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 Air and Weather 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 39). 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 Addressed

The Air and Weather 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 earth science and engineering design with some core ideas related to the observable properties of air as matter (physical science).

Earth and Space Sciences

Framework core idea ESS1: Earth’s place in the universe—What is the universe, and what is Earth’s place in it?

- **ESS1.A: The universe and its stars**
  What is the universe, and what goes on in stars? [Patterns of the motion of the Sun, Moon, and stars in the sky can be observed, described, and predicted. At night one can see the light coming from many stars with the naked eye, but telescopes make it possible to see many more and to observe them and the Moon and planets in greater detail.]

- **ESS1.B: Earth and the solar system**
  What are the predictable patterns caused by Earth’s movement in the solar system? [Seasonal patterns of sunrise and sunset can be observed, described, and predicted.]

The following NGSS grade 1 performance expectations for ESS2 are derived from the Framework disciplinary core ideas above.

- **1-ESS1-1.** Use observations of the Sun, Moon, and stars to describe patterns that can be predicted. [Clarification Statement: Examples of patterns could include that the sun and moon appear to rise in one part of the sky, move across the sky, and set; and stars other than our sun are visible at night but not during the day.] [Assessment Boundary: Assessment of star patterns is limited to stars being seen at night and not during the day.]

- **1-ESS1-2.** Make observations at different times of the year to relate the amount of daylight to the time of year. [Clarification Statement: Emphasis is on relative comparisons of the amount of daylight in the winter to the amount in the spring or fall.] [Assessment Boundary: Assessment is limited to relative amounts of daylight, not quantifying the hours or time of daylight.]
Framework core idea ESS2: Earth’s systems—How and why is Earth constantly changing?

- **ESS2.D:** Weather and climate
  
  *What regulates weather and climate?* [Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time.]

The following NGSS kindergarten performance expectations for ESS2 are derived from the Framework disciplinary core ideas above.

- **K-ESS2-1.** Use and share observations of local weather conditions to describe patterns over time. [Clarification Statement: Examples of qualitative observations could include descriptions of the weather (such as sunny, cloudy, rainy, and warm); examples of quantitative observations could include numbers of sunny, windy, and rainy days in a month. Examples of patterns could include that it is usually cooler in the morning than in the afternoon and the number of sunny days versus cloudy days in different months.] [Assessment Boundary: Assessment of quantitative observations limited to whole numbers and relative measures such as warmer/cooler.]

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.]

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.]
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.]

The following NGSS grade 2 performance expectations for PS1 are derived from the Framework disciplinary core ideas above.

- 2-PS1-1. Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.
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.
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? [People encounter questions about the natural world every day. There are many types of tools produced by engineering that can be used in science to help answer these questions through observation or measurement. Observations and measurements are also used in engineering to help test and refine design ideas.]

- **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? [People depend on various technologies in their lives; human life would be very different without technology. Every human-made product is designed by applying some knowledge of the natural world and is built by using materials derived from the natural world, even when the materials are not themselves natural—for example, spoons made from refined metals. Thus, developing and using technology has impacts on the natural world.]

No separate performance expectations described for core idea ETS2 (see *Next Generation Science Standards*, 2013, volume 2, appendix J, for an explanation and elaboration).
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).
   - Ask and/or identify questions that can be answered by an investigation.
   - Define a simple problem that can be solved through the development of a new or improved object or tool.

2. **Developing and using models**
   - Distinguish between a model and the actual object, process, and/or events the model represents.
   - Compare models to identify common features and differences.
   - Develop and/or use a model to represent amounts, relationships, relative scales, and/or patterns in the natural and designed world(s).

3. **Planning and carrying out investigations**
   - Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.
   - Make observations (firsthand or from media) 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 and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems.
   - Analyze data from tests of an object or tool to determine if it works as intended.

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 quantitative 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.

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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. Seven practices are incorporated into the learning experiences in the Air and Weather Module.

