The NSTA Quick-Reference Guide to

# THE THREE DIMENSIONS

# The NSTA Quick-Reference Guide to THE THREE DIMENSIONS

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# Introduction

Since its release in 2014, the *NSTA Quick-Reference Guide* has become an essential tool for many educators across the country. Whether they were in states that had officially adopted the *Next Generation Science Standards* (*NGSS*), states that had developed their own standards based on *A Framework for K–12 Science Education* (the *Framework*), or states where teachers just wanted to engage in three-dimensional teaching in their classroom, educators consult the "purple book" to aid them in their work, as it frequently is a more useful reference than the standards themselves.

One of the reasons that the *Quick-Reference Guide* is so useful is that helps educators explore the complex structure of three-dimensional standards. The standards feature performance expectations (PEs) that describe what students are able to do at the end of instruction, but each PE integrates particular elements of the practices, core ideas, and crosscutting concepts together. These elements are the bulleted statements that appear in the foundation box below the list of PEs.

It is essential to understand that the PEs are **not** meant to dictate what takes place during instruction. While summative assessments are expected to focus on a particular combination of the three dimensions as described in the PE, curriculum developers and classroom teachers have the freedom to mix and match the three dimensions in a wide variety of ways. In fact, to learn any particular disciplinary core idea or crosscutting concept, students will need to engage in multiple practices in a well-thought-out sequence of learning experiences. Thus, educators can integrate the three dimensions in a way that will be most effective and efficient for their students. Planning those experiences requires frequently looking up the elements of all three dimensions, which is why a tool like the *Quick-Reference Guide* is so useful.

The original version of the *Quick-Reference Guide* was designed specifically as a tool to support educators that had adopted the *NGSS*. But since the release of the *Quick-Reference Guide*, many states have developed their own standards based on the *Framework*. Whether adopting the *NGSS* or developing their own standards, nearly every state now has standards that use the three dimensions. This new version of the *Quick-Reference Guide* has been carefully revised to meet the needs of all educators who are engaged in three-dimensional teaching and learning.

This new version of the *Quick-Reference Guide* still contains the most useful features of the original, including

- Descriptions of the science and engineering practices and the crosscutting concepts from the *Framework*
- K–12 progressions of the elements of all three dimensions, as well as the connections to the nature of science and the connections to engineering
- Chapters devoted to elements of the three dimensions in each grade span: K–2, 3–5, 6–8, and 9–12

- Tools to help make sense of the standards such as an overview of the three dimensions, a guide to inside the standards box, and a Venn diagram of practices in science, mathematics, and English language arts

In addition, the new *Quick-Reference Guide* contains several new features that should make it even more helpful:

- A unique code for every element (based on the codes in the *NSTA Atlas of the Three Dimensions*) that makes it much easier to reference a particular element.
- Information about the performance expectations (PEs) contained in their own chapter so that they are available to educators from states that have adopted the *NGSS* or that have standards with many of the same PEs as the *NGSS*.
- A list of performance expectations that includes the text of the clarification statements and assessment boundaries.
- Tables that make clear which elements of the three dimensions were integrated together for every performance expectation and how science standards are connected to standards in mathematics and English language arts.
- Chapters that focus on elements of the three dimensions in a particular grade span with lists of the disciplinary core ideas in that grade span that are easy to read.
- New tools for working with standards such as questions for unpacking standards, a rubric for evaluating three-dimensional lessons and units, information about using phenomena in three-dimensional lessons and units, and a diagram describing how modeling, explaining, and arguing connect phenomena and science ideas.

Furthermore, the design and colors of the tables have been updated to give the *Quick-Reference Guide* a fresher look. Whether you used earlier versions of the "purple book," or this is your first time using the *Quick-Reference Guide*, this new version will likely become an indispensable tool in your work supporting three-dimensional teaching and learning.

# Acknowledgments

As I stated in the Acknowledgments of the original versions of the *Quick-Reference Guide*, the thousands of educators involved in the production and review of *A Framework for K–12 Science Education* (the *Framework*), the *Next Generation Science Standards* (*NGSS*), and other science standards based on the *Framework* deserve a huge thanks. Almost every word in this publication is drawn directly from those documents (but any errors that appear here are mine). In addition, I want to thank those educators involved in developing earlier standards documents, including the *Atlas of Science Literacy*, *National Science Education Standards*, *Benchmarks for Science Literacy*, and *Science for All Americans*.

I also need to extend a word of thanks to a few individuals for their help in developing the original version of the *Quick-Reference Guide* and this new version. When Claire Reinburg was director of NSTA Press, she saw the potential in turning a set of charts I had developed into a book. This led to the publication of the original *Quick-Reference Guide*, which became one of NSTA's bestselling books, so I thank her for her vision and for understanding the needs of educators. This new version of the *Quick-Reference Guide* came about during discussions with Tricia Shelton, the chief learning officer at NSTA and an educator whose leadership around the implementation of three-dimensional teaching and learning has been highly influential in my own work. So, I thank Tricia as well. I also thank Emily Brady, Catherine Lorrain, Will Thomas, Katherine Hall, and Cathy Iammartino for their work producing the book.

This version of the *Quick-Reference Guide* benefits in many ways from work I did developing the *NSTA Atlas of the Three Dimensions*. Therefore, the many people I thanked in the Acknowledgments of the *Atlas* deserve thanks for making this book possible as well.

I also want to thank several "power users" of the original *Quick-Reference Guides*. Over the years, the NSTA Curators, members of the Peer Review Panels at Achieve and NextGen Science, and EdReports Reviewers have made it clear to me how useful a resource the "purple book" is and ways that it could be better. The same can be said for many people who have attended NSTA workshops in the last several years where the *Quick-Reference Guide* has been an essential tool for their work exploring the standards. In addition, special thanks to David Grossman, Holly Hereau, Jacqueline Lovejoy, Emily Mathews, Joyce Tugel, and Kate Soriano for their review and feedback on the manuscript for this new version.

Finally, I thank the many educators working to make the vision of science literacy described in the *Framework*, *NGSS*, and other similar standards a reality for their students. Without your efforts, the contents of this book are nothing more than words on the page. My hope is that this book makes your work a little bit easier.

# About the Editor

**Ted Willard** is a senior subject matter expert in science for Discovery Education where he develops three-dimensional, phenomenon-based science curricula. Before joining Discovery Education, Ted spent eight years as the in-house standards expert for the National Science Teaching Association (NSTA). In this role, he supported implementation of the *Next Generation Science Standards* (*NGSS*), other standards based on *A Framework for K–12 Science Education*, and three-dimensional, phenomenon-based learning. He is the author of *The NSTA Atlas of the Three Dimensions* (NSTA Press, 2020) and editor of *The NSTA Quick-Reference Guide to the* NGSS (NSTA Press, 2014) and *The NSTA Quick-Reference Guide to the Three Dimensions* (NSTA Press, 2022).

Before joining NSTA, Ted spent 12 years at Project 2061 for the American Association for the Advancement of Science (AAAS), where he was responsible for the development of the *Atlas of Science Literacy, Volume 2* (AAAS, 2007). He was also involved in many of Project 2061's efforts in standards-based education reform, including teacher professional learning, curriculum resources development, assessment development, and science education research. Earlier in his career, Ted was a high school physics teacher. He has a degree in Earth, atmospheric, and planetary science from the Massachusetts Institute of Technology.

# CHAPTER 1

# Descriptions of the Science and Engineering Practices From the *Framework**

* Excerpted with permission from: National Research Council (NRC). 2012. *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: National Academies Press.

# Science and Engineering Practice 1: Asking Questions and Defining Problems

Questions are the engine that drive science and engineering.

Science asks

- What exists and what happens?
- Why does it happen?
- How does one know?

Engineering asks

- What can be done to address a particular human need or want?
- How can the need be better specified?
- What tools and technologies are available, or could be developed, for addressing this need?

Both science and engineering ask

- How does one communicate about phenomena, evidence, explanations, and design solutions?

Asking questions is essential to developing scientific habits of mind. Even for individuals who do not become scientists or engineers, the ability to ask well-defined questions is an important component of science literacy, helping to make them critical consumers of scientific knowledge.

