

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 **Variables and Design 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 41). Each FOSS module K–5 and middle school course 6–8 has a functional role in the FOSS conceptual frameworks that were developed based on a decade of research on science education and the influence of *A Framework for K–12 Science Education* (2012) and *Next Generation Science Standards* (NGSS, 2013).

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

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

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

Teach the 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

Engineering, Technology, and the Applications of Science

- MS-ETS1-1
- MS-ETS1-2
- MS-ETS1-3
- MS-ETS1-4



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: Interdependence of science, engineering, and technology

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 **Variables and Design Course** connects with the NRC *Framework* 6–8 grade band and the NGSS performance expectations for middle school. The course focuses on core ideas for engineering design.

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).]

- **ETS1.B: Developing possible solutions**

What is the process for developing potential design solutions? [A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. In any case, it is important to be able to communicate and explain solutions to others. Models of all kinds are important for testing solutions, and computers are a valuable tool for simulating systems.]

- **ETS1.C: Optimizing the design solution**

How can the various proposed design solutions be compared and improved? [There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. Comparing different designs could involve running them through the same kinds of tests and systematically recording the results to determine which design performs best. Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. This iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test

results leads to greater refinement and ultimately to an optimal solution. Once such a suitable solution is determined, it is important to describe that solution, explain how it was developed, and describe the features that make it successful.]

The following NGSS grades 6–8 performance expectations for ETS1 are derived from the Framework disciplinary core ideas 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.
- **MS-ETS1-2.** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- **MS-ETS1-3.** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- **MS-ETS1-4.** Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

► 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 State*. Washington, DC: National Academies Press, 2013.

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

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.

Science and Engineering Practices Addressed

1. Asking questions and defining problems

- Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.
- Ask questions to determine relationships between independent and dependent variables and relationships in models.
- Ask questions to clarify and/or refine a model, an explanation, or an engineering problem.
- Define a design problem that can be solved through the development of an object, tool, process, or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions.

2. Developing and using models

- 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 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.
- Conduct an investigation and/or evaluate and/or revise the experimental design to produce data to serve as the basis for evidence that meet the goals of the investigation.
- 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.
- Analyze and interpret data to provide evidence for phenomena.
- Analyze data to define an optimal operational range for a proposed object, tool, process, or system that best meets criteria for success.

5. **Using mathematics and computational thinking**

- Use mathematical representations to describe and/or support scientific conclusions and design solutions.

6. **Constructing explanations and designing solutions**

- Construct an explanation that includes qualitative or quantitative relationships between variables that predict and/or describe phenomena.
- Construct an explanation using models or representations.
- Apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process, or system.
- Undertake a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.
- Optimize performance of a design by prioritizing criteria, making trade-offs, testing, revising, and retesting.

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.
- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria.

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).
- Communicate scientific and/or technical information (e.g., about a proposed object, tool, process, system) in writing and/or through oral presentations.

CROSCUTTING CONCEPTS

A Framework for K–12 Science Education describes seven crosscutting concepts as essential elements of a K–12 science and engineering curriculum. 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.

Crosscutting Concepts Addressed

Patterns: *Observed patterns in nature guide organization and classification and 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.

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.*

- 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.

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

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

- 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 its functions.*

- Structures can be designed to serve particular functions by taking into account properties of different materials, and how materials can be shaped and used.

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.

- Small changes in one part of a system might cause large changes in another part.

Connections to the Nature of Science

- **Scientific knowledge is based on empirical evidence.** Scientific knowledge is based on logical and conceptual connections between evidence and explanations.
- **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.** Advances in technology influence the progress of science, and science has influenced advances in technology. Scientists and engineers are guided by habits of mind such as intellectual honesty, tolerance of ambiguity, skepticism, and openness to new ideas.
- **Science addresses questions about the natural and material world.** Scientific knowledge can describe the consequences of actions but is not responsible for decisions that society takes.

