, sound, and motion.</td>
</tr>
<tr>
<td></td>
<td>• Conductors are materials through which electric current can flow; all metals are conductors.</td>
<td>• A circuit is a system that includes a pathway through which electric current flows.</td>
</tr>
<tr>
<td></td>
<td>• Any change of motion requires a force.</td>
<td>• Motion of one object can transfer to motion of other objects in a collision.</td>
</tr>
<tr>
<td></td>
<td>• Gravity is a pulling force that acts between all masses.</td>
<td>• Waves are a repeating pattern of motion that transfer energy.</td>
</tr>
<tr>
<td>Motion and Matter (grade 3)</td>
<td></td>
<td>• An object is seen when light from an object enters and is detected by the eye.</td>
</tr>
<tr>
<td>Materials and Motion (grade K)</td>
<td>• Pushes and pulls can have different strengths and directions.</td>
<td>• A bigger push or pull makes things go faster.</td>
</tr>
<tr>
<td></td>
<td>• Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it.</td>
<td>• When objects touch or collide, they push on one another and can change motion.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Sunlight warms Earth’s surface.</td>
</tr>
</tbody>
</table>
**NOTE**

See the Assessment chapter at the end of this *Investigations Guide* for more details on how the FOSS embedded and benchmark 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.

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**Motion and Stability: Forces and Interactions**

- 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.
- A wheel-and-axle system with two sizes of wheels describes a curved path.
- A twirly bird is a simple winged system that spins when it interacts with air; variables affect twirler performance.
- Tops exhibit rotational motion (spinning) when torque is applied to the axial shaft; variables affect top performance.
## Matter Content Sequence

This table shows the five FOSS modules and courses that address the matter content sequence, 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 **Motion and Matter Module** dealing with matter 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>
<tbody>
<tr>
<td><strong>Chemical Interactions</strong></td>
<td>- Matter is made of atoms.</td>
<td>• During chemical reactions, particles in reactants rearrange to form new products.</td>
</tr>
<tr>
<td>(middle school)</td>
<td>- Substances are defined by chemical formulas.</td>
<td>• Energy transfer to/from the particles in a substance can result in phase change.</td>
</tr>
<tr>
<td></td>
<td>- Elements are defined by unique atoms.</td>
<td>• During dissolving, one substance is reduced to particles (solute), which are distributed uniformly throughout the particles of the other substance (solvent).</td>
</tr>
<tr>
<td></td>
<td>- The properties of matter are determined by the kinds and behaviors of its atoms.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Atomic theory explains the conservation of matter.</td>
<td></td>
</tr>
<tr>
<td><strong>Mixtures and Solutions</strong></td>
<td>- Solid matter can break into pieces too small to see.</td>
<td>• A mixture is two or more intermingled substances.</td>
</tr>
<tr>
<td>(grade 5)</td>
<td>- Mass is conserved (not created or lost) during changes.</td>
<td>• Dissolving occurs when one substance disappears in a second substance.</td>
</tr>
<tr>
<td></td>
<td>- Properties can be used to identify substances (e.g., solubility).</td>
<td>• A chemical reaction occurs when substances mix and new products result.</td>
</tr>
<tr>
<td></td>
<td>- Relative density can be used to seriate solutions of different concentrations.</td>
<td>• Melting is an interaction between one substance and heat.</td>
</tr>
<tr>
<td><strong>Motion and Matter</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(grade 3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Solids and Liquids</strong></td>
<td>- Common matter is solid, liquid, and gas.</td>
<td>• Solids interact with water in various ways: float, sink, dissolve, swell, change.</td>
</tr>
<tr>
<td>(grade 2)</td>
<td>- Solid matter has definite shape.</td>
<td>• Liquids interact with water in various ways: layer, mix, change color.</td>
</tr>
<tr>
<td></td>
<td>- Liquid matter has definite volume.</td>
<td>• Substances change state (e.g., melt, freeze) when heated or cooled.</td>
</tr>
<tr>
<td></td>
<td>- Gas matter has neither definite shape nor volume and expands to fill containers.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Intrinsic properties of matter can be used to organize objects (e.g., color, shape).</td>
<td></td>
</tr>
<tr>
<td><strong>Materials and Motion</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(grade K)</td>
<td>- Wood, paper, rock, and fabric are examples of solid materials.</td>
<td>• Wood, paper, and fabric can be changed by sanding, coloring, tearing, etc.</td>
</tr>
<tr>
<td></td>
<td>- Solid objects are made of solid materials.</td>
<td>• Common materials can be changed into new materials (paper making, weaving, etc.).</td>
</tr>
<tr>
<td></td>
<td>- Solid objects have properties.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- The whole (object) can be broken into smaller pieces.</td>
<td>• Water can change to ice in a freezer, and ice can change to water in a room.</td>
</tr>
</tbody>
</table>
NOTE