Scientific questions arise in a variety of ways. They can be driven by curiosity about the world (e.g., Why is the sky blue?). They can be inspired by a model's or theory's predictions or by attempts to extend or refine a model or theory (e.g., How does the particle model of matter explain the incompressibility of liquids?). Or they can result from the need to provide better solutions to a problem. For example, the question of why it is impossible to siphon water above a height of 32 feet led Evangelista Torricelli (17th-century inventor of the barometer) to his discoveries about the atmosphere and the identification of a vacuum.

Questions are also important in engineering. Engineers must be able to ask probing questions in order to define an engineering problem. For example, they may ask: What is the need or desire that underlies the problem? What are the criteria (specifications) for a successful solution? What are the constraints? Other questions arise when generating possible solutions: Will this solution meet the design criteria? Can two or more ideas be combined to produce a better solution? What are the possible trade-offs? And more questions arise when testing solutions: Which ideas should be tested? What evidence is needed to show which idea is optimal under the given constraints?

The experience of learning science and engineering should therefore develop students' ability to ask—and indeed, encourage them to ask—well-formulated questions that can be investigated empirically. Students also need to recognize the distinction between questions that can be answered empirically and those that are answerable only in other domains of knowledge or human experience.

## GOALS

By grade 12, students should be able to

- Ask questions about the natural and human-built worlds—for example: Why are there seasons? What do bees do? Why did that structure collapse? How is electric power generated?
- Distinguish a scientific question (e.g., Why do helium balloons rise?) from a nonscientific question (Which of these colored balloons is the prettiest?).
- Formulate and refine questions that can be answered empirically in a science classroom and use them to design an inquiry or construct a pragmatic solution.
- Ask probing questions that seek to identify the premises of an argument, request further elaboration, refine a research question or engineering problem, or challenge the interpretation of a data set—for example: How do you know? What evidence supports that argument?
- Note features, patterns, or contradictions in observations and ask questions about them.
- For engineering, ask questions about the need or desire to be met in order to define constraints and specifications for a solution.

## PROGRESSION

Students at any grade level should be able to ask questions of each other about the texts they read, the features of the phenomena they observe, and the conclusions they draw from their models or scientific investigations. For engineering, they should ask questions to define the problem to be solved and to elicit ideas that lead to the constraints and specifications for its solution. As they progress across the grades, their questions should become more relevant, focused, and sophisticated. Facilitating such evolution will require a classroom culture that respects and values good questions, that offers students opportunities to refine their questions and questioning strategies, and that incorporates the teaching of effective questioning strategies across all grade levels. As a result, students will become increasingly proficient at posing questions that request relevant empirical evidence; that seek to refine a model, an explanation, or an engineering problem; or that challenge the premise of an argument or the suitability of a design.

# CHAPTER 2

# Descriptions of the Crosscutting Concepts From the *Framework**

* Excerpted with permission from: National Research Council (NRC). 2012. *A framework for K–12 science education: Practices, crosscutting concepts, and core ideas.* Washington, DC: National Academies Press.

# Crosscutting Concept 1: Patterns

Patterns exist everywhere—in regularly occurring shapes or structures and in repeating events and relationships. For example, patterns are discernible in the symmetry of flowers and snowflakes, the cycling of the seasons, and the repeated base pairs of DNA. Noticing patterns is often a first step to organizing and asking scientific questions about why and how the patterns occur.

One major use of pattern recognition is in classification, which depends on careful observation of similarities and differences; objects can be classified into groups on the basis of similarities of visible or microscopic features or on the basis of similarities of function. Such classification is useful in codifying relationships and organizing a multitude of objects or processes into a limited number of groups. Patterns of similarity and difference and the resulting classifications may change, depending on the scale at which a phenomenon is being observed. For example, isotopes of a given element are different—they contain different numbers of neutrons—but from the perspective of chemistry they can be classified as equivalent because they have identical patterns of chemical interaction. Once patterns and variations have been noted, they lead to questions; scientists seek explanations for observed patterns and for the similarity and diversity within them. Engineers often look for and analyze patterns, too. For example, they may diagnose patterns of failure of a designed system under test in order to improve the design, or they may analyze patterns of daily and seasonal use of power to design a system that can meet the fluctuating needs.

The ways in which data are represented can facilitate pattern recognition and lead to the development of a mathematical representation, which can then be used as a tool in seeking an underlying explanation for what causes the pattern to occur. For example, biologists studying changes in population abundance of several different species in an ecosystem can notice the correlations between increases and decreases for different species by plotting all of them on the same graph and can eventually find a mathematical expression of the interdependences and food-web relationships that cause these patterns.

## PROGRESSION

Human beings are good at recognizing patterns; indeed, young children begin to recognize patterns in their own lives well before coming to school. They observe, for example, that the Sun and the Moon follow different patterns of appearance in the sky. Once they are students, it is important for them to develop ways to recognize, classify, and record patterns in the phenomena they observe. For example, elementary students can describe and predict the patterns in the seasons of the year; they can observe and record patterns in the similarities and differences between parents and their offspring. Similarly, they can investigate the characteristics that allow classification of animal types (e.g., mammals, fish, insects), of plants (e.g., trees, shrubs, grasses), or of materials (e.g., wood, rock, metal, plastic).

These classifications will become more detailed and closer to scientific classifications in the upper elementary grades, when students should also begin to analyze patterns in rates of change—for example, the growth rates of plants under different conditions. By middle school, students can begin to relate patterns to the nature of microscopic and atomic-level structure—for example, they may note that chemical molecules contain particular ratios of different atoms. By high school, students should recognize that different patterns may be observed at each of the scales at which a system is studied. Thus classifications used at one scale may fail or need revision when information from smaller or larger scales is introduced (e.g., classifications based on DNA comparisons vs. those based on visible characteristics).

# CHAPTER 3

## Tools for Working With Standards

# Inside the Standards Box

## What Is Assessed

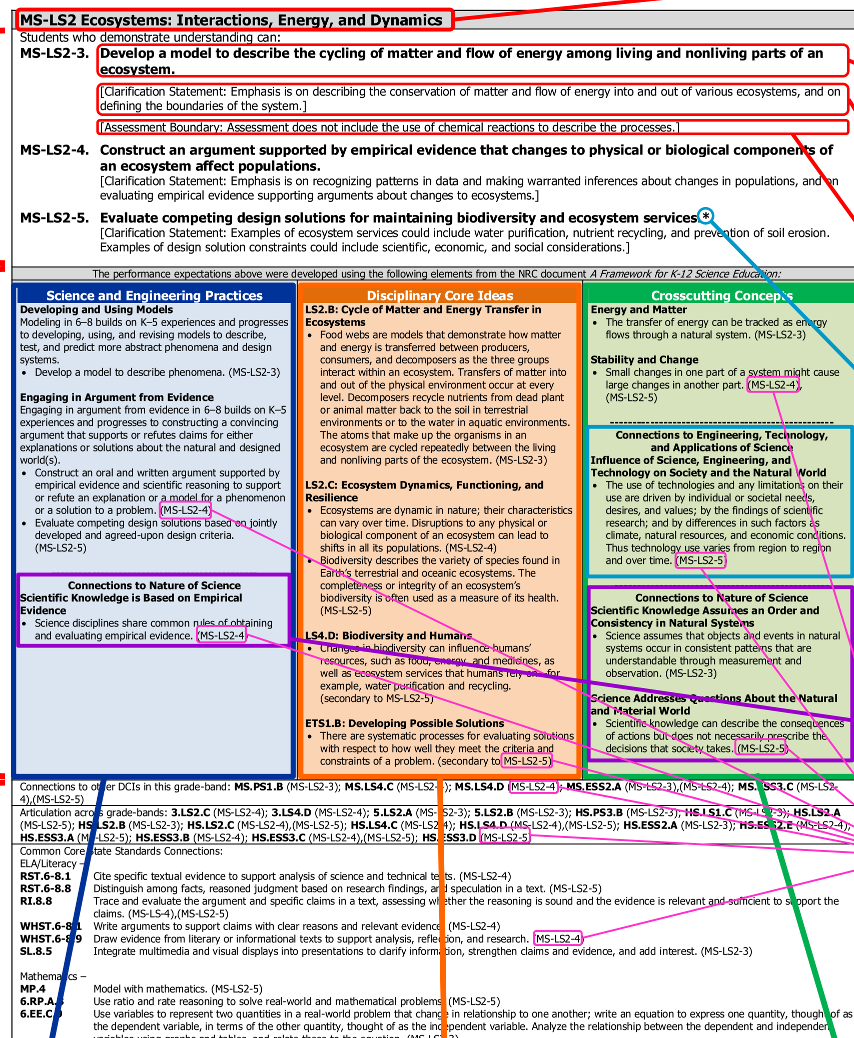
A collection of several performance expectations describing what students should be able to do at the end of instruction

## Foundation Box

The practices, disciplinary core ideas, and crosscutting concepts from *A Framework for K–12 Science Education* that were used to form the performance expectations

## Connection Box

Places elsewhere within these standards (or in mathematics or ELA standards) that are connected to the performance expectations on this page



**MS-LS2 Ecosystems: Interactions, Energy, and Dynamics**

Students who demonstrate understanding can:

**MS-LS2-3.** **Develop a model to describe the cycling of matter and flow of energy among living and nonliving parts of an ecosystem.**
[Clarification Statement: Emphasis is on describing the conservation of matter and flow of energy into and out of various ecosystems, and on defining the boundaries of the system.]
[Assessment Boundary: Assessment does not include the use of chemical reactions to describe the processes.]