The learning progression for this dimension of the framework is addressed in *Next Generation Science Standards 2013*, volume 2, appendix F. Elements of the learning progression for practices recommended for grade 1 as described in the performance expectations appear in bullets below each practice.
7. Obtaining, evaluating, and communicating information

- Read grade-appropriate texts and/or use media to obtain scientific and/or technical information to determine patterns in and/or evidence about the natural and designed world(s).
- Communicate information or design ideas and/or solutions with others in oral and/or written forms using models, drawings, writing, or numbers that provide detail about scientific ideas, practices, and/or design 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.

Systems and system models
- Systems in the natural and designed world have parts that work together.

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

Stability and change
- Some things stay the same while other things change.
Connections: Understandings about the Nature of Science

Science addresses questions about the natural and material worlds.

- Scientists study the natural and material worlds.

Scientific knowledge is based on empirical evidence.

- Scientists look for patterns and order when making observations about the world.

Scientific investigations use a variety of methods.

- Scientists use different ways to study the world.

Scientific knowledge assumes an order and consistency in natural systems.

- Many events are repeated.

Connections: Science, Technology, Society, and the Environment

Interdependence of science, engineering, and technology

- Science and engineering involve the use of tools to observe and measure things.

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.

CONNECTIONS

See Next Generation Science Standards, 2013, volume 2, appendix H and appendix J, 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 1 and FOSS and Common Core Math—Grade 1 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, page 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: atmosphere and planet Earth; 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 frameworks (pages 41, 43, and 45), which show the structure of scientific knowledge taught and assessed in this module, and the content sequence (pages 46–49), graphic and narrative descriptions that put 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, page 342)
BACKGROUND FOR THE CONCEPTUAL FRAMEWORK in Air and Weather

There are three conceptual frameworks for the disciplinary core ideas in this module for grade 1—two with a focus on earth science and one on engineering design. As curriculum developers we felt that focusing only on Earth’s place in the universe is limiting for grade 1 students in that it doesn’t provide an age-appropriate context for students to have opportunities for engaging in science and engineering practices. To provide experiences that related to the interests of the students and were more teachable and learnable, we integrated the dynamic atmosphere framework. The core ideas in this framework extend from kindergarten and provide foundational experiences about the structure of matter focusing on air.

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 streaming out 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 release 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 heat up. Warm water molecules “share” their heat with the other air molecules (primarily nitrogen and oxygen) when they collide with them. The atmosphere is heated indirectly by energy from the Sun.

For primary students, it is sufficient to point out that they are warm when they stand in the sunshine. Extend this warming experience to embrace all things on which the Sun shines, including the land, air, and water.
Air and Weather

Air and weather are inseparable. Air is a gas and, like all gases, is invisible and fills the space it’s in. Weather is the result of what is going on in the air around us. Is it hot or cold? Temperature is measured by using a thermometer to see how hot the air is. Is it calm, breezy, or blustery? Wind is an indicator of the force and direction of the movement of air. Is it foggy, rainy, or snowy? These words describe the amount and condition of the water in the air. Without air, there is no weather. This is an understanding that should begin to develop with primary students.

Stated more precisely, weather is the condition of the atmosphere at a particular location at a specific time. Earth’s atmosphere is air, a complex gaseous layer that forms the outermost part of the planet. The atmosphere extends from the surface of Earth out to a distance of about 800 kilometers (km). If Earth were an apple, the skin would represent the thickness of the atmosphere. The atmosphere doesn’t end in an absolute way, however; it gets thinner and thinner as one moves away from Earth, until it becomes so thin that for all practical purposes it ends. The part of the atmosphere with which meteorologists are most concerned is the first 15 km, known as the troposphere. It is here that just about all of what we know as weather takes place.

Earth’s atmosphere is an earth material. It has been here as long as Earth itself, but its composition has changed radically over time. The original atmosphere was composed of carbon dioxide, water vapor, and ammonia. As time passed, water vapor that originated within Earth was ejected into the atmosphere in great quantities as a result of volcanism at Earth’s surface. Earth was a violent, inhospitable place with high temperatures, poisonous gases for an atmosphere, and water only as vapor.