We have included experiences that engage students with the core ideas PS1.A: Structure and properties of matter, and PS1.B: Chemical reactions, because they are so important to the understanding of conservation of mass. There are not specific NGSS Performance Expectations at this grade level that incorporate these disciplinary core ideas. The experiences in Investigation 4 build on concepts of matter and its interactions developed at grade 2 and are foundational for concepts developed in grade 5.

<table>
<thead>
<tr>
<th>Matter has structure</th>
<th>Matter interacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Measurement can be used to confirm that the mass of the whole is equal to the mass of its parts.</td>
<td>• A mixture is two or more intermingled substances.</td>
</tr>
<tr>
<td></td>
<td>• A solution results when a solid material dissolves in a liquid.</td>
</tr>
<tr>
<td></td>
<td>• Mass is conserved when objects or materials are mixed.</td>
</tr>
<tr>
<td></td>
<td>• During chemical reactions, starting materials change into new materials.</td>
</tr>
</tbody>
</table>
CONNECTIONS TO NGSS BY INVESTIGATION

### Science and Engineering Practices

<table>
<thead>
<tr>
<th>Inv. 1: Forces</th>
<th>Inv. 2: Patterns of Motion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asking questions</td>
<td>Asking questions and defining problems</td>
</tr>
<tr>
<td>Developing and using models</td>
<td>Planning and carrying out investigations</td>
</tr>
<tr>
<td>Planning and carrying out investigations</td>
<td>Analyzing and interpreting data</td>
</tr>
<tr>
<td>Analyzing and interpreting data</td>
<td>Constructing explanations and designing solutions</td>
</tr>
<tr>
<td>Using mathematics and computational thinking</td>
<td>Obtaining, evaluating, and communicating information</td>
</tr>
<tr>
<td>Constructing explanations</td>
<td>Constructing explanations and designing solutions</td>
</tr>
<tr>
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</tr>
</tbody>
</table>

### Connections to Common Core State Standards—ELA

| RI 2: Determine the main idea of a text. |
| RI 3: Describe the relationship of scientific ideas or concepts. |
| RI 5: Use text features to locate information. |
| RI 6: Distinguish their own point of view from that of the author of a text. |
| RI 7: Use information gained from illustrations to demonstrate understanding of the text. |
| SL 1: Engage in collaborative discussions. |
| L 5: Demonstrate understanding of word relationships. |
| L 6: Acquire and use domain-specific words. |

### Full Option Science System

- **PS2.A: Forces and motion**
  - Each force acts on one particular object and has both a strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object’s speed or direction of motion. (3-PS2-1)
  - The patterns of an object’s motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (3-PS2-2)

- **PS2.B: Types of interactions**
  - Objects in contact exert forces on each other. (3-PS2-1)
  - Electric and magnetic forces between a pair of objects do not require that the objects be in contact. The sizes of the forces in each situation depend on the properties of the objects and their distances apart and, for forces between two magnets, on their orientation relative to each other. (3-PS2-3, 3-PS2-4)

- **Patterns**
  - Cause and effect
  - Systems and system models

- **Asking questions and defining problems**
  - Planning and carrying out investigations
  - Analyzing and interpreting data
  - Constructing explanations and designing solutions
  - Obtaining, evaluating, and communicating information