**MS-LS2-4.** **Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.**
[Clarification Statement: Emphasis is on recognizing patterns in data and making warranted inferences about changes in populations, and on evaluating empirical evidence supporting arguments about changes to ecosystems.]

**MS-LS2-5.** **Evaluate competing design solutions for maintaining biodiversity and ecosystem services.***
[Clarification Statement: Examples of ecosystem services could include water purification, nutrient recycling, and prevention of soil erosion. Examples of design solution constraints could include scientific, economic, and social considerations.]

The performance expectations above were developed using the following elements from the NRC document *A Framework for K-12 Science Education:*

**Science and Engineering Practices**

**Developing and Using Models**
Modeling in 6–8 builds on K–5 experiences and progresses to developing, using, and revising models to describe, test, and predict more abstract phenomena and design systems.
- Develop a model to describe phenomena. (MS-LS2-3)

**Engaging in Argument from Evidence**
Engaging in argument from evidence in 6–8 builds on K–5 experiences and progresses to constructing a convincing argument that supports or refutes claims for either explanations or solutions about the natural and designed world(s).
- Construct 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. (MS-LS2-4)
- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-LS2-5)

**Connections to Nature of Science**
**Scientific Knowledge is Based on Empirical Evidence**
- Science disciplines share common rules of obtaining and evaluating empirical evidence. (MS-LS2-4)

**Disciplinary Core Ideas**

**LS2.B: Cycle of Matter and Energy Transfer in Ecosystems**
- Food webs are models that demonstrate how matter and energy is transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level. Decomposers recycle nutrients from dead plant or animal matter back to the soil in terrestrial environments or to the water in aquatic environments. The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and nonliving parts of the ecosystem. (MS-LS2-3)

**LS2.C: Ecosystem Dynamics, Functioning, and Resilience**
- Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations. (MS-LS2-4)
- Biodiversity describes the variety of species found in Earth's terrestrial and oceanic ecosystems. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health. (MS-LS2-5)

**LS4.D: Biodiversity and Humans**
- Changes in biodiversity can influence humans' resources, such as food, energy, and medicines, as well as ecosystem services that humans rely on—for example, water purification and recycling. (secondary to MS-LS2-5)

**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. (secondary to MS-LS2-5)

**Crosscutting Concepts**

**Energy and Matter**
- The transfer of energy can be tracked as energy flows through a natural system. (MS-LS2-3)

**Stability and Change**
- Small changes in one part of a system might cause large changes in another part. (MS-LS2-4), (MS-LS2-5)

**Connections to Engineering, Technology, and Applications of Science**
**Influence of Science, Engineering, and Technology on Society and the Natural World**
- The use of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. Thus technology use varies from region to region and over time. (MS-LS2-5)

**Connections to Nature 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. (MS-LS2-3)

**Science Addresses Questions About the Natural and Material World**
- Scientific knowledge can describe the consequences of actions but does not necessarily prescribe the decisions that society takes. (MS-LS2-5)

Connections to other DCIs in this grade-band: **MS.PS1.B** (MS-LS2-3); **MS.LS4.C** (MS-LS2-4); **MS.LS4.D** (MS-LS2-4); **MS.ESS2.A** (MS-LS2-3),(MS-LS2-4); **MS.ESS3.C** (MS-LS2-4),(MS-LS2-5)

Articulation across grade-bands: **3.LS2.C** (MS-LS2-4); **3.LS4.D** (MS-LS2-4); **5.LS2.A** (MS-LS2-3); **5.LS2.B** (MS-LS2-3); **HS.PS3.B** (MS-LS2-3); **HS.LS1.C** (MS-LS2-3); **HS.LS2.A** (MS-LS2-5); **HS.LS2.B** (MS-LS2-3); **HS.LS2.C** (MS-LS2-4),(MS-LS2-5); **HS.LS4.C** (MS-LS2-4); **HS.LS4.D** (MS-LS2-4),(MS-LS2-5); **HS.ESS2.A** (MS-LS2-3); **HS.ESS2.E** (MS-LS2-4); **HS.ESS3.A** (MS-LS2-5); **HS.ESS3.B** (MS-LS2-4); **HS.ESS3.C** (MS-LS2-4),(MS-LS2-5); **HS.ESS3.D** (MS-LS2-5)

Common Core State Standards Connections:
ELA/Literacy –

| | |
|---|---|
| **RST.6-8.1** | Cite specific textual evidence to support analysis of science and technical texts. (MS-LS2-4) |
| **RST.6-8.8** | Distinguish among facts, reasoned judgment based on research findings, and speculation in a text. (MS-LS2-5) |
| **RI.8.8** | Trace and evaluate the argument and specific claims in a text, assessing whether the reasoning is sound and the evidence is relevant and sufficient to support the claims. (MS-LS-4),(MS-LS2-5) |
| **WHST.6-8.1** | Write arguments to support claims with clear reasons and relevant evidence. (MS-LS2-4) |
| **WHST.6-8.9** | Draw evidence from literary or informational texts to support analysis, reflection, and research. (MS-LS2-4) |
| **SL.8.5** | Integrate multimedia and visual displays into presentations to clarify information, strengthen claims and evidence, and add interest. (MS-LS2-3) |

Mathematics –

| | |
|---|---|
| **MP.4** | Model with mathematics. (MS-LS2-5) |
| **6.RP.A.3** | Use ratio and rate reasoning to solve real-world and mathematical problems. (MS-LS2-5) |
| **6.EE.C.9** | Use variables to represent two quantities in a real-world problem that change in relationship to one another; write an equation to express one quantity, thought of as the dependent variable, in terms of the other quantity, thought of as the independent variable. Analyze the relationship between the dependent and independent variables using graphs and tables, and relate these to the equation. (MS-LS2-3) |

## Title

The title for a set of performance expectations. It is not necessarily unique and may be reused at several different grade levels.

## Performance Expectations

A statement that combines practices, core ideas, and crosscutting concepts together to describe how students can show what they have learned.

## Clarification Statement

A statement that supplies examples or additional clarification to the performance expectation.

## Assessment Boundary

A statement that provides guidance about the scope of the performance expectation at a particular grade level.

## Engineering Connection (*)

An asterisk indicates a performance expectation integrates traditional science content with engineering through a practice or core idea.

## Connections to Engineering, Technology, and Applications of Science

These connections are drawn from the disciplinary core ideas for engineering, technology, and applications of science in the *Framework*.

## Connections to the Nature of Science

Connections are listed in either the practices or the crosscutting connections section of the foundation box.

## Codes for Performance Expectations

Every performance expectation has a unique code and items in the foundation box and connection box reference this code. In the connections to common core, italics indicate a potential connection rather than a required prerequisite connection.

## Scientific & Engineering Practices Elements

Activities that scientists and engineers engage in to either make sense of phenomena or to solve a problem

## Disciplinary Core Ideas Elements

Ideas in science and engineering that have broad importance within and across disciplines as well as relevance in people's lives.

## Crosscutting Concepts Elements

Concepts, such as *Patterns* and *Cause and Effect*, which provide important lenses into asking questions about phenomena.

