

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 are bundled in the **Planetary Science Course** to provide a coherent set of instructional materials for teaching and learning. This chapter also provides details about how this FOSS course fits into the matrix of the FOSS Program (page 49). 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 course with the confidence that the developers have carefully considered the latest research and have integrated into each investigation the three dimensions of the NRC *Framework* and NGSS, and have designed powerful connections to the Common Core State Standards for English Language Arts.

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The NGSS Performance Expectations bundled in this course include

Physical Sciences

- MS-PS2-4 (foundational)
- MS-PS4-2 (foundational)

Earth and Space Sciences

- MS-ESS1-1
- MS-ESS1-2
- MS-ESS1-3
- MS-ESS1-4 (foundational)
- MS-ESS2-2
- MS-ESS2-4 (foundational)
- MS-ESS3-1 (foundational)
- MS-ESS3-2 (foundational)
- MS-ESS3-3
- MS-ESS3-4

Engineering, Technology, and Applications of Science

- MS-ETS1-1 (foundational)



DISCIPLINARY CORE IDEAS

A *Framework for K–12 Science Education* has three core ideas in earth and space sciences.

ESS1: Earth’s place in the universe

ESS2: Earth’s systems

ESS3: Earth and human activity

The questions and descriptions of the core ideas in the text on these pages are taken from the NRC *Framework* for grades 6–8 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 middle school.

Disciplinary Core Ideas Addressed

The **Planetary Science Course** connects with the NRC *Framework* 6–8 grade band and the NGSS performance expectations for the middle school grades. The course focuses on core ideas for Earth sciences primarily and physical sciences and engineering secondarily.

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 apparent motion of the Sun, the Moon, and stars in the sky can be observed, described, predicted, and explained with models. The universe began with a period of extreme and rapid expansion known as the Big Bang. Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.]

- **ESS1.B: Earth and the solar system**

What are the predictable patterns caused by Earth’s movement in the solar system? [The solar system consists of the Sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the Sun by its gravitational pull on them. This model of the solar system can explain tides, eclipses of the Sun and the Moon, and the motion of the planets in the sky relative to the stars. Earth’s spin axis is fixed in direction over the short term, but tilted relative to its orbit around the Sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year.]

- **ESS1.C: The history of planet Earth**

How do people reconstruct and date events in Earth’s planetary history? [The geological time scale interpreted from rock strata provides a way to organize Earth’s history. Major historical events include the formation of mountain chains and ocean basins, the evolution and extinction of particular living organisms, volcanic eruptions, periods of massive glaciation, and development of watersheds and rivers through glaciation and water erosion. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.]

The following NGSS grade 6–8 performance expectations for ESS1 are derived from the Framework disciplinary core idea above.

- **MS-ESS1-1.** Develop and use a model of the Earth–Sun–Moon system to describe the cyclic patterns of lunar phases, eclipses

of the Sun and Moon, and seasons. [Clarification Statement: Examples of models can be physical, graphical, or conceptual.]

- **MS-ESS1-2.** Develop and use a model to describe the role of gravity in the motions within galaxies and the solar system. [Clarification Statement: Emphasis for the model is on gravity as the force that holds together the solar system and Milky Way galaxy and controls orbital motions within them. Examples of models can be physical (such as the analogy of distance along a football field or computer visualizations of elliptical orbits) or conceptual (such as mathematical proportions relative to the size of familiar objects such as their school or state).] [Assessment Boundary: Assessment does not include Kepler’s laws of orbital motion or the apparent retrograde motion of the planets as viewed from Earth.]
- **MS-ESS1-3.** Analyze and interpret data to determine scale properties of objects in the solar system. [Clarification Statement: Emphasis is on the analysis of data from Earth-based instruments, space-based telescopes, and spacecraft to determine similarities and differences among solar system objects. Examples of scale properties include the sizes of an object’s layers (such as crust and atmosphere), surface features (such as volcanoes), and orbital radius. Examples of data include statistical information, drawings and photographs, and models.] [Assessment Boundary: Assessment does not include recalling facts about properties of the planets and other solar system bodies.]
- **MS-ESS1-4.** Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth’s 4.6-billion-year-old history. [Clarification Statement: Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth’s history. Examples of Earth’s major events could range from being very recent (such as the last Ice Age or the earliest fossils of *Homo sapiens*) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.] [Assessment Boundary: Assessment does not include recalling the names of specific periods or epochs and events within them.]

NOTE: This standard is also a main focus of the **FOSS Earth History Course**.

▶ REFERENCES

National Research Council. *A Framework for K–12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: National Academies Press, 2012.

NGSS Lead States. *Next Generation Science Standards: For States, by States*. Washington, DC: National Academies Press, 2013.

National Governors Association Center for Best Practices and Council of Chief State School Officers. *Common Core State Standards for English Language Arts and Literacy in History/Social Studies, Science, and Technical Subjects*. Washington, DC: 2010.

Framework core idea ESS2: Earth’s systems—How and why is Earth constantly changing?

- **ESS2.A: Earth’s materials and systems**

How do Earth’s systems interact? [All Earth processes are the result of energy flowing and matter cycling within and among the planet’s systems. The planet’s systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth’s history and will determine its future.]

- **ESS2.C: The roles of water in Earth’s surface processes**

How do the properties and movements of water shape Earth’s surface and affect its systems? [Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation as well as downhill flows on land. Water’s movements—both on the land and underground—cause weathering and erosion, which change the land’s surface features and create underground formations.]

The following NGSS grade 6–8 performance expectations for ESS2 are derived from the Framework disciplinary core idea above.