Eventually Earth and its atmosphere cooled to the point where the water vapor could condense into liquid, and it started to rain. So great was the moisture concentration in the atmosphere that it rained hard and continuously for several million years! When the rain stopped, Earth had a different look—it was a water planet with a vast ocean covering much of the surface.
Primary students will be interested in exploring the air around them today. As they explore the phenomena on a macroscopic level, they can begin to build models. Air, like all gases, can be compressed. This means the particles can be pushed closer together, so that a quantity of gas takes up less space. The application of pressure can push a large quantity of air into a small space, as a bicycle pump compresses air and forces it into a tire or a balloon pump pushes air into a balloon.

**Energy and Weather**

An atmosphere of air is not going to produce weather without one additional critically important component: a source of energy to make things happen. On Earth, that energy source is the Sun. The Sun puts the air into motion (wind) and brings other materials into the air to contribute to the weather. So let’s make some weather.

Water vapor, a gas, is always being injected into the atmosphere. Solar energy evaporates water from lakes, rivers, the ocean, and other wet surfaces. Plants transpire water vapor, and animals exhale it. This water in gaseous form joins the other gases in the air. It is a fact of nature that warm air can hold more water vapor than cold air can. The amount of water in air is called humidity. Humid air is less dense than dry air, and warm air is less dense than cool air, so warm, humid air will rise.

As air rises, it cools. Cool air holds less vapor, so the vapor begins to condense as tiny droplets of liquid water on dust particles in the air. When this happens, the invisible water vapor becomes visible as clouds. When conditions are right, perhaps in the mountains, you can watch clouds form as condensation occurs. If conditions change, you can watch clouds disappear as they return to vapor.

If the cloud is relatively warm, water will continue to condense, and tiny droplets will join together until they are big enough to fall. If the cloud cools until the condensing water freezes, the accumulation of ice will eventually yield to gravity and head for Earth. If the air is cold all the way down, we see snow. If the air warms and the snow melts, we see rain. If turbulence tosses the snow back up several times, ice crystals may stick together to form hail.

**Observation and Forecasting**

Primary students will be able to make meaningful observations of the weather in their neighborhoods and will learn some fundamental facts about the behavior of air, but they are unlikely at this stage in their cognitive development to put the two together to understand some of
the fundamental principles that drive the weather. They will, however, be excited about extreme and catastrophic weather.

When young students see TV reports of tornados and hurricanes, they may recognize them as winds and know that they are the result of air in motion—serious high-speed motion. The causes of such dramatic winds—the clashes of warm and cold fronts or the juxtaposition of high- and low-pressure areas—will escape them. When they see reports of droughts, floods, or intense blizzards, they recognize them as extensions of sunny, rainy, and snowy weather, but at levels usually beyond their personal experience. They start to develop an understanding of the extremes of weather as a result of their studies of local weather.

**Up in the Sky**

The objects in the sky that we can observe directly include the Sun, the Moon, and the stars. The Sun is the most reliable and predictable of the bunch, and the easiest to find. Primary students might know that it “comes up” in the morning, is high overhead at midday, and “goes down” at night. They might know where to look for it during the day, and might be able to predict when and where it will rise the next day.

They might not realize, however, that the height to which the Sun rises above the southern horizon changes with the season. Because of the tilt of Earth’s axis, North America shifts position until the Sun is more directly overhead as the summer solstice approaches. And the converse is true—the Sun dips lower and lower in the noon sky as the winter solstice approaches. The result is that the angle that the sunlight hits Earth changes throughout the year and affects the temperature on Earth. The other result is that the length of the daylight changes with the longest daylight day at the summer solstice.

The Moon is a trickier companion. It is visible sometimes at night and sometimes during the day. In fact, the Moon splits each month evenly between day and night. The Moon’s shape also appears to change with the Moon’s time of arrival and departure in the sky. The changes in shape are known as phases, and one complete pass through the phases, the lunar cycle, takes

**CONCEPTUAL FRAMEWORK**

**Earth Science, Earth’s Place in the Universe: Air and Weather**

**Structure**

**Concept A**

Earth is part of a planetary system in the universe.