# Guiding Questions for Unpacking the Standards

**Identify Performance Expectations**

**Unpack SEPs** | **Unpack DCIs** | **Unpack CCCs**

| Guiding Questions for Unpacking the Science and Engineering Practices | Guiding Questions for Unpacking the Disciplinary Core Ideas | Guiding Questions for Unpacking the Crosscutting Concepts |
|---|---|---|
| **1. Describe the practice and its features.**<br>• What does it mean to "do" the practice?<br>• What are the essential aspects of this practice?<br>• What possible intersections might there be with other practices?<br>**2. Identify the requisite knowledge and skills.**<br>• What knowledge and skills do students need to use in order to show that they can perform the practice?<br>**3. Specify evidence of high-level performance.**<br>• What evidence would you expect to see for each aspect of this practice?<br>• What are the different levels of performance for each aspect of this practice? | **1. Elaborate major ideas.**<br>• What is the intended meaning of the element of the core idea?<br>• Is there one idea or several separate ideas in the statement?<br>• What terminology is explicitly used in the core idea?<br>**2. Define boundary conditions.**<br>• What peripheral ideas or terms are not essential for understanding the core idea?<br>**3. Describe prior knowledge.**<br>• What other knowledge and skills (both from this topic and from other topics) do students need in order to understand this core idea?<br>**4. Identify student challenges.**<br>• Are there any commonly held ideas that differ in important ways from the scientifically accepted understanding?<br>• What methods can be used to determine students' current understandings?<br>• In what ways can instruction directly address or leverage students' current understandings?<br>**5.Brainstorm phenomena.**<br>• What phenomena would provide examples of this core idea? | **1. Describe essential features.**<br>• What are the key aspects of this crosscutting concept?<br>• What explanatory value does this crosscutting concept have?<br>• How might students' understanding of this crosscutting concept grow over time?<br>**2. Identify substantive intersections with science practices and disciplinary core ideas.**<br>• Which practices provide unforced and meaningful connections with this crosscutting concept?<br>• What are some concepts or contexts in life, Earth, and physical science that would provide good opportunities for students to explore this crosscutting concept? |

*From: The NSTA Atlas of the Three Dimensions* (Willard, 2020) based on procedures described in *Creating and Using Instructionally Supportive Assessments in* NGSS *Classrooms* (Harris, Krajcik, and Pellegrino, forthcoming).

# CHAPTER 4

# K–12 Progressions of the Elements of the Three Dimensions

| **AQDP: Ask Questions and Define Problems** | | | **Science and Engineering Practices** |
|---|---|---|---|
| *Asking questions and defining problems in K–2 builds on prior experiences and progresses to simple descriptive questions that can be tested.* | *Asking questions and defining problems in 3–5 builds on K–2 experiences and progresses to specifying qualitative relationships.* | *Asking questions and defining problems in 6–8 builds on K–5 experiences and progresses to specifying relationships between variables, clarify arguments and models.* | *Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.* |
| **AQDP-P1:** Ask questions based on observations to find more information about the natural and/or designed world(s). | **AQDP-E1:** Ask questions about what would happen if a variable is changed. | **AQDP-M1:** Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.<br>**AQDP-M2:** Ask questions to identify and/or clarify evidence and/or the premise(s) of an argument.<br>**AQDP-M3:** Ask questions to determine relationships between independent and dependent variables and relationships in models.<br>**AQDP-M4:** Ask questions to clarify and/or refine a model, an explanation, or an engineering problem. | **AQDP-H1:** Ask questions that arise from careful observation of phenomena, or unexpected results, to clarify and/or seek additional information.<br>**AQDP-H2:** Ask questions that arise from examining models or a theory, to clarify and/or seek additional information and relationships.<br>**AQDP-H3:** Ask questions to determine relationships, including quantitative relationships, between independent and dependent variables.<br>**AQDP-H4:** Ask questions to clarify and refine a model, an explanation, or an engineering problem. |
| **AQDP-P2:** Ask and/or identify questions that can be answered by an investigation. | **AQDP-E2:** Identify scientific (testable) and non-scientific (non-testable) questions.<br>**AQDP-E3:** Ask questions that can be investigated and predict reasonable outcomes based on patterns such as cause and effect relationships. | **AQDP-M5:** Ask questions that require sufficient and appropriate empirical evidence to answer.<br>**AQDP-M6:** 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. | **AQDP-H5:** Evaluate a question to determine if it is testable and relevant.<br>**AQDP-H6:** Ask questions that can be investigated within the scope of the school laboratory, research facilities, or field (e.g., outdoor environment) with available resources and, when appropriate, frame a hypothesis based on a model or theory. |
| *No elements in his grade band* | *No elements in this grade band* | **AQDP-M7:** Ask questions that challenge the premise(s) of an argument or the interpretation of a data set. | **AQDP-H7:** Ask and/or evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of the design. |
| **AQDP-P3:** Define a simple problem that can be solved through the development of a new or improved object or tool. | **AQDP-E4:** Use prior knowledge to describe problems that can be solved.<br>**AQDP-E5:** Define a simple design problem that can be solved through the development of an object, tool, process, or system and includes several criteria for success and constraints on materials, time, or cost. | **AQDP-M8:** 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. | **AQDP-H8:** Define a design problem that involves the development of a process or system with interacting components and criteria and constraints that may include social, technical and/or environmental considerations.<br>**AQDP-H9:** Analyze complex real-world problems by specifying criteria and constraints for successful solutions. |

| CE: Cause and Effect: Mechanism and Explanation | | | Crosscutting Concepts |
|---|---|---|---|
| **CE-P1:** Simple tests can be designed to gather evidence to support or refute student ideas about causes.<br>**CE-P2:** Events have causes that generate observable patterns. | **CE-E1:** Cause and effect relationships are routinely identified, tested, and used to explain change.<br>**CE-E2:** Events that occur together with regularity might or might not be a cause and effect relationship. | **CE-M1:** Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation.<br>**CE-M2:** Cause and effect relationships may be used to predict phenomena in natural or designed systems.<br>**CE-M3:** Phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability. | **CE-H1:** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.<br>**CE-H2:** Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.<br>**CE-H3:** Systems can be designed to cause a desired effect.<br>**CE-H4:** Changes in systems may have various causes that may not have equal effects. |
| **SPQ: Scale, Proportion, and Quantity** | | | **Crosscutting Concepts** |
| **SPQ-P1:** Relative scales allow objects and events to be compared and described (e.g., bigger and smaller; hotter and colder; faster and slower).<br>**SPQ-P2:** Standard units are used to measure length. | **SPQ-E1:** Natural objects and/or observable phenomena exist from the very small to the immensely large or from very short to very long time periods.<br>**SPQ-E2:** Standard units are used to measure and describe physical quantities such as weight, time, temperature, and volume. | **SPQ-M1:** Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.<br>**SPQ-M2:** The observed function of natural and designed systems may change with scale.<br>**SPQ-M3:** 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.<br>**SPQ-M4:** Scientific relationships can be represented through the use of algebraic expressions and equations.<br>**SPQ-M5:** Phenomena that can be observed at one scale may not be observable at another scale. | **SPQ-H1:** The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.<br>**SPQ-H2:** Some systems can only be studied indirectly as they are too small, too large, too fast, or too slow to observe directly.<br>**SPQ-H3:** Patterns observable at one scale may not be observable or exist at other scales.<br>**SPQ-H4:** Using the concept of orders of magnitude allows one to understand how a model at one scale relates to a model at another scale.<br>**SPQ-H5:** Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). |
| **SYS: Systems and System Models** | | | **Crosscutting Concepts** |
| **SYS-P1:** Objects and organisms can be described in terms of their parts.<br>**SYS-P2:** Systems in the natural and designed world have parts that work together. | **SYS-E1:** A system is a group of related parts that make up a whole and can carry out functions its individual parts cannot.<br>**SYS-E2:** A system can be described in terms of its components and their interactions. | **SYS-M1:** Systems may interact with other systems; they may have sub-systems and be a part of larger complex systems.<br>**SYS-M2:** Models can be used to represent systems and their interactions—such as inputs, processes and outputs—and energy and matter flows within systems.<br>**SYS-M3:** Models are limited in that they only represent certain aspects of the system under study. | **SYS-H1:** Systems can be designed to do specific tasks.<br>**SYS-H2:** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models.<br>**SYS-H3:** Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales.<br>**SYS-H4:** Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. |