- **MS-ESS2-2.** Construct an explanation based on evidence for how geoscience processes have changed Earth’s surface at varying time and spatial scales. [Clarification Statement: Emphasis is on how processes change Earth’s surface at time and spatial scales that can be large (such as slow plate motions or the uplift of large mountain ranges) or small (such as rapid landslides or microscopic geochemical reactions), and how many geoscience processes (such as earthquakes, volcanoes, and meteor impacts) usually behave gradually but are punctuated by catastrophic events. Examples of geoscience processes include surface weathering and deposition by the movements of water, ice, and wind. Emphasis is on geoscience processes that shape local geographic features, where appropriate.]

NOTE: This standard is also a main focus of the **FOSS Earth History Course**.

- **MS-ESS2-4.** Develop a model to describe the cycling of water through Earth’s systems driven by energy from the Sun and the force of gravity. [Clarification Statement: Emphasis is on the ways water changes its state as it moves through the multiple pathways of the hydrologic cycle. Examples of models can be conceptual or physical.] [Assessment Boundary: A quantitative understanding of the latent heats of vaporization and fusion is not assessed.]

NOTE: This standard is also a main focus of the **FOSS Weather and Water Course**.

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? [Humans depend on Earth’s land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. Renewable energy resources, and the technologies to exploit them, are being rapidly developed.]

- **ESS3.C: Human impacts on Earth systems**

How do humans change the planet? [Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of many other species. But changes to Earth’s environments can have different impacts (negative and positive) for different living things. Typically, as human populations and per capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise.]

- **ESS3.D: Global climate change**

How do people model and predict the effect of human activities on Earth’s climate? [Human activities, such as the release of greenhouse gases from burning fossil fuels, are major factors in the current rise in Earth’s mean surface temperature (global warming). Reducing human vulnerability to whatever climate changes do occur depends on the understanding of climate science, engineering capabilities, and other kinds of knowledge, such as understanding of human behavior, and on applying that knowledge wisely in decisions and activities.]

The following NGSS grade 6–8 performance expectations for ESS3 are derived from the Framework disciplinary core idea above.

- **MS-ESS3-1. Construct a scientific explanation based on evidence for how the uneven distributions of Earth’s mineral, energy, and groundwater resources are the result of past and current geoscience processes.** [Clarification Statement: Emphasis is on how these resources are limited and typically non-renewable, and how their distributions are significantly changing as a result of removal by humans. Examples of uneven distributions of resources as a result of past processes include but are not limited to petroleum (locations of the burial of organic marine sediments and subsequent geologic traps), metal ores (locations of past volcanic and hydrothermal activity associated with subduction zones), and soil (locations of active weathering and/or deposition of rock).]

NOTE: This standard is also a main focus of the **FOSS Earth History Course**.

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 grades 6–8 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 grades 6–8.

- **MS-ESS3-2.** Analyze and interpret data on natural hazards to forecast future catastrophic events and inform the development of technologies to mitigate their effects. [Clarification Statement: Emphasis is on how some natural hazards, such as volcanic eruptions and severe weather, are preceded by phenomena that allow for reliable predictions, but others, such as earthquakes, occur suddenly and with no notice, and thus are not yet predictable. Examples of natural hazards can be taken from interior processes (such as earthquakes and volcanic eruptions), surface processes (such as mass wasting and tsunamis), or severe weather events (such as hurricanes, tornadoes, and floods). Examples of data can include the locations, magnitudes, and frequencies of the natural hazards. Examples of technologies can be global (such as satellite systems to monitor hurricanes or forest fires) or local (such as building basements in tornado-prone regions or reservoirs to mitigate droughts).]

NOTE: This standard is also a main focus of the **FOSS Weather and Water Course** and **FOSS Earth History Course**.

- **MS-ESS3-3.** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. [Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).]

NOTE: This standard is also a main focus of the **FOSS Populations and Ecosystems Course**.

- **MS-ESS3-4.** Construct an argument supported by evidence for how increases in human population and per capita consumption of natural resources impact Earth’s systems. [Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth’s systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.]

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.B: Types of interactions**

What underlying forces explain the variety of interactions observed?

[Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—for example, Earth and the Sun. Long-range gravitational interactions govern the evolution and maintenance of large-scale systems in space, such as galaxies or the solar system, and determine the patterns of motion within those structures.]

The following NGSS grade 6–8 performance expectation for PS2 is derived from the Framework disciplinary core idea above.

- **MS-PS2-4.** Construct and present arguments using evidence to support the claim that gravitational interactions are attractive and depend on the masses of interacting objects. [Clarification Statement: Examples of evidence for arguments could include data generated from simulations or digital tools; and charts displaying mass, strength of interaction, distance from the Sun, and orbital periods of objects within the solar system.] [Assessment Boundary: Assessment does not include Newton’s law of gravitation or Kepler’s laws.]

NOTE: This standard is also a main focus of the **FOSS Gravity and Kinetic Energy Course**.

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

- **PS4.B: Electromagnetic radiation**

What is light? How can one explain the varied effects that involve light? What other forms of electromagnetic radiation are there? [When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object’s material and the frequency (color) of the light. A wave model of light is useful for explaining brightness, color, and the frequency-dependent bending of light at a surface between media (prisms). However, because light can travel through space, it cannot be a matter wave, like sound or water waves.]

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

The questions and descriptions of the core ideas in the text on these pages are taken from the NRC Framework for grades 6–8 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 grades 6–8.

The following NGSS grade 6–8 performance expectation for PS4 is derived from the Framework disciplinary core idea above.