- The Sun provides Earth with light and heat. The Sun can be observed from Earth only during the day.
- The Moon can be seen sometimes at night and sometimes during the day. It looks different every day, but looks the same again about every 4 weeks.
- There are more stars in the sky than anyone can easily see or count.

**Interactions**

**Concept A**

Patterns of change and apparent motion can be observed, described, and explained with models.

- The Sun and Moon can be observed moving across the sky; we see them at different locations in the sky, depending on the time of day or night.
about 4 weeks. Students can observe the Moon in three of its four key phases—first quarter, full Moon, and third quarter, each occurring 1 week apart. The new Moon, the fourth key phase, is invisible and is an important part of the lunar cycle. The cycle of phases is a product of the Moon’s 4-week orbit around Earth.

The Moon before the first quarter and after the third quarter is in the crescent phase, and the rounding Moon before and after the full Moon is in the gibbous phase. The Moon is said to be waxing as the visible portion increases from new to full, and waning from full to new. Understanding why we see phases of the Moon is hard because it involves the relative position and motions of the Sun, Earth, and the Moon. The mechanism of Moon phases is conceptually difficult for primary students, but they can successfully observe and record the changing shapes and observe the overall pattern of the changes in the Moon’s appearance.

On a dark night, a human can typically see 1000–2000 stars. This is a minute fraction of the several hundred billion stars in our galaxy. The intensity of light reaching Earth from most of them is so low that it simply cannot stimulate a photoreceptor. When a telescope, a powerful light-capturing instrument, is positioned between the view of the sky and the eye, stars in the deepest reaches of the galaxy snap into view, and details appear on closer objects, like the Moon, planets, and the Sun.

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 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 solution 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 learn about air resistance and use that information to build a parachute that delivers supplies safely to the ground.

**Developing possible solutions** involves making decisions about the materials available and thoughtfully making a design about how they can be used, in this case, to build a functional parachute. They should communicate their solutions orally and with drawings and words.

**Comparing different solutions** to improve the design involves testing several designs to see how well each one meets the challenge. First graders are not expected to conduct tests with controlled variables, but they should be able to determine if an object or tool, such as a parachute, meets the challenge 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.

In this module, there is one investigation in which students explore the disciplinary core ideas of engineering design in the context of building and testing parachutes. 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

| Concept A | Defining and delimiting engineering problems.
| --- | ---
|  | • Asking questions, making observations, and gathering information are helpful in thinking about a problem. Before beginning to design a solution, it is important to clearly understand the problem.
| Concept B | Developing possible 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.
|  | • A great variety of objects can be built up from a small set of pieces.
|  | • Different properties are suited to different purposes.
| Concept C | Optimizing the design solution.
|  | • Because there is always more than one possible solution to a problem, it is useful to compare and test designs.
## Dynamic Atmosphere Content Sequence

This table shows the five FOSS modules and courses that address the content sequence “dynamic atmosphere” for grades K–8. Running through the sequence are the two progressions—structure of Earth and Earth interactions. The supporting elements in each module (somewhat abbreviated) are listed. The elements for the Air and Weather Module are expanded to show how they fit into the sequence.