| PS1: Matter and Its Interactions | | | | Disciplinary Core Ideas |
|---|---|---|---|---|
| PS1.A: Structure and Properties of Matter | PS1.A-P1: Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties<br>PS1.A-P2: Different properties are suited to different purposes.<br>PS1.A-P3: A great variety of objects can be built up from a small set of pieces. | PS1.A-E1: Matter of any type can be subdivided into particles that are too small to see, but even then the matter still exists and can be detected by other means. A model showing that gases are made from matter particles that are too small to see and are moving freely around in space can explain many observations, including the inflation and shape of a balloon and the effects of air on larger particles or objects.<br>PS1.A-E2: The amount (weight) of matter is conserved when it changes form, even in transitions in which it seems to vanish.<br>PS1.A-E3: Measurements of a variety of properties can be used to identify materials. (Boundary: At this grade level, mass and weight are not distinguished, and no attempt is made to define the unseen particles or explain the atomic-scale mechanism of evaporation and condensation.) | PS1.A-M1: Substances are made from different types of atoms, which combine with one another in various ways. Atoms form molecules that range in size from two to thousands of atoms.<br>PS1.A-M2: Each pure substance has characteristic physical and chemical properties (for any bulk quantity under given conditions) that can be used to identify it.<br>PS1.A-M3: Gases and liquids are made of molecules or inert atoms that are moving about relative to each other.<br>PS1.A-M4: In a liquid, the molecules are constantly in contact with others; in a gas, they are widely spaced except when they happen to collide. In a solid, atoms are closely spaced and may vibrate in position but do not change relative locations.<br>PS1.A-M5: Solids may be formed from molecules, or they may be extended structures with repeating subunits (e.g., crystals).<br>PS1.A-M6: The changes of state that occur with variations in temperature or pressure can be described and predicted using these models of matter. | PS1.A-H1: Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons.<br>PS1.A-H2: The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.<br>PS1.A-H3: The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.<br>PS1.A-H4: Stable forms of matter are those in which the electric and magnetic field energy is minimized. A stable molecule has less energy, by an amount known as the binding energy, than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. |

| LS1: From Molecules to Organisms: Structures and Processes | | | | Disciplinary Core Ideas |
|---|---|---|---|---|
| LS1.A: Structure and Function | LS1.A-P1: All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water, and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive and grow. | LS1.A-E1: Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. | LS1.A-M1: All living things are made up of cells, which is the smallest unit that can be said to be alive. An organism may consist of one single cell (unicellular) or many different numbers and types of cells (multicellular).<br>LS1.A-M2: Within cells, special structures are responsible for particular functions, and the cell membrane forms the boundary that controls what enters and leaves the cell.<br>LS1.A-M3: In multicellular organisms, the body is a system of multiple interacting subsystems. These subsystems are groups of cells that work together to form tissues and organs that are specialized for particular body functions. | LS1.A-H1: Systems of specialized cells within organisms help them perform the essential functions of life.<br>LS1.A-H2: All cells contain genetic information in the form of DNA molecules. Genes are regions in the DNA that contain the instructions that code for the formation of proteins, which carry out most of the work of cells.<br>LS1.A-H3: Multicellular organisms have a hierarchical structural organization, in which any one system is made up of numerous parts and is itself a component of the next level.<br>LS1.A-H4: Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Feedback mechanisms can encourage (through positive feedback) or discourage (negative feedback) what is going on inside the living system. |
| LS1.B: Growth and Development of Organisms | LS1.B-P1: Adult plants and animals can have young. In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive. | LS1.B-E1: Reproduction is essential to the continued existence of every kind of organism. Plants and animals have unique and diverse life cycles. | LS1.B-M1: Organisms reproduce, either sexually or asexually, and transfer their genetic information to their offspring.<br>LS1.B-M2: Animals engage in characteristic behaviors that increase the odds of reproduction.<br>LS1.B-M3: Plants reproduce in a variety of ways, sometimes depending on animal behavior and specialized features for reproduction.<br>LS1.B-M4: Genetic factors as well as local conditions affect the growth of the adult plant. | LS1.B-H1: In multicellular organisms individual cells grow and then divide via a process called mitosis, thereby allowing the organism to grow. The organism begins as a single cell (fertilized egg) that divides successively to produce many cells, with each parent cell passing identical genetic material (two variants of each chromosome pair) to both daughter cells. Cellular division and differentiation produce and maintain a complex organism, composed of systems of tissues and organs that work together to meet the needs of the whole organism. |

| ESS3: Earth and Human Activity | | | | Disciplinary Core Ideas |
|---|---|---|---|---|
| **ESS3.A: Natural Resources** | **ESS3.A-P1:** Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do. | **ESS3.A-E1:** Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not. | **ESS3.A-M1:** 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. These resources are distributed unevenly around the planet as a result of past geologic processes. | **ESS3.A-H1:** Resource availability has guided the development of human society.<br>**ESS3.A-H2:** All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. |
| **ESS3.B: Natural Hazards** | **ESS3.B-P1:** Some kinds of severe weather are more likely than others in a given region. Weather scientists forecast severe weather so that the communities can prepare for and respond to these events. | **ESS3.B-E1:** A variety of natural hazards result from natural processes. Humans cannot eliminate natural hazards but can take steps to reduce their impacts. | **ESS3.B-M1:** 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. | **ESS3.B-H1:** Natural hazards and other geologic events have shaped the course of human history; they have significantly altered the sizes of human populations and have driven human migrations. |
| **ESS3.C: Human Impacts on Earth Systems** | **ESS3.C-P1:** Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things. | **ESS3.C-E1:** Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments. | **ESS3.C-M1:** Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things.<br>**ESS3.C-M2:** 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.C-H1:** The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.<br>**ESS3.C-H2:** Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. |

| | | | | |
|---|---|---|---|---|
| **ESS3.D: Global Climate Change** | *No elements in this grade band* | *No elements in this grade band* | **ESS3.D-M1:** 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 the level of climate change and reducing human vulnerability to whatever climate changes do occur depend 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. | **ESS3.D-H1:** Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.<br>**ESS3.D-H2:** Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. |
| **ETS1: Engineering Design** | | | | **Disciplinary Core Ideas** |
| **ETS1.A: Defining and Delimiting an Engineering Problem** | **ETS1.A-P1:** A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions.<br>**ETS1.A-P2:** Asking questions, making observations, and gathering information are helpful in thinking about problems.<br>**ETS1.A-P3:** Before beginning to design a solution, it is important to clearly understand the problem. | **ETS1.A-E1:** Possible solutions to a problem are limited by available materials and resources (constraints). The success of a designed solution is determined by considering the desired features of a solution (criteria). Different proposals for solutions can be compared on the basis of how well each one meets the specified criteria for success or how well each takes the constraints into account. | **ETS1.A-M1:** 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 is likely to limit possible solutions. | **ETS1.A-H1:** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them.<br>**ETS1.A-H2:** Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. |

| Connections to Engineering, Technology, and Applications of Science | | | | |
|---|---|---|---|---|
| **INTER: Interdependence of Science, Engineering, and Technology** | **INTER-P1:** People encounter questions about the natural world every day.<br>**INTER-P2:** Science and engineering involve the use of tools to observe and measure things. | **INTER-E1:** Science and technology support each other.<br>**INTER-E2:** Tools and instruments are used to answer scientific questions, while scientific discoveries lead to the development of new technologies.<br>**INTER-E3:** Scientific discoveries about the natural world can often lead to new and improved technologies, which are develpped through the engineering design process<br>**INTER-E4:** Knowledge of relevant scientific concepts and research findings is important in engineering. | **INTER-M1:** 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.<br>**INTER-M2:** Science and technology drive each other forward.<br>**INTER-M3:** Technologies extend the measurement, exploration, modeling, and computational capacity of scientific investigations. | **INTER-H1:** Science and engineering complement each other in the cycle known as research and development (R&D).<br>**INTER-H2:** Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. |
| **INFLU: Influence of Science, Engineering, and Technology on Society and the Natural World** | **INFLU-P1:** Every human-made product is designed by applying some knowledge of the natural world and is built by using natural materials.<br>**INFLU-P2:** Taking natural materials to make things impacts the environment.<br>**INFLU-P3:** People depend on various technologies in their lives; human life would be very different without technology. | **INFLU-E1:** People's needs and wants change over time, as do their demands for new and improved technologies.<br>**INFLU-E2:** Engineers improve existing technologies or develop new ones to increase their benefits, decrease known risks, and meet societal demands.<br>**INFLU-E3:** When new technologies become available, they can bring about changes in the way people live and interact with one another. | **INFLU-M1:** All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment.<br>**INFLU-M2:** The uses of technologies and any limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions.<br>**INFLU-M3:** Technology use varies over time and from region to region. | **INFLU-H1:** Modern civilization depends on major technological systems, such as agriculture, health, water, energy, transportation, manufacturing, construction, and communications.<br>**INFLU-H2:** Engineers continuously modify these systems to increase benefits while decreasing costs and risks.<br>**INFLU-H3:** New technologies can have deep impacts on society and the environment, including some that were not anticipated.<br>**INFLU-H4:** Analysis of costs and benefits is a critical aspect of decisions about technology. |