- **MS-PS4-2.** Develop and use a model to describe that waves are reflected, absorbed, or transmitted through various materials. [Clarification Statement: Emphasis is on both light and mechanical waves. Examples of models could include drawings, simulations, and written descriptions.] [Assessment Boundary: Assessment is limited to qualitative applications pertaining to light and mechanical waves.]

NOTE: This standard is also a main focus of the **FOSS Waves Course**.

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? [The more precisely a design task’s criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions (e.g., familiarity with the local climate may rule out certain plants for the school garden).]

The following NGSS grade 6–8 performance expectation for ETS1 is derived from the Framework disciplinary core idea above.

- **MS-ETS1-1.** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

Science and Engineering Practices Addressed

1. Asking questions

- Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.
- Ask questions to identify and/or clarify evidence and/or the premise(s) of an argument.
- Ask questions to clarify and/or refine a model, an explanation, or an engineering problem.
- Ask questions that can be investigated within the scope of the classroom, outdoor environment, and museums and other public facilities with available resources and, when appropriate, frame a hypothesis based on observations and scientific principles.

2. Developing and using models

- Evaluate limitations of a model for a proposed object or tool.
- Develop and/or revise a model to show the relationships among variables, including those that are not observable but predict observable phenomena.
- Develop and/or use a model to predict and/or describe phenomena.
- Develop a model to describe unobservable mechanisms.
- Develop and/or use a model to generate data to test ideas about phenomena in natural or designed systems, including those representing inputs and outputs, and those at unobservable scales.

3. Planning and carrying out investigations

- Plan an investigation individually and collaboratively, and in the design: identify independent and dependent variables and controls, what tools are needed to do the gathering, how measurements will be recorded, and how many data are needed to support a claim.
- Collect data to serve as the basis for evidence to answer scientific questions or test design solutions under a range of conditions.

4. Analyzing and interpreting data

- Construct, analyze, and/or interpret graphical displays of data and/or large data sets to identify linear and nonlinear relationships.
- Use graphical displays (e.g., maps, charts, graphs, and/or tables) of large data sets to identify temporal and spatial relationships.
- Analyze and interpret data to provide evidence for phenomena.

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.

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 grades 6–8 as described in the performance expectations appear in bullets below each practice.

5. Using mathematics and computational thinking

- Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends.
- Use mathematical representations to describe and/or support scientific conclusions and design solutions.
- Create algorithms (a series of ordered steps) to solve a problem.
- Apply mathematical concepts and/or processes (e.g., ratio, rate, percent, basic operations, simple algebra) to scientific and engineering questions and problems.

6. Constructing explanations

- Construct an explanation that includes qualitative or quantitative relationships between variables that predict and/or describe phenomena.
- Construct an explanation using models or representations.
- Construct a scientific explanation based on valid and reliable evidence obtained from sources (including the students' own experiments) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.
- Apply scientific ideas, principles, and/or evidence to construct, revise, and/or use an explanation for real-world phenomena, examples, or events.

7. Engaging in argument from evidence

- Respectfully provide and receive critiques about one's explanations, procedures, models, and questions by citing relevant evidence and posing and responding to questions that elicit pertinent elaboration and detail.
- Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.

8. Obtaining, evaluating, and communicating information

- Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).
- Integrate qualitative and/or quantitative scientific and/or technical information in written text with that contained in media and visual displays to clarify claims and findings.

Crosscutting Concepts Addressed

Patterns: *Observed patterns in nature guide organization and classification, and they prompt questions about relationships and causes underlying them.*

- Patterns in rates of change and other numerical relationships can provide information about natural and human-designed systems.
- Patterns can be used to identify cause-and-effect relationships.
- Graphs, charts, and images can be used to identify patterns in data.

Cause and effect: *Events have causes, sometimes simple, sometimes multifaceted. Deciphering causal relationships, and the mechanisms by which they are mediated, is a major activity of science and engineering.*

- Cause-and-effect relationships may be used to predict phenomena in natural or designed systems.
- Phenomena may have more than one cause, and some cause-and-effect relationships in systems can only be described using probability.

Scale, proportion, and quantity: *In considering phenomena, it is critical to recognize what is relevant at different size, time, and energy scales, and to recognize proportional relationships between different quantities as scales change.*

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.
- Proportional relationships (e.g., speed as the ratio of distance traveled to time taken) among different types of quantities provide information about the magnitude of properties and processes.
- Scientific relationships can be represented through the use of algebraic expressions and equations.
- Phenomena that can be observed at one scale may not be observable at another scale.

Systems and system models: *A system is an organized group of related objects or components; models can be used for understanding and predicting the behavior of systems.*

- Systems may interact with other systems; they may have subsystems and be a part of larger complex systems.

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 grades 6–8 in the NGSS and are incorporated into the learning opportunities in the **Planetary Science Course**.

The learning progression for this dimension of the framework is addressed in volume 2, appendix G, of the NGSS. Elements of the learning progression for crosscutting concepts recommended for grades 6–8, as described in the performance expectations, appear after bullets below each concept.

- Models can be used to represent systems and their interactions—such as inputs, processes, and outputs—and energy, matter, and information flows within systems.

Energy and matter: *Tracking energy and matter flows into, out of, and within systems helps one understand their system’s behavior.*

- Energy may take different forms (e.g., energy in fields, thermal energy, energy of motion).
- The transfer of energy can be tracked as energy flows through a designed or natural system.

Structure and function: *The way an object is shaped or structured determines many of its properties and functions.*

- Complex and microscopic structures and systems can be visualized, modeled, and used to describe how their function depends on the shapes, composition, and relationships among its parts; therefore, complex natural and designed structures/systems can be analyzed to determine how they function.