- **RI 1: Ask and answer questions.**
  - RI 5: Use text features to locate information.
  - RI 7: Use information gained from illustrations to demonstrate understanding of the text.
  - SL 1: Engage in collaborative discussions.
  - SL 3: Ask and answer questions about information from a speaker.
  - SL 5: Create engaging audio recordings of stories or poems that demonstrate fluid reading at an understandable pace.
  - L 4: Determine or clarify the meaning of new or unknown words.
  - L 5: Demonstrate understanding of word relationships.
<table>
<thead>
<tr>
<th>Disciplinary Core Ideas</th>
<th>Crosscutting Concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PS2.A: Forces and motion</strong></td>
<td><strong>Patterns</strong></td>
</tr>
<tr>
<td>1. Each force acts on one particular object and has both a strength and a direction. An object at rest typically has multiple forces acting on it, but they add to give zero net force on the object. Forces that do not sum to zero can cause changes in the object's speed or direction of motion. (3-PS2-1)</td>
<td><strong>Cause and effect</strong></td>
</tr>
<tr>
<td>2. The patterns of an object's motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. (3-PS2-2)</td>
<td><strong>Systems and system models</strong></td>
</tr>
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<td><strong>PS2.B: Types of interactions</strong></td>
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<tr>
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### Science and Engineering Practices

- 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

### Inv. 3: Engineering

- Planning and carrying out investigations
- Analyzing and interpreting data
- Constructing explanations
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

### Inv. 4: Mixtures

- Planning and carrying out investigations
- Analyzing and interpreting data
- Constructing explanations
- Engaging in argument from evidence
- Obtaining, evaluating, and communicating information

### Connections to Common Core State Standards—ELA

- **RI 1:** Ask and answer questions.
- **RI 2:** Determine the main idea of a text; recount the key details.
- **RI 3:** Describe the relationship between steps in technical procedures in a text.
- **W 3:** Write narratives.
- **SL 1:** Engage in collaborative discussions.
- **SL 4:** Report on a topic or text.
- **L 6:** Acquire and use domain-specific words.

- **RI 2:** Determine the main idea of a text; recount the key details.
- **RI 3:** Describe the relationship between scientific ideas using cause and effect.
- **RI 4:** Determine the meaning of domain-specific words and phrases in text.
- **RI 5:** Use text features to locate information.
- **RI 10:** Read and comprehend science text.
- **RF 4c:** Use context to confirm understandings of words.
- **SL 1:** Engage in collaborative discussions.
- **SL 4:** Report on a topic or text.
### Disciplinary Core Ideas

**PS2.A: Forces and motion**
- The patterns of an object’s motion in various situations can be observed and measured; when that past motion exhibits a regular pattern, future motion can be predicted from it. *(3-PS2-2)*

**ETS1.A: Defining and delimiting engineering problems**
- Possible solutions are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. *(3–5 ETS1-1)*

**PS1.A: Structures and properties of matter**
- The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish. *(foundational)*
- Measurements of a variety of properties can be used to identify materials. *(foundational)*

**ETS1.B: Developing possible solutions**
- At whatever stage, communicating with peers about proposed solutions is an important part of the design process, and shared ideas can lead to improved designs. *(3–5 ETS1-1)*

**ETS1.C: Optimizing the design solution**
- Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and the constraints. *(3–5 ETS1-1)*

**PS1.B: Chemical reactions**
- When two or more different substances are mixed, a new substance with different properties may be formed. *(foundational)*
- No matter what reaction or change in properties occurs, the total weight of the substances does not change. *(foundational)*

### Crosscutting Concepts

- Patterns
- Cause and effect
- Systems and system models
- Cause and effect
- Scale, proportion, and quantity
- Energy and matter
## RECOMMENDED FOSS NEXT GENERATION K–8 SCOPE AND SEQUENCE

### Integrated Middle Grades

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

### Grade Scope and Sequence

<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>
</table>