| Connections to the Nature of Science That Are Associated With the Practices | | | | |
|---|---|---|---|---|
| **VOM: Scientific Investigations Use a Variety of Methods** | **VOM-P1:** Science investigations begin with a question.<br>**VOM-P2:** Science uses different ways to study the world. | **VOM-E1:** Science methods are determined by questions.<br>**VOM-E2:** Science investigations use a variety of methods, tools, and techniques. | **VOM-M1:** Science investigations use a variety of methods and tools to make measurements and observations.<br>**VOM-M2:** Science investigations are guided by a set of values to ensure accuracy of measurements, observations, and objectivity of findings.<br>**VOM-M3:** Science depends on evaluating proposed explanations.<br>**VOM-M4:** Scientific values function as criteria in distinguishing between science and non-science. | **VOM-H1:** Science investigations use diverse methods and do not always use the same set of procedures to obtain data.<br>**VOM-H2:** New technologies advance scientific knowledge.<br>**VOM-H3:** Scientific inquiry is characterized by a common set of values that include: logical thinking, precision, open-mindedness, objectivity, skepticism, replicability of results, and honest and ethical reporting of findings.<br>**VOM-H4:** The discourse practices of science are organized around disciplinary domains that share exemplars for making decisions regarding the values, instruments, methods, models, and evidence to adopt and use.<br>**VOM-H5:** Scientific investigations use a variety of methods, tools, and techniques to revise and produce new knowledge. |
| **BEE: Science Knowledge Is Based on Empirical Evidence** | **BEE-P1:** Scientists look for patterns and order when making observations about the world. | **BEE-E1:** Science findings are based on recognizing patterns.<br>**BEE-E2:** Science uses tools and technologies to make accurate measurements and observations. | **BEE-M1:** Science knowledge is based upon logical and conceptual connections between evidence and explanations.<br>**BEE-M2:** Science disciplines share common rules of obtaining and evaluating empirical evidence. | **BEE-H1:** Science knowledge is based on empirical evidence.<br>**BEE-H2:** Science disciplines share common rules of evidence used to evaluate explanations about natural systems.<br>**BEE-H3:** Science includes the process of coordinating patterns of evidence with current theory.<br>**BEE-H4:** Science arguments are strengthened by multiple lines of evidence supporting a single explanation. |
| **OTR: Scientific Knowledge Is Open to Revision in Light of New Evidence** | **OTR-P1:** Science knowledge can change when new information is found. | **OTR-E1:** Science explanations can change based on new evidence. | **OTR-M1:** Scientific explanations are subject to revision and improvement in light of new evidence.<br>**OTR-M2:** The certainty and durability of science findings varies.<br>**OTR-M3:** Science findings are frequently revised and/or reinterpreted based on new evidence. | **OTR-H1:** Scientific explanations can be probabilistic.<br>**OTR-H2:** Most scientific knowledge is quite durable but is, in principle, subject to change based on new evidence and/or reinterpretation of existing evidence.<br>**OTR-H3:** Scientific argumentation is a mode of logical discourse used to clarify the strength of relationships between ideas and evidence that may result in revision of an explanation. |

# CHAPTER 5

# Elements of the Three Dimensions for Grades K–2

## Science and Engineering Practices for Grades K–2

### AQDP: Ask Questions and Define Problems

*Asking questions and defining problems in K–2 builds on prior experiences and progresses to simple descriptive questions that can be tested.*

**AQDP-P1:** Ask questions based on observations to find more information about the natural and/or designed world(s).

**AQDP-P2:** Ask and/or identify questions that can be answered by an investigation.

**AQDP-P3:** Define a simple problem that can be solved through the development of a new or improved object or tool.

### MOD: Developing and Using Models

*Modeling in K–2 builds on prior experiences and progresses to include using and developing models (i.e., diagram, drawing, physical replica, diorama, dramatization, or storyboard) that represent concrete events or design solutions.*

**MOD-P1:** Distinguish between a model and the actual object, process, and/or events the model represents.

**MOD-P2:** Compare models to identify common features and differences.

**MOD-P3:** Develop and/or use a model to represent amounts, relationships, relative scales (bigger, smaller), and/or patterns in the natural and designed world(s).

**MOD-P4:** Develop a simple model based on evidence to represent a proposed object or tool.

### INV: Planning and Carrying Out Investigations

*Planning and carrying out investigations to answer questions or test solutions to problems in K–2 builds on prior experiences and progresses to simple investigations, based on fair tests, which provide data to support explanations or design solutions.*

**INV-P1:** With guidance, plan and conduct an investigation in collaboration with peers.

**INV-P2:** Plan and conduct an investigation collaboratively to produce data to serve as the basis for evidence to answer a question.

INV-P3: Evaluate different ways of observing and/or measuring a phenomenon to determine which way can answer a question.

**INV-P4:** Make observations (firsthand or from media) to collect data that can be used to make comparisons.

**INV-P5:** Make observations (firsthand or from media) and/or measurements of a proposed object or tool or solution to determine if it solves a problem or meets a goal.

**INV-P6:** Make predictions based on prior experiences.

### DATA: Analyzing and Interpreting Data

*Analyzing data in K–2 builds on prior experiences and progresses to collecting, recording, and sharing observations.*

**DATA-P1:** Record information (observations, thoughts, and ideas).

**DATA-P2:** Use and share pictures, drawings, and/or writings of observations.

**DATA-P3:** Use observations (firsthand or from media) to describe patterns and/or relationships in the natural and designed world(s) in order to answer scientific questions and solve problems.

**DATA-P4:** Compare predictions (based on prior experiences) to what occurred (observable events).

**DATA-P5:** Analyze data from tests of an object or tool to determine if it works as intended.

### MATH: Using Mathematics and Computational Thinking

*Mathematical and computational thinking in K–2 builds on prior experience and progresses to recognizing that mathematics can be used to describe the natural and designed world(s).*

**MATH-P1:** Decide when to use qualitative vs. quantitative data.

**MATH-P2:** Use counting and numbers to identify and describe patterns in the natural and designed world(s).

**MATH-P3:** Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs.

**MATH-P4:** Use quantitative data to compare two alternative solutions to a problem.

## CEDS: Constructing Explanations and Designing Solutions

*Constructing explanations and designing solutions in K–2 builds on prior experiences and progresses to the use of evidence and ideas in constructing evidence-based accounts of natural phenomena and designing solutions.*

**CEDS-P1:** Use information from observations (firsthand and from media) to construct an evidence-based account for natural phenomena.

**CEDS-P2:** Use tools and/or materials to design and/or build a device that solves a specific problem or a solution to a specific problem.

**CEDS-P3:** Generate and/or compare multiple solutions to a problem.

## ARG: Engaging in Argument From Evidence

*Engaging in argument from evidence in K–2 builds on prior experiences and progresses to comparing ideas and representations about the natural and designed world(s).*

**ARG-P1:** Identify arguments that are supported by evidence.

**ARG-P2:** Distinguish between explanations that account for all gathered evidence and those that do not.

**ARG-P3:** Analyze why some evidence is relevant to a scientific question and some is not.

**ARG-P4:** Distinguish between opinions and evidence in one's own explanations.

**ARG-P5:** Listen actively to arguments to indicate agreement or disagreement based on evidence, and/or to retell the main points of the argument.