Stability and change: *For both designed and natural systems, conditions that affect stability and factors that control rates of change are critical elements to consider and understand.*

- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and forces at different scales, including the atomic scale.
- Stability might be disturbed either by sudden events or gradual changes that accumulate over time.

Connections to the Nature of Science

- **Scientific knowledge is based on empirical evidence.** Scientific knowledge is based upon logical and conceptual connections between evidence and explanations. Science disciplines share common rules of obtaining and evaluating empirical evidence.
- **Scientific knowledge is open to revision in light of new evidence.** The certainty and durability of scientific findings vary. Scientific findings are frequently revised and/or reinterpreted based on new evidence.
- **Science models, laws, mechanisms, and theories explain natural phenomena.** Theories are explanations for observable phenomena. Scientific theories are based on a body of evidence developed over time. Laws are regularities or mathematical descriptions of natural phenomena. A hypothesis is used by scientists as an idea that may contribute important new knowledge for the evaluation of a scientific theory. The term “theory” as used in science is very different from the common use outside of science.
- **Scientific knowledge assumes an order and consistency in natural systems.** Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation.
- **Science is a human endeavor.** Men and women from different social, cultural, and ethnic backgrounds work as scientists and engineers. Scientists and engineers rely on human qualities such as persistence, precision, reasoning, logic, imagination, and creativity. They are guided by habits of mind, such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas. Advances in technology influence the progress of science, and science has influenced advances in technology.
- **Science addresses questions about the natural and material world.** Scientific knowledge is constrained by human capacity, technology, and materials. Science limits its explanations to systems that lend themselves to observation and empirical evidence. Scientific knowledge can describe consequences of actions but is not responsible for society’s decisions.

CONNECTIONS

See volume 2, appendix H and appendix J, in the NGSS for more on these connections. For details on learning connections to Common Core State Standards English Language Arts and Math, see the chapters FOSS and Common Core ELA and FOSS and Common Core Math in *Teacher Resources*.

FOSS CONCEPTUAL FRAMEWORK

FOSS has conceptual structure at the course level. The concepts are carefully selected and organized in a sequence that makes sense to students when presented as intended. In the last half decade, research has focused on learning progressions. The idea behind a learning progression is that **core ideas** in science are complex and wide-reaching—ideas such as the structure of matter or the relationship between the distribution and function of organisms. From the age of awareness throughout life, matter and organisms are important to us. There are things we can and should understand about them in our primary school years, and progressively more complex and sophisticated things we should know about them as we gain experience and develop our cognitive abilities. When we as educators can determine those logical progressions, we can develop meaningful and effective curriculum.

FOSS has elaborated learning progressions for core ideas in science for kindergarten through grade 8. Developing the learning progressions involves identifying successively more sophisticated ways of thinking about core ideas over multiple years. “If mastery of a core idea in a science discipline is the ultimate educational destination, then well-designed learning progressions provide a map of the routes that can be taken to reach that destination” (National Research Council, *A Framework for K–12 Science Education*, 2012, page 26).

The FOSS modules (grades K–5) and courses (grades 6–8) are organized into three domains: physical science, earth science, and life science. Each domain is subdivided into two strands, each representing a core scientific idea, as shown in the columns in the table: matter/energy and change, atmosphere and Earth/rocks and landforms, structure and function/complex systems. The sequence of modules and courses in each strand relates to the core ideas described in the national framework. Modules at the bottom of the table form the foundation in the primary grades. The core ideas develop in complexity as they proceed up the columns.

In addition to the science content framework, every course provides opportunities for students to engage in and understand science practices, and many courses explore issues related to engineering practices and the use of natural resources.

The science content used to develop the FOSS courses describes what we want students to learn; the science and engineering practices describe how we want students to learn; and crosscutting concepts stitch the whole effort into a coherent fabric describing the whole natural world. Practices involve a number of habits of mind and philosophical orientations, and these, too, will develop in richness and complexity as students advance through their science studies. Science and engineering practices involve behaviors, so they can be best assessed while in progress. Thus, assessment of practices is based on teacher observation. The indicators of progress include students involved in the many aspects of active thinking, students motivated to learn, and students taking responsibility for their own learning.

FOSS Next Generation—K–8 Sequence

		PHYSICAL SCIENCE		EARTH SCIENCE		LIFE SCIENCE	
		MATTER	ENERGY AND CHANGE	ATMOSPHERE AND EARTH	ROCKS AND LANDFORMS	STRUCTURE/FUNCTION	COMPLEX SYSTEMS
6–8		Waves; Gravity and Kinetic Energy		Planetary Science		Heredity and Adaptation	
		Chemical Interactions		Earth History		Populations and Ecosystems	
		Electromagnetic Force		Weather and Water		Diversity of Life; Human Systems Interactions	
5		Mixtures and Solutions		Earth and Sun		Living Systems	
4			Energy		Soils, Rocks, and Landforms	Environments	
3		Motion and Matter		Water and Climate		Structures of Life	
2		Solids and Liquids			Pebbles, Sand, and Silt	Insects and Plants	
1			Sound and Light	Air and Weather		Plants and Animals	
K		Materials and Motion		Trees and Weather		Animals Two by Two	

BACKGROUND FOR THE CONCEPTUAL FRAMEWORK *in Planetary Science*

Earth Interactions

A subject as huge as astronomy suggests the need for specialization. Some astronomers direct their powerful telescopes into deep space, looking for galaxies in the throes of birth or death to better understand the mysteries of the life cycles of huge systems. Others study the multitudes of stars and reservoirs of raw materials contained in our galaxy. Other teams of astronomers search for planets around distant stars, and some design elaborate Earth-based receivers to scan the universe for signs of extraterrestrial intelligence. But perhaps the most comprehensive body of astronomical knowledge has been accumulated by scientists who study the objects in our planetary system—the planets, satellites, and lesser objects and debris that orbit the Sun. Planetary science is the study of planets and their moons—their size, composition, and motion in relationship to one another, along with the other objects circling a star.