<table>
<thead>
<tr>
<th>Module or course</th>
<th>Structure of Earth</th>
<th>Earth interactions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Weather and Water</strong></td>
<td>• Weather is the condition of Earth’s atmosphere at a given time in a local place; climate is the range of an area’s weather conditions over years.</td>
<td>• Complex patterns of interactions determine local weather patterns.</td>
</tr>
<tr>
<td>(middle school)</td>
<td>• Weather happens in the troposphere.</td>
<td>• Energy transfers from one place to another by radiation and conduction.</td>
</tr>
<tr>
<td></td>
<td>• Density is a ratio of a mass and its volume.</td>
<td>• Convection is the circulation of a fluid that results from energy transfer in a fluid.</td>
</tr>
<tr>
<td></td>
<td>• The angle at which light from the Sun strikes the surface of Earth is the solar angle.</td>
<td>• When air masses of different densities meet, weather changes.</td>
</tr>
<tr>
<td></td>
<td>• Complex patterns of interactions determine local weather patterns.</td>
<td>• The Sun’s energy drives the water cycle and weather.</td>
</tr>
<tr>
<td><strong>Earth and Sun</strong> (grade 5)</td>
<td>• Weather is described in terms of variables including temperature, humidity, wind, and air pressure.</td>
<td>• The different energy-absorbing properties of earth materials lead to uneven heating of Earth’s surface and convection currents.</td>
</tr>
<tr>
<td></td>
<td>• Scientists observe, measure, and record patterns of weather to make predictions.</td>
<td>• Evaporation and condensation contribute to the movement of water through the water cycle.</td>
</tr>
<tr>
<td></td>
<td>• The Sun is the major source of energy that heats Earth; land, water, and air heat up at different rates.</td>
<td>• Climate—the range of an area’s typical weather conditions—is changing globally; this change will impact all life.</td>
</tr>
<tr>
<td></td>
<td>• Most of Earth’s water is in the ocean.</td>
<td></td>
</tr>
<tr>
<td><strong>Water and Climate</strong></td>
<td>• Water is found almost everywhere on Earth (e.g., vapor, clouds, rain, snow, ice). Most of Earth’s water is in the ocean.</td>
<td></td>
</tr>
<tr>
<td>(grade 3)</td>
<td>• Water expands when heated, contracts when cooled, and expands when it freezes.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Cold water is more dense than warmer water; liquid water is more dense than ice.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Scientists observe, measure, and record patterns of weather to make predictions.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Soils retain more water than rock particles.</td>
<td></td>
</tr>
<tr>
<td><strong>Air and Weather</strong> (grade 1)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Trees and Weather</strong> (grade K)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Weather is the condition of the air outside; weather changes.</td>
<td>• Each season has typical weather conditions that can be observed, compared, and predicted.</td>
</tr>
<tr>
<td></td>
<td>• Temperature is how hot or cold it is, and can be measured with a thermometer.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Wind is moving air; wind socks indicate direction and speed.</td>
<td></td>
</tr>
</tbody>
</table>
**Structure of Earth**

- Air is matter (gas) and takes up space.
- Weather describes conditions in the air outside.
- Weather conditions can be measured using tools such as thermometers, wind vanes, anemometers, and rain gauges.
- Clouds are made of liquid water drops.

**Earth interactions**

- The Sun heats Earth during the day.
- Wind is moving air.
- Daily changes in temperature and weather type can be observed, compared, and predicted.
- Each season has typical weather conditions that can be compared and predicted.
- Weather affects animals and plants.
Earth’s Place in the Universe Content Sequence

This table shows the four FOSS modules and courses that address the content sequence “Earth’s place in the universe” for grades K–8. Running through the sequence are the two progressions—structure and interactions. The supporting elements in each module (somewhat abbreviated) are listed. The elements for the **Air and Weather Module** are expanded to show how they fit into the sequence.

### Earth’s Place in the Universe

<table>
<thead>
<tr>
<th>Module or course</th>
<th>Structure</th>
<th>Interactions</th>
</tr>
</thead>
</table>
| **Planetary Science**  | • Earth and Sun are part of the Milky Way galaxy; many such systems exist in the universe. Gravity holds objects in orbit.  
• Earth’s axis tilts at an angle of 23.5° and points toward the North Star.  
• The Moon has surface features that can be identified in telescope images.  
• Location or position can be described in terms of a frame of reference.  
• Scale can be expressed as a ratio when an object and its representation are measured in related units.  
• The temperature on planets in the solar system depends on two major variables—the distance from the Sun and the nature of the planet’s atmosphere. | • Patterns of apparent motion of the Sun, the Moon, and stars can be observed, described, predicted, and explained with models.  
• Models of the solar system can explain tides, eclipses of the Sun and Moon, and motion of the planets relative to the stars.  
• Earth’s spin axis is fixed in direction but tilted relative to its orbit around the Sun; seasons are a result of that tilt, as is differential intensity of light in different areas of Earth during the year.  
• Earth and the Moon have been and continue to be bombarded by meteoroids at the same rate.  
• The solar system formed during a sequence of events that started with a nebula. |
| **Earth and Sun**       | • The Moon can be observed both day and night, but the Sun only during the day.  
• Moon phase is the portion of the illuminated half of the Moon that is visible from Earth.  
• The solar system includes the Sun and other objects that orbit it (Earth and the Moon, other planets, moons, asteroids)  
• Stars are at different distances from Earth. The position of stars relative to one another creates patterns (constellations). | • Shadows change (length and direction) during the day because the position of the Sun changes in the sky.  
• The cyclical change between day and night is the result of a rotating Earth in association with a stationary Sun.  
• The pulling force of gravity keeps the planets and other objects in orbit.  
• Moon phases have a monthly cycle.  
• Earth revolves around the Sun, so we see different stars during each season. |
| **Air and Weather**     |                                                                 |                                                                              |
| **Trees and Weather**   | • Objects can be seen in the sky.                                         | • Trees change through the seasons.                                           |
Structure Interactions