Connections to Engineering, Technology, and Applications of Science

- **Interdependence of science, engineering, and technology.** Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems. Science and technology drive each other forward. Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations.
- **Influence of engineering, technology, and science on society and the natural world.** The uses of technologies are driven by people’s needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Technology use varies over time and from region to region.

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		ENGINEERING DESIGN
	MATTER	ENERGY AND CHANGE	ATMOSPHERE AND EARTH	ROCKS AND LANDFORMS	STRUCTURE/FUNCTION	COMPLEX SYSTEMS	
6–8	Waves; Gravity and Kinetic Energy Chemical Interactions Electromagnetic Force		Planetary Science Earth History Weather and Water		Heredity and Adaptation Populations and Ecosystems Diversity of Life; Human Systems Interactions		Variables and Design
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 Variables and Design*

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 solving well-defined problems. 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 NRC *Framework* and in the NGSS. The three basic ideas of engineering design are defining the problem, developing possible solutions, and optimizing the design.

Defining the problem “with precision” means having a clear understanding of specific criteria and constraints in a complex problem that might have a broad societal or environmental impact. In this course, students identify and define their own community problem.

Developing possible solutions at the middle school level focuses not only on generating design ideas, but also on evaluating different ideas in a systematic way, such as a trade-off matrix to determine the most promising designs. Those most promising designs would be tested, and their results would be combined into a new solution.

TEACHING NOTE

The **FOSS Variables and Design Course** is designed for grades 5–8, most typically used to start a middle school student’s science education at the beginning of grade 6 or in a STEM elective course.

Optimizing the design involves an iterative process of testing the best design, systematically analyzing the results, modifying the design while controlling variables, retesting, comparing results, and again modifying the design. They may go through this cycle several times to optimize a design. Students need to know that “failure” is not only OK, but expected in engineering design. Having something fail drives you to improve the system and make progress. Collaboration is an important aspect of engineering design; learning from the successes and failures of other design groups can be very productive. Students exchange design feedback with other groups to practice being receptive to collaborative input.

In this course, students explore the disciplinary core ideas of engineering design in depth in the last two investigations. The first investigation focuses on the work of scientists as a way to help students differentiate this role from engineering. In other FOSS courses, you will find that students engage in engineering practices to varying degrees. 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 disciplinary core ideas about the design process. This course provides the most in-depth engineering design experiences of all.

CONCEPTUAL FRAMEWORK

Engineering Design: Variables and Design

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.

Concept B Developing possible solutions

- A solution needs to be tested and then modified on the basis of the test results in order to improve it.
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.
- Models of all kinds are important for testing solutions.

Concept C Optimizing the design solution

- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.

Engineering Design Sequence

This table shows selected modules and courses for grades K–8 in the FOSS content sequence for physical science, with an emphasis on the modules that inform the Engineering Design strand. The supporting elements in these modules (somewhat abbreviated) are listed. The elements for the **Variables and Design Course** are expanded to show how they fit into the sequence.

Module or course	ENGINEERING DESIGN
Variables and Design (middle school)	
Motion and Matter (grade 3)	<ul style="list-style-type: none"> • Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each one takes the constraints into account. • Research before designing, testing possible solutions, and communicating with peers about possible solutions are all important parts of the design process. • Tests are designed to identify inadequacies, which will suggest design elements to improve.
Materials and Motion (grade K)	<ul style="list-style-type: none"> • A situation that people want to change or create can be approached as a problem to be solved through engineering. • 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. • Designs can be conveyed through sketches, drawings, or physical models. These representations are helpful for communicating ideas for a problem’s solutions to other people. • Because there is always more than one possible solution to a problem, it is useful to compare and test designs.

ENGINEERING DESIGN

Variables and Design

- 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.
- A solution needs to be tested and then modified on the basis of the test results in order to improve it.
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem.
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors.
- Models of all kinds are important for testing solutions.
- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design.
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution.