We tend to use the terms *solar system* and *planetary system* interchangeably. This is reasonable because until very recently we knew of only one planetary system—the one dominated by our star, Sol. However, *solar system* refers to a specific case of a planetary system—our case.

The solar system had its beginning about 4.57 billion years ago. The Sun and eight planets accreted from a modest accumulation of spiraling space debris—chunks, dust, and gases (including water)—spinning around in a region some considerable distance from the center of the Milky Way galaxy. At that time, the universe was already billions of years old. It is estimated that the Sun is in its midlife vitality, and will continue to function more or less in its present role for another 5 billion years. At that time, it will make a final grandstand display, expanding 250 times its present diameter (a red dwarf) as it exhausts its reserves of hydrogen fuel. Our burnt-out Sun will then decline and collapse into a kind of stellar corpse called a white dwarf, and the solar system as we know it will cease to exist.

The inquiry proposed in this course on planetary science will not progress in the direction just suggested, from the outermost reaches toward Earth. Rather, the sequence will start with our most familiar solar system object, Earth, and build out from there. The first extraterrestrial way station will be the Moon, followed by the other planets. This approach also recapitulates the rich history of discovery

and philosophical reform that accompanied the introduction of what in those days were heretical notions of the origin and governance of celestial objects.

Developing Scientific Thinking

As curriculum developers, we ask students to consider two questions as they investigate planetary science: What do you know? How do you know it? Students sometimes consider the first question to be the most important as it relates to science content, but really the second question is of equal or greater importance.

Planetary science is excellent for exercising the emerging ability of middle school students to use inferential thinking. The study of planetary science reveals a history of ideas coalesced from indirect evidence rather than ideas built out of concrete experience. How did ancient astronomers conclude that Earth is round? What caused the craters on the Moon? Why are some surfaces of the Moon largely flat and unmarred?

CONCEPTUAL FRAMEWORK

Earth's Place in the Universe: Planetary Science

Structure of Earth

Concept C Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources.

- As human population increases, so does the human need for resources from Earth's systems.

Concept D Earth is part of a planetary system in the universe.

- The solar system consists of the Sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the Sun by its gravitational pull on them.
- The solar system appears to have formed from a disk of dust and gas, drawn together by gravity.
- Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe.

Earth Interactions

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

- Patterns of the apparent motion of the Sun, the Moon, and stars in the sky can be observed, described, predicted, and explained with models.
- This model of the solar system can explain eclipses of the Sun and the Moon.

Concept B Earth's system and human activities affect each other.

- All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems.
- Typically as human populations and per capita consumption of natural resources increase, so do the negative impacts on Earth's systems unless the activities and technologies involved are engineered otherwise.

Concept C The orbits of Earth around the Sun and of the Moon around Earth, together with the rotation of Earth about its axis between its North and South Poles, cause observable patterns.

- The day/night cycle of a planet results from its rotation on an axis.
- Seasons are a result of Earth's tilt relative to its orbit around the Sun, and are caused by the differential intensity of sunlight on different areas of Earth across the year.
- Moon phases are explained by the position of the Moon in relation to the Sun and the view of the Moon that can be seen from Earth.

CONCEPTUAL FRAMEWORK
Energy and Change: Planetary Science

Motion and Stability: Forces and Interactions

- Concept B** All interactions between objects arise from a few types of forces, primarily gravity and electromagnetism.
- Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the Sun.
 - Stability might be disturbed either by sudden events or gradual changes that accumulate over time.

Energy Transfer and Conservation

- Concept C** Waves are a repeating pattern of motion that transfers energy from place to place without displacement of matter. Electromagnetic waves can be detected over a wide range of frequencies; some can be observed by humans, others can be detected by designed technologies.
- A wave model can be used to explain the properties of light (brightness, color, and frequency-dependent bending).
 - Electromagnetic waves form a spectrum of different wavelengths. Some electromagnetic radiation (visible light) can be detected by humans. An object can be seen when light reflected from its surface enters the eye.

Where did the Moon come from? How can you tell planets from stars? Throughout this course, students will find opportunities to propose explanations for objects, structures, and phenomena they encounter in their excursion through the solar system.

Planetary science has a history and a future. The history is a fascinating progression of discoveries of objects and phenomena in near space—in large measure, a chronicle of the advance of technology. The history of our investigation of the solar system is a history of ideas—ideas reinforced through experimentation and observation. It is this dimension of the study of the solar system that will provide the greatest benefit to students: the opportunity to revisit the thinking behind the big ideas in planetary science.

Engineering in Planetary Science

And the future? Students will learn that there is much to be explored in the cosmos, and that there are corners of the universe in which we have not yet begun to peek. They will learn about the challenges of space exploration, primarily distance, and consider from an engineering standpoint the challenge of protecting Earth from impacts with other celestial objects. What are engineers doing to develop technology to detect and destroy or deflect potential impactors?

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.

In this course, there is one investigation in which students explore the disciplinary core ideas of engineering design in the context of Earth impact detection and prevention. In this course, students engage only with defining an engineering problem. But students engage in the full engineering design process in other FOSS courses. 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: Planetary Science

- Concept A** Defining and delimiting engineering problems
- The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge likely to limit possible solutions.

Earth Science 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 main content progressions—structure and Earth interactions. The supporting elements in these modules (somewhat abbreviated) are listed. The elements for the **Planetary Science Course** are expanded to show how they fit into the sequence.

EARTH’S PLACE IN THE UNIVERSE		
Module or course	Structure of Earth	Earth interactions
Planetary Science (middle school)		
Earth and Sun (grade 5)	<ul style="list-style-type: none"> • 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). 	<ul style="list-style-type: none"> • 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. • We see different stars during each season because Earth revolves around the Sun.
Air and Weather (grade 1)	<ul style="list-style-type: none"> • 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. 	<ul style="list-style-type: none"> • 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.
Trees and Weather (grade K)	<ul style="list-style-type: none"> • Objects can be seen in the sky. 	<ul style="list-style-type: none"> • Trees change through the seasons.

	Structure of Earth	Earth interactions
Planetary Science	<ul style="list-style-type: none"> As human population increases, so does the human need for resources from Earth's systems. The solar system consists of the Sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the Sun by its gravitational pull on them. The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. 	<ul style="list-style-type: none"> Patterns of the apparent motion of the Sun, the Moon, and stars in the sky can be observed, described, predicted, and explained with models. This model of the solar system can explain eclipses of the Sun and the Moon. All Earth processes are the result of energy flowing and matter cycling within and among the planet's systems. Typically as human populations and per capita consumption of natural resources increase, so do the negative impacts on Earth's systems unless the activities and technologies involved are engineered otherwise. The day/night cycle of a planet results from its rotation on an axis. Seasons are a result of Earth's tilt relative to its orbit around the Sun, and are caused by the differential intensity of sunlight on different areas of Earth across the year. Moon phases are explained by the position of the Moon in relation to the Sun and the view of the Moon that can be seen from Earth.

NOTE

See the Assessment chapter in this *Investigations Guide* for more details on how the FOSS embedded and benchmark assessment opportunities align to the conceptual framework 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 course include

Physical Sciences

MS-PS2-4 (foundational)
MS-PS4-2 (foundational)

Earth and Space Sciences

MS-ESS1-1
MS-ESS1-2
MS-ESS1-3
MS-ESS1-4 (foundational)
MS-ESS2-2
MS-ESS2-4 (foundational)
MS-ESS3-1 (foundational)
MS-ESS3-3
MS-ESS3-4

Engineering, Technology, and the Applications of Science

MS-ETS1-1 (foundational)

See pages 36–42 in this chapter for more details on the Grades 6–8 NGSS Performance Expectations.

CONNECTIONS TO NGSS BY INVESTIGATION

Science and Engineering Practices

Asking questions
 Developing and using models
 Planning and carrying out investigations
 Analyzing and interpreting data
 Using mathematics and computational thinking
 Engaging in argument from evidence
 Obtaining, evaluating, and communicating information

Connections to Common Core State Standards—ELA

Reading—Literacy in Science and Technical Subjects

2. Determine the central ideas or conclusions of a text; provide an accurate summary of the text.
4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases.
6. Analyze the author’s purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.
7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually.

Writing—Literacy in Science and Technical Subjects

1. Write arguments.
8. Gather relevant information from multiple print and digital sources.
9. Draw evidence from informational texts to support analysis, reflection, and research.
10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

Speaking and Listening

1. Engage effectively in a range of collaborative discussions with diverse partners on middle school topics, texts, and issues, building on others’ ideas and expressing their own clearly.
3. Delineate and evaluate a speaker’s argument.
4. Present claims and findings.

Language

4. Determine or clarify the meaning of unknown words and phrases.
5. Demonstrate understanding of word relationships and nuances in word meanings.
6. Acquire and use academic and domain-specific words and phrases.

Inv. 1: Earth as a System

Disciplinary Core Ideas

Crosscutting Concepts

ESS1.A: The universe and its stars

- Patterns of the apparent motion of the Sun, the Moon, and stars in the sky can be observed, described, predicted, and explained with models. (MS-ESS1-1)

ESS3.C: Human impacts on Earth systems

- Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3, MS-ESS3-4)

Patterns
Scale, proportion, and quantity
Systems and system models

Science and Engineering Practices

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

Connections to Common Core State Standards—ELA

Reading—Literacy in Science and Technical Subjects

1. Cite evidence to support analysis of science and text.
2. Determine the central ideas or conclusions of a text; provide an accurate summary of the text.
4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases.
7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually.
9. Compare and contrast information from experiments, simulations, video, or multimedia sources with that from reading a text.
10. Read and comprehend science independently and proficiently.

Writing—Literacy in Science and Technical Subjects

1. Write arguments.
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
5. Develop and strengthen writing.
8. Gather relevant information from multiple print and digital sources.

Speaking and Listening

1. Engage effectively in a range of collaborative discussions with diverse partners on middle school topics, texts, and issues, building on others' ideas and expressing their own clearly.

Language

4. Determine or clarify the meaning of unknown words and phrases.
6. Acquire and use academic and domain-specific words and phrases.

Disciplinary Core Ideas

Crosscutting Concepts

ESS1.A: The universe and its stars

- Patterns of the apparent motion of the Sun, the Moon, and stars in the sky can be observed, described, predicted, and explained with models. (MS-ESS1-1)

ESS1.B: Earth and the solar system

- This model of the solar system can explain eclipses of the Sun and the Moon. Earth's spin axis is fixed in direction over the short-term but tilted relative to its orbit around the Sun. The seasons are a result of that tilt and are caused by the differential intensity of sunlight on different areas of Earth across the year. (MS-ESS1-1)

- Patterns
- Cause and effect
- Scale, proportion, and quantity
- Systems and system models
- Energy and matter
- Structure and function

**Science and
Engineering Practices**

Asking questions
Developing and using models
Planning and carrying out investigations
Using mathematics and computational thinking
Obtaining, evaluating, and communicating information

**Connections to
Common Core State Standards—ELA**

Writing—Literacy in Science and Technical Subjects

- 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- 7. Conduct short research projects to answer a question.

Language

- 4. Determine or clarify the meaning of unknown words and phrases.
- 6. Acquire and use academic and domain-specific words and phrases.

Inv. 3: Moon Study

Disciplinary Core Ideas

ESS1.A: The universe and its stars

- Patterns of the apparent motion of the Sun, the Moon, and stars in the sky can be observed, described, predicted, and explained with models. (MS-ESS1-1)

ESS1.B: Earth and the solar system

- The solar system consists of the Sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the Sun by its gravitational pull on them. (MS-ESS1-3)

Crosscutting Concepts

Patterns
Scale, proportion, and quantity
Systems and system models

Science and Engineering Practices

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

Connections to Common Core State Standards—ELA

Reading—Literacy in Science and Technical Subjects

- 1. Cite evidence to support analysis of science and text.
- 6. Analyze the author’s purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.
- 7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually.
- 10. Read and comprehend science independently and proficiently.

Writing—Literacy in Science and Technical Subjects

- 2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
- 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

Speaking and Listening

- 1. Engage effectively in a range of collaborative discussions with diverse partners on middle school topics, texts, and issues, building on others’ ideas and expressing their own clearly.

Language

- 4. Determine or clarify the meaning of unknown words and phrases.
- 6. Acquire and use academic and domain-specific words and phrases.

Inv. 4: Phases of the Moon

Disciplinary Core Ideas

ESS1.A: The universe and its stars

- Patterns of the apparent motion of the Sun, the Moon, and stars in the sky can be observed, described, predicted, and explained with models. (MS-ESS1-1)

ESS1.B: Earth and the solar system

- The solar system consists of the Sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the Sun by its gravitational pull on them. (MS-ESS1-3)

Crosscutting Concepts

Patterns
Cause and effect
Systems and system models

Science and Engineering Practices

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

Connections to Common Core State Standards—ELA

Reading—Literacy in Science and Technical Subjects

1. Cite evidence to support analysis of science and text.
2. Determine the central ideas or conclusions of a text; provide an accurate summary of the text.
4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases.
5. Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to an understanding of the topic.
6. Analyze the author’s purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.
9. Compare and contrast information from experiments, simulations, video, or multimedia sources with that from reading a text.
10. Read and comprehend science independently and proficiently.

Writing—Literacy in Science and Technical Subjects

1. Write arguments.
2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
5. Develop and strengthen writing.
7. Conduct short research projects to answer a question.
8. Gather relevant information from multiple print and digital sources.
9. Draw evidence from informational texts to support analysis, reflection, and research.

Speaking and Listening

1. Engage effectively in a range of collaborative discussions with diverse partners on middle school topics, texts, and issues, building on others’ ideas and expressing their own clearly.
4. Present claims and findings.

Language

4. Determine or clarify the meaning of unknown words and phrases.
5. Demonstrate understanding of word relationships and nuances in word meanings.

Inv. 5: Craters

Disciplinary Core Ideas

ESS1.A: The universe and its stars

- Patterns of the apparent motion of the Sun, the Moon, and stars in the sky can be observed, described, predicted, and explained with models. (MS-ESS1-1)

ESS1.B: Earth and the solar system

- The solar system consists of the Sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the Sun by its gravitational pull on them. (MS-ESS1-3)

ESS1.C: The history of planet Earth

- The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale. (MS-ESS1-4)

ESS3.B: Natural hazards

- Mapping the history of natural hazards in a region, combined with an understanding of related geologic forces can help forecast the locations and likelihoods of future events. (MS-ESS3-2).

ESS2.A: Earth's materials and systems

- The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. (MS-ESS2-2)

ETS1.A: Defining and delimiting an engineering problem

- The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1)

Crosscutting Concepts

Patterns

Cause and effect

Scale, proportion, and quantity

Systems and system models

Stability and change

Science and Engineering Practices

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

Connections to Common Core State Standards—ELA

Reading—Literacy in Science and Technical Subjects

1. Cite evidence to support analysis of science and text.
2. Determine the central ideas or conclusions of a text; provide an accurate summary of the text.
4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases.
5. Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to an understanding of the topic.
6. Analyze the author’s purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.
7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
8. Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.
9. Compare and contrast information from experiments, simulations, video, or multimedia sources with that from reading a text.
10. Read and comprehend science independently and proficiently.

Writing—Literacy in Science and Technical Subjects

2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
5. Develop and strengthen writing.
9. Draw evidence from informational texts to support analysis, reflection, and research.

Speaking and Listening

1. Engage effectively in a range of collaborative discussions with diverse partners on middle school topics, texts, and issues, building on others’ ideas and expressing their own clearly.

Language

4. Determine or clarify the meaning of unknown words and phrases.
5. Demonstrate understanding of word relationships and nuances in word meanings.
6. Acquire and use academic and domain-specific words and phrases.

Disciplinary Core Ideas

ESS1.A: The universe and its stars

- Earth and its solar system are part of the Milky Way galaxy, which is one of many galaxies in the universe. (MS-ESS1-2)

ESS1.B: Earth and the solar system

- The solar system consists of the Sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the Sun by its gravitational pull on them. (MS-ESS1-2, MS-ESS1-3)
- The solar system appears to have formed from a disk of dust and gas, drawn together by gravity. (MS-ESS1-2)
- Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. (MS-ESS2-4)

PS2.B: Types of interactions

- Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the Sun. (MS-PS2-4)

Crosscutting Concepts

Patterns
Cause and effect
Scale, proportion, and quantity
Systems and system models
Stability and change

Science and Engineering Practices

Asking questions
 Developing and using models
 Analyzing and interpreting data
 Using mathematics and computational thinking
 Constructing explanations
 Engaging in argument from evidence
 Obtaining, evaluating, and communicating information

Connections to Common Core State Standards—ELA

Reading—Literacy in Science and Technical Subjects

1. Cite evidence to support analysis of science and text.
2. Determine the central ideas or conclusions of a text; provide an accurate summary of the text.
4. Determine the meaning of symbols, key terms, and other domain-specific words and phrases.
5. Analyze the structure an author uses to organize a text, including how the major sections contribute to the whole and to an understanding of the topic.
6. Analyze the author’s purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.
7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually.
10. Read and comprehend science independently and proficiently.

Writing—Literacy in Science and Technical Subjects

2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/experiments, or technical processes.
4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
7. Conduct short research projects to answer a question.
8. Gather relevant information from multiple print and digital sources.
9. Draw evidence from informational texts to support analysis, reflection, and research.

Language

4. Determine or clarify the meaning of unknown words and phrases.
6. Acquire and use academic and domain-specific words and phrases.

Inv. 7: The Solar System

Disciplinary Core Ideas

ESS1.B: Earth and the solar system

- The solar system consists of the Sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the Sun by its gravitational pull on them. (MS-ESS1-2, MS-ESS1-3)

ESS2.A: Earth's materials and systems

- The planet's systems interact over scales that range from microscopic to global in size, and they operate over fractions of a second to billions of years. These interactions have shaped Earth's history and will determine its future. (MS-ESS2-2)

ESS2.C: The roles of water in Earth's surface processes

- Water's movements—both on the land and underground—cause weathering and erosion, which change the land's surface features and create underground formations. (MS-ESS2-2)
- Water continually cycles among land, ocean, and atmosphere via transpiration, evaporation, condensation and crystallization, and precipitation, as well as downhill flows on land. (MS-ESS2-4)

ESS3.A: Natural resources

- Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. (MS-ESS3-1)

ESS3.C: Human impacts on Earth systems

- Typically as human populations and per capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3, MS-ESS3-4)

Crosscutting Concepts

Patterns
Cause and effect
Scale, proportion, and quantity
Systems and system models
Stability and change

Science and Engineering Practices

Asking questions and defining problems
 Developing and using models
 Analyzing and interpreting data
 Constructing explanations
 Obtaining, evaluating, and communicating information

Connections to Common Core State Standards—ELA

Reading—Literacy in Science and Technical Subjects

2. Determine the central ideas or conclusions of a text; provide an accurate summary of the text.
6. Analyze the author’s purpose in providing an explanation, describing a procedure, or discussing an experiment in a text.
7. Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually.
8. Distinguish among facts, reasoned judgment based on research findings, and speculation in a text.
10. Read and comprehend science independently and proficiently.

Writing—Literacy in Science and Technical Subjects

4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
8. Gather relevant information from multiple print and digital sources.

Speaking and Listening

1. Engage effectively in a range of collaborative discussions with diverse partners on middle school topics, texts, and issues, building on others’ ideas and expressing their own clearly.

Language

6. Acquire and use academic and domain-specific words and phrases.

Inv. 8: Space Exploration

Disciplinary Core Ideas

PS4.B: Electromagnetic radiation

- When light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light. (MS-PS4-2)

ETS1.A: Defining and delimiting engineering problems

- The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1)

Crosscutting Concepts

Patterns
Scale, proportion, and quantity
Energy and matter

Science and Engineering Practices

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

Connections to Common Core State Standards—ELA

Reading—Literacy in Science and Technical Subjects

- 1. Cite evidence to support analysis of science and text.
- 10. Read and comprehend science independently and proficiently.

Writing—Literacy in Science and Technical Subjects

- 4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- 9. Draw evidence from informational texts to support analysis, reflection, and research.

Speaking and Listening

- 1. Engage effectively in a range of collaborative discussions with diverse partners on middle school topics, texts, and issues, building on others' ideas and expressing their own clearly.

Language

- 4. Determine or clarify the meaning of unknown words and phrases.
- 6. Acquire and use academic and domain-specific words and phrases.

Inv. 9: Orbits and New Worlds

Disciplinary Core Ideas

ESS1.A: The universe and its stars

- Patterns of the apparent motion of the Sun, the Moon, and stars in the sky can be observed, described, predicted, and explained with models. (MS-ESS1-1)

ESS1.B: Earth and the solar system

- The solar system consists of the Sun and a collection of objects, including planets, their moons, and asteroids that are held in orbit around the Sun by its gravitational pull on them. (MS-ESS1-3)

PS2.B: Types of interactions

- Gravitational forces are always attractive. There is a gravitational force between any two masses, but it is very small except when one or both of the objects have large mass—e.g., Earth and the Sun. (MS-PS2-4)

Crosscutting Concepts

Patterns
Cause and effect
Scale, proportion, and quantity
Systems and system models

FOSS NEXT GENERATION K-8 SCOPE AND SEQUENCE

Grade	Integrated Middle Grades				
6-8	 Heredity and Adaptation*	 Electromagnetic Force*	 Gravity and Kinetic Energy*	 Waves*	 Planetary Science
	 Chemical Interactions		 Earth History		 Populations and Ecosystems
	 Weather and Water		 Diversity of Life		 Human Systems Interactions*

*Half-length courses

 Physical Science content

 Earth Science content

 Life Science content

 Engineering content

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