The Moon can be seen sometimes at night and sometimes during the day. It looks different every day, but looks the same again about every 4 weeks.

There are more stars in the sky than anyone can easily see or count.

The Sun can be seen only in the daytime.

The Sun and Moon can be observed moving across the sky; we see them at different locations in the sky, depending on the time of day or night.

The Sun appears to rise in the east, move across the sky during the day, and set in the west.

The hours of daylight changes with the seasons.

**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.

The NGSS Performance Expectations addressed in this module include:

**Earth and Space Sciences**
1-ESS1-1
1-ESS1-2
K-ESS2-1 (extended)
K-ESS3-3 (extended)

**Physical Sciences**
2-PS1-1 (foundational)

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

See pages 30–34 in this chapter for more details on the Grade 1 NGSS Performance Expectations.
<table>
<thead>
<tr>
<th>Inv. 1: Exploring Air</th>
<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 in a text.</td>
<td></td>
</tr>
<tr>
<td>Developing and using models</td>
<td>RI 2: Identify the main topic and retell key details of a text.</td>
<td></td>
</tr>
<tr>
<td>Planning and carrying out</td>
<td>RI 5: Know and use text features.</td>
<td></td>
</tr>
<tr>
<td>Analyzing and interpreting data</td>
<td>SL 1: Participate in collaborative conversations.</td>
<td></td>
</tr>
<tr>
<td>Constructing explanations and designing solutions</td>
<td>W 5: Respond to questions and suggestions from peers.</td>
<td></td>
</tr>
<tr>
<td>Obtaining, evaluating, and communicating information</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Inv. 2: Observing the Sky</th>
<th>Science and Engineering Practices</th>
<th>Connections to Common Core State Standards for ELA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Developing and using models</td>
<td>L 4: Determine or clarify the meaning of unknown and multiple-meaning words and phrases.</td>
<td></td>
</tr>
<tr>
<td>Planning and carrying out investigations</td>
<td>RI 1: Ask and answer questions about key details in a text.</td>
<td></td>
</tr>
<tr>
<td>Analyzing and interpreting data</td>
<td>RI 2: Identify the main topic and retell key details of a text.</td>
<td></td>
</tr>
<tr>
<td>Using mathematics and computational thinking</td>
<td>RI 3: Describe the connection between pieces of information in a text.</td>
<td></td>
</tr>
<tr>
<td>Constructing explanations</td>
<td>RI 4: Ask and answer questions to help determine or clarify the meaning of words and phrases in a text.</td>
<td></td>
</tr>
<tr>
<td>Obtaining, evaluating, and communicating information</td>
<td>RI 5: Know and use text features.</td>
<td></td>
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<tr>
<td></td>
<td>RI 6: Distinguish between information provided by illustrations and by words.</td>
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<tr>
<td></td>
<td>RI 7: Use the illustrations and details in a text to describe its key ideas.</td>
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<tr>
<td></td>
<td>RI 8: Identify the reasons an author gives to support points.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RI 9: Identify similarities in and differences between two texts on the same topic.</td>
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</tr>
<tr>
<td></td>
<td>SL 1: Participate in collaborative conversations.</td>
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</tr>
<tr>
<td></td>
<td>SL 3: Ask and answer questions about what a speaker says.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>W 5: Respond to questions and suggestions from peers.</td>
<td></td>
</tr>
</tbody>
</table>
## Connections to NGSS by Investigation

### Disciplinary Core Ideas

<table>
<thead>
<tr>
<th>PS1.A: Structure and properties of matter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Matter can be described and classified by its observable properties.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ETS1.A: Defining and delimiting engineering problems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before beginning to design a solution, it is important to clearly understand the problem. (K-2 ETS1-1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ETS1.B: Developing possible solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solution to other people. (K-2 ETS1-2)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ETS1.C: Optimizing the design solution</th>
</tr>
</thead>
<tbody>
<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>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ESS1.A: The universe and its stars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patterns of the motion of the Sun, Moon, and stars in the sky can be observed, described, and predicted. (1-ESS1-1)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ESS1.B: Earth and the solar system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seasonal patterns of sunrise and sunset can be observed, described, and predicted. (1-ESS1-2)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ESS2.D: Weather and climate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time. (Extended for K-ESS2-1)</td>
</tr>
</tbody>
</table>

<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>

### Crosscutting Concepts

- Cause and effect
- Systems and system models
- Structure and function
- Patterns
- Cause and effect
- Stability and change
# AIR AND WEATHER — Framework and NGSS

<table>
<thead>
<tr>
<th>Science and Engineering Practices</th>
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</tr>
</thead>
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<td>RI 1: Ask and answer questions about key details in a text.</td>
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<tr>
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<tr>
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<td>RI 3: Describe the connection between pieces of information in a text.</td>
</tr>
<tr>
<td>Constructing explanations and designing solutions</td>
<td>RI 4: Ask and answer questions to help determine or clarify the meaning of words and phrases in a text.</td>
</tr>
<tr>
<td>Obtaining, evaluating, and communicating information</td>
<td>RI 5: Know and use text features.</td>
</tr>
<tr>
<td></td>
<td>RI 8: Identify the reasons an author gives to support points.</td>
</tr>
</tbody>
</table>

**Inv. 3: Wind Explorations**

- Asking questions
- Planning and carrying out investigations
- Analyzing and interpreting data
- Using mathematics and computational thinking
- Constructing explanations
- Obtaining, evaluating, and communicating information


**Inv. 4: Looking for Change**

- L 4: Determine or clarify the meaning of unknown and multiple-meaning words and phrases.
- RI 1: Ask and answer questions about key details in a text.
- RI 2: Identify the main topic and retell key details of a text.
- RI 3: Describe the connection between pieces of information in a text.
- RI 7: Use the illustrations and details in a text to describe its key ideas.
- SL 5: Add drawings or other visual displays to clarify ideas.
- W 7: Participate in shared research and writing projects.
### Disciplinary Core Ideas

<table>
<thead>
<tr>
<th></th>
<th></th>
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<tbody>
<tr>
<td>• Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time. (Extended for K-ESS2-1)</td>
<td>• Patterns of the motion of the Sun, Moon, and stars in the sky can be observed, described, and predicted. (1-ESS1-1)</td>
<td>• Weather is the combination of sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time. (Extended for K-ESS2-1)</td>
<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>
<th>ESS1.B: Earth and the solar system</th>
<th>Patterns</th>
<th>Stability and change</th>
</tr>
</thead>
<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-ESS3-1)</td>
<td>• Seasonal patterns of sunrise and sunset can be observed, described, and predicted. (1-ESS1-2)</td>
<td>Patterns</td>
<td>Cause and effect</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Scale, proportion, and quantity</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Structure and function</td>
</tr>
</tbody>
</table>

### Crosscutting Concepts

- Patterns
- Cause and effect
- Scale, proportion, and quantity
- Structure and function
- Stability and change
### RECOMMENDED FOSS NEXT GENERATION K–8

<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>

*Half-length courses

**Physical Science content**  
**Earth Science content**  
**Life Science content**  
**Engineering content**