**ARG-P6:** Construct an argument with evidence to support a claim.

**ARG-P7:** Make a claim about the effectiveness of an object, tool, or solution that is supported by relevant evidence.

## INFO: Obtaining, Evaluating, and Communicating Information

*Obtaining, evaluating, and communicating information in K–2 builds on prior experiences and uses observations and texts to communicate new information.*

**INFO-P1:** Read grade-appropriate texts and/or use media to obtain scientific and/or technical information to determine patterns in and/or evidence about the natural and designed world(s).

**INFO-P2:** Describe how specific images (e.g., a diagram showing how a machine works) support a scientific or engineering idea.

**INFO-P3:** Obtain information using various texts, text features (e.g., headings, tables of contents, glossaries, electronic menus, icons), and other media that will be useful in answering a scientific question and/or supporting a scientific claim.

**INFO-P4:** Communicate information or design ideas and/or solutions with others in oral and/or written forms using models, drawings, writing, or numbers that provide detail about scientific ideas, practices, and/or design ideas.

## Crosscutting Concepts for Grades K–2

### PAT: Patterns

**PAT-P1:** Patterns in the natural and human designed world can be observed, used to describe phenomena, and used as evidence.

### CE: Cause and Effect: Mechanism and Explanation

**CE-P1:** Simple tests can be designed to gather evidence to support or refute student ideas about causes.

**CE-P2:** Events have causes that generate observable patterns.

### SPQ: Scale, Proportion, and Quantity

**SPQ-P1:** Relative scales allow objects and events to be compared and described (e.g., bigger and smaller; hotter and colder; faster and slower).

**SPQ-P2:** Standard units are used to measure length.

### SYS: Systems and System Models

**SYS-P1:** Objects and organisms can be described in terms of their parts.

**SYS-P2:** Systems in the natural and designed world have parts that work together.

### EM: Energy and Matter: Flows, Cycles, and Conservation

**EM-P1:** Objects may break into smaller pieces and be put together into larger pieces, or change shapes.

### SF: Structure and Function

**SF-P1:** The shape and stability of structures of natural and designed objects are related to their function(s).

### SC: Stability and Change

**SC-P1:** Some things stay the same while other things change.

**SC-P2:** Things may change slowly or rapidly.

# Disciplinary Core Ideas: Physical Science for Grades K–2

## PS1: Matter and Its Interactions

### PS1.A: Structure and Properties of Matter

**PS1.A-P1:** Different kinds of matter exist and many of them can be either solid or liquid, depending on temperature. Matter can be described and classified by its observable properties

**PS1.A-P2:** Different properties are suited to different purposes.

**PS1.A-P3:** A great variety of objects can be built up from a small set of pieces.

### PS1.B: Chemical Reactions

**PS1.B-P1:** Heating or cooling a substance may cause changes that can be observed. Sometimes these changes are reversible, and sometimes they are not.

### PS1.C: Nuclear Processes

*No elements in this grade band*

## PS2: Motion and Stability: Forces and Interactions

### PS2.A: Forces and Motion

**PS2.A-P1:** Pushes and pulls can have different strengths and directions.

**PS2.A-P2:** Pushing or pulling on an object can change the speed or direction of its motion and can start or stop it.

### PS2.B: Types of Interactions

**PS2.B-P1:** When objects touch or collide, they push on one another and can change motion.

## PS3: Energy

### PS3.A: Definitions of Energy

*No elements in this grade band*

### PS3.B: Conservation of Energy and Energy Transfer

**PS3.B-P1:** Sunlight warms Earth's surface.

### PS3.C: Relationship Between Energy and Forces

**PS3.C-P1:** A bigger push or pull makes things speed up or slow down more quickly.

### PS3.D: Energy in Chemical Processes and Everyday Life

*No elements in this grade band*

## PS4: Waves and Their Applications in Technologies for Information Transfer

### PS4.A: Wave Properties

**PS4.A-P1:** Sound can make matter vibrate, and vibrating matter can make sound.

### PS4.B: Electromagnetic Radiation

**PS4.B-P1:** Objects can be seen only when light is available to illuminate them. Some objects give off their own light.

**PS4.B-P2:** Some materials allow light to pass through them, others allow only some light through, and still others block all the light and create a dark shadow on any surface beyond them, where the light cannot reach. Mirrors can be used to redirect a light beam. (Boundary: The idea that light travels from place to place is developed through experiences with light sources, mirrors, and shadows, but no attempt is made to discuss the speed of light.)

### PS4.C: Information Technologies and Instrumentation

**PS4.C-P1:** People use a variety of devices to communicate (send and receive information) over long distances.

## Disciplinary Core Ideas: Life Science for Grades K–2

### LS1: From Molecules to Organisms: Structures and Processes

**LS1.A: Structure and Function**

LS1.A-P1: All organisms have external parts. Different animals use their body parts in different ways to see, hear, grasp objects, protect themselves, move from place to place, and seek, find, and take in food, water, and air. Plants also have different parts (roots, stems, leaves, flowers, fruits) that help them survive and grow.

**LS1.B: Growth and Development of Organisms**

LS1.B-P1: Adult plants and animals can have young. In many kinds of animals, parents and the offspring themselves engage in behaviors that help the offspring to survive.

**LS1.C: Organization for Matter and Energy Flow in Organisms**

LS1.C-P1: All animals need food in order to live and grow. They obtain their food from plants or from other animals. Plants need water and light to live and grow.

**LS1.D: Information Processing**

LS1.D-P1: Animals have body parts that capture and convey different kinds of information needed for growth and survival. Animals respond to these inputs with behaviors that help them survive. Plants also respond to some external inputs.

### LS2: Ecosystems: Interactions, Energy, and Dynamics

**LS2.A: Interdependent Relationships in Ecosystems**

LS2.A-P1: Plants depend on water and light to grow.

LS2.A-P2: Plants depend on animals for pollination or to move their seeds around.

**LS2.B: Cycles of Matter and Energy Transfer in Ecosystems**

*No elements in this grade band*

**LS2.C: Ecosystem Dynamics, Functioning, and Resilience**

*No elements in this grade band*

**LS2.D: Social Interactions and Group Behavior**

*No elements in this grade band*

### LS3: Heredity: Inheritance and Variation of Traits

**LS3.A: Inheritance of Traits**

LS3.A-P1: Young animals are very much, but not exactly, like, their parents. Plants also are very much, but not exactly, like their parents.

**LS3.B: Variation of Traits**

LS3.B-P1: Individuals of the same kind of plant or animal are recognizable as similar but can also vary in many ways.

### LS4: Biological Evolution: Unity and Diversity

**LS4.A: Evidence of Common Ancestry and Diversity**

LS4.A-E1: Some kinds of plants and animals that once lived on Earth are no longer found anywhere.

**LS4.B: Natural Selection**

*No elements in this grade band*

**LS4.C: Adaptation**

*No elements in this grade band*

**LS4.D: Biodiversity and Humans**

LS4.D-P1: There are many different kinds of living things in any area, and they exist in different places on land and in water.

# Disciplinary Core Ideas: Earth and Space Science for Grades K–2

## ESS1: Earth's Place in the Universe

**ESS1.A: The Universe and Its Stars**

**ESS1.A-P1:** Patterns of the motion of the Sun, Moon, and stars in the sky can be observed, described, and predicted.

**ESS1.B: Earth and the Solar System**

**ESS1.B-P1:** Seasonal patterns of Sunrise and Sunset can be observed, described, and predicted.

**ESS1.C: The History of Planet Earth**

**ESS1.C-P1:** Some events happen very quickly; others occur very slowly, over a time period much longer than one can observe.

## ESS2: Earth's Systems

**ESS2.A: Earth Materials and Systems**

**ESS2.A-P1:** Wind and water can change the shape of the land.

**ESS2.B: Plate Tectonics and Large-Scale System Interactions**

**ESS2.B-P1:** Maps show where things are located. One can map the shapes and kinds of land and water in any area.

**ESS2.C: The Roles of Water in Earth's Surface Processes**

**ESS2.C-P1:** Water is found in the ocean, rivers, lakes, and ponds. Water exists as solid ice and in liquid form.

**ESS2.D: Weather and Climate**

**ESS2.D-P1:** Weather is the combination of Sunlight, wind, snow or rain, and temperature in a particular region at a particular time. People measure these conditions to describe and record the weather and to notice patterns over time.

**ESS2.E: Biogeology**

**ESS2.E-P1:** Plants and animals can change their environment.

## ESS3: Earth and Human Activity

**ESS3.A: Natural Resources**

**ESS3.A-P1:** Living things need water, air, and resources from the land, and they live in places that have the things they need. Humans use natural resources for everything they do.

**ESS3.B: Natural Hazards**

**ESS3.B-P1:** Some kinds of severe weather are more likely than others in a given region. Weather scientists forecast severe weather so that the communities can prepare for and respond to these events.

**ESS3.C: Human Impacts on Earth Systems**

**ESS3.C-P1:** Things that people do to live comfortably can affect the world around them. But they can make choices that reduce their impacts on the land, water, air, and other living things.

**ESS3.D: Global Climate Change**

*No elements in this grade band*

## Disciplinary Core Ideas: Engineering, Technology, and Applications of Science for Grades K–2

### ETS1: Engineering Design

**ETS1.A: Defining and Delimiting an Engineering Problem**

**ETS1.A-P1:** A situation that people want to change or create can be approached as a problem to be solved through engineering. Such problems may have many acceptable solutions.

**ETS1.A-P2:** Asking questions, making observations, and gathering information are helpful in thinking about problems.

**ETS1.A-P3:** Before beginning to design a solution, it is important to clearly understand the problem.

**ETS1.B: Developing Possible Solutions**

**ETS1.B-P1:** Designs can be conveyed through sketches, drawings, or physical models. These representations are useful in communicating ideas for a problem's solutions to other people.

**ETS1.C: Optimizing the Design Solution**

**ETS1.C-P1:** Because there is always more than one possible solution to a problem, it is useful to compare and test designs.

## Connections to Engineering, Technology, and Applications of Science for Grades K–2

### INFLU: Influence of Science, Engineering, and Technology on Society and the Natural World

**INTER-P1:** People encounter questions about the natural world every day.

**INTER-P2:** Science and engineering involve the use of tools to observe and measure things.

### INTER: Interdependence of Science, Engineering, and Technology

**INFLU-P1:** Every human-made product is designed by applying some knowledge of the natural world and is built by using natural materials.

**INFLU-P2:** Taking natural materials to make things impacts the environment.

**INFLU-P3:** People depend on various technologies in their lives; human life would be very different without technology.

# Connections to the Nature of Science for Grades K–2

## Connections to the Nature of Science That Are Associated With the Practices

**VOM: Scientific Investigations Use a Variety of Methods**

**VOM-P1:** Science investigations begin with a question.
**VOM-P2:** Science uses different ways to study the world.

**BEE: Science Knowledge Is Based on Empirical Evidence**

**BEE-P1:** Scientists look for patterns and order when making observations about the world.

**OTR: Scientific Knowledge Is Open to Revision in Light of New Evidence**

**OTR-P1:** Science knowledge can change when new information is found.

**ENP: Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**

**ENP-P1:** Science uses drawings, sketches, and models as a way to communicate ideas.
**ENP-P2:** Science searches for cause and effect relationships to explain natural events.

## Connections to the Nature of Science That Are Associated With the Crosscutting Concepts

**WOK: Science Is a Way of Knowing**

**WOK-P1:** Science knowledge helps us know about the world.

**AOC: Scientific Knowledge Assumes an Order and Consistency in Natural Systems**

**AOC-P1:** Science assumes natural events happen today as they happened in the past.
**AOC-P2:** Many events are repeated.

**HE: Science Is a Human Endeavor**

**HE-P1:** People have practiced science for a long time.
**HE-P2:** Men and women of diverse backgrounds are scientists and engineers.

**AQAW: Science Addresses Questions About the Natural and Material World**

**AQAW-P1:** Scientists study the natural and material world.

# CHAPTER 9

## Performance Expectations

# List of All Performance Expectations With Clarification Statements and Assessment Boundaries

## Kindergarten

**K-PS2-1:** Plan and conduct an investigation to compare the effects of different strengths or different directions of pushes and pulls on the motion of an object
**Clarification Statement:** Examples of pushes or pulls could include a string attached to an object being pulled, a person pushing an object, a person stopping a rolling ball, and two objects colliding and pushing on each other.
**Assessment Boundary:** Assessment is limited to different relative strengths or different directions, but not both at the same time. Assessment does not include non-contact pushes or pulls such as those produced by magnets.

**K-PS2-2:** Analyze data to determine if a design solution works as intended to change the speed or direction of an object with a push or a pull.
**Clarification Statement:** Examples of problems requiring a solution could include having a marble or other object move a certain distance, follow a particular path, and knock down other objects. Examples of solutions could include tools such as a ramp to increase the speed of the object and a structure that would cause an object such as a marble or ball to turn.
**Assessment Boundary:** Assessment does not include friction as a mechanism for change in speed.

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

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

**K-LS1-1:** Use observations to describe patterns of what plants and animals (including humans) need to survive.
**Clarification Statement:** Examples of patterns could include that animals need to take in food but plants do not; the different kinds of food needed by different types of animals; the requirement of plants to have light; and, that all living things need water.

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

**K-ESS2-2:** Construct an argument supported by evidence for how plants and animals (including humans) can change the environment to meet their needs.
**Clarification Statement:** Examples of plants and animals changing their environment could include a squirrel digs in the ground to hide its food and tree roots can break concrete.

**K-ESS3-1:** Use a model to represent the relationship between the needs of different plants and animals (including humans) and the places they live.
**Clarification Statement:** Examples of relationships could include that deer eat buds and leaves, therefore, they usually live in forested areas; and, grasses need sunlight so they often grow in meadows. Plants, animals, and their surroundings make up a system.

**K-ESS3-2:** Ask questions to obtain information about the purpose of weather forecasting to prepare for, and respond to, severe weather.
**Clarification Statement:** Emphasis is on local forms of severe weather.

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

## Grade 1

**1-PS4-1:** Plan and conduct investigations to provide evidence that vibrating materials can make sound and that sound can make materials vibrate.
**Clarification Statement:** Examples of vibrating materials that make sound could include tuning forks and plucking a stretched string. Examples of how sound can make matter vibrate could include holding a piece of paper near a speaker making sound and holding an object near a vibrating tuning fork.

**1-PS4-2:** Make observations to construct an evidence-based account that objects in darkness can be seen only when illuminated.
**Clarification Statement:** Examples of observations could include those made in a completely dark room, a pinhole box, and a video of a cave explorer with a flashlight. Illumination could be from an external light source or by an object giving off its own light.

# The Connections Box

On the standards page, three connection boxes are located below the foundation boxes. The information in those boxes has been used to develop the list below. The list is designed to support a coherent vision of the standards by showing how the disciplinary core ideas (DCIs) that are related to a particular performance expectation (PEs) connect to other DCIs and how the PEs in science connect to the *Common Core State Standards (CCSS).* The connections are grouped into three sections:

### Connections to other DCIs in this grade level

This column lists the DCIs that connect a given performance expectation to material covered at the same grade level but outside the presented sets of performance expectations. For example, both physical science and life science performance expectations contain core ideas related to photosynthesis and could be taught in relation to one another. Ideas within the same main DCI as the performance expectation (e.g., PS1.C for HS-PS1-1) are not included in the connection box, nor are ideas within the same topic arrangement as a performance expectation (e.g., HS.ESS2.B for HS-ESS1-6).

### Articulation of DCIs across grade levels

This column lists DCIs that either (1) provide a foundation for student understanding of the core ideas in a given performance expectation (usually at prior grade levels) or (2) build on the foundation provided by the core ideas in this performance expectation (usually at subsequent grade levels).

### Connections to the *CCSS*

The final two columns list pre-requisite or connected *CCSS* in English mathematics and language arts/literacy that align to given performance expectations. For example, performance expectations that require student use of exponential notation will align with the corresponding *CCSS* for mathematics. An effort has been made to ensure that the mathematical skills that students need for science were taught in a previous year where possible. Items appearing in italics are not pre-requisite to the successful accomplishment of a given performance expectation but are otherwise connected to it.

—Adapted from "How to Read the *Next Generation Science Standards*" (pp. xxii–xxvi of the *NGSS*)

| PE Code | Conn. to Other DCIs in This Grade Level or Band | Articulations of DCIs Across Grade Levels or Bands | Conn. to CCSS in Mathematics | Conn. to CCSS in English Language Arts/Literacy |
|