NOTE

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

Engineering, Technology, and the Applications of Science

- MS-ETS1-1
- MS-ETS1-2
- MS-ETS1-3
- MS-ETS1-4

See page 35 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
 Constructing explanations
 Obtaining, evaluating, and communicating information

Connections to Common Core State Standards—ELA

Reading—Literacy in Science and Technical Subjects

1. Cite specific textual evidence to support analysis of science and technical texts.
2. Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.
3. Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
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.
9. Compare and contrast the information gained from experiments, video, or multimedia sources with that gained from reading a text on the same topic.
10. Read and comprehend science/technical texts in grades 6–8 text independently and proficiently.

Speaking and Listening

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

Writing—Literacy in Science and Technical Subjects

2. Write informative/explanatory texts.
5. With some guidance and support, develop and strengthen writing.
8. Gather relevant information from multiple print and digital sources, using search terms effectively.
9. Draw evidence from informational texts to support analysis, reflection, and research.

Language

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

Disciplinary Core Ideas

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)

ETS1.B: Developing possible solutions

- A solution needs to be tested, and then modified on the basis of the test results in order to improve it. (MS-ETS1-4)

Crosscutting Concepts

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

Science and Engineering Practices

Defining problems
 Developing and using models
 Planning and carrying out investigations
 Analyzing and interpreting data
 Designing solutions
 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 specific textual evidence to support analysis of science and technical texts.
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.
10. Read and comprehend science/technical texts in grades 6–8 text independently and proficiently.

Speaking and Listening

1. Engage effectively in a range of collaborative discussions with diverse partners, building on others' ideas and expressing their own clearly.
4. Present claims and findings.
5. Include visual displays.

Writing—Literacy in Science and Technical Subjects

4. Produce clear and coherent writing.
8. Gather relevant information from multiple print and digital sources, using search terms effectively.

Language

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

Disciplinary Core Ideas

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)

ETS1.B: Developing possible solutions

- A solution needs to be tested, and then modified on the basis of the test results, in order to improve it. (MS-ETS1-4)
- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2, MS-ETS1-3)
- Sometimes parts of different solutions can be combined to create a solution that is better than any of its predecessors. (MS-ETS1-3)
- Models of all kinds are important for testing solutions. (MS-ETS1-4)

ETS1.C: Optimizing the design solution

- Although one design may not perform the best across all tests, identifying the characteristics of the design that performed the best in each test can provide useful information for the redesign process—that is, some of those characteristics may be incorporated into the new design. (MS-ETS1-3)
- The iterative process of testing the most promising solutions and modifying what is proposed on the basis of the test results leads to greater refinement and ultimately to an optimal solution. (MS-ETS1-4)

Crosscutting Concepts

Patterns
Cause and effect
Systems and system models
Energy and matter
Structure and function

Science and Engineering Practices

Asking questions and defining problems
 Developing and using models
 Planning and carrying out investigations
 Constructing explanations and designing solutions
 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 specific textual evidence to support analysis of science and technical texts.
2. Determine the central ideas or conclusions of a text; provide an accurate summary of the text distinct from prior knowledge or opinions.
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 the information gained from experiments, video, or multimedia sources with that gained from reading a text on the same topic.

Speaking and Listening

1. Engage effectively in a range of collaborative discussions with diverse partners, building on others’ ideas and expressing their own clearly.
3. Delineate and evaluate a speaker’s argument.

Writing—Literacy in Science and Technical Subjects

1. Write arguments.
2. Write informative/explanatory texts.
7. Conduct short research projects to answer a question.
8. Gather relevant information from multiple print and digital sources, using search terms effectively.

Language

5. Demonstrate understanding of word relationships and nuances in word meaning.

Disciplinary Core Ideas

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)

ETS1.B: Developing possible solutions

- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2, MS-ETS1-3)
- Models of all kinds are important for testing solutions. (MS-ETS1-4)

ETS2.A: Interdependence of science, engineering, and technology

- Engineering advances have led to important discoveries in virtually every field of science, and scientific discoveries have led to the development of entire industries and engineered systems.

Crosscutting Concepts

Cause and effect
Systems and system models
Stability and change

RECOMMENDED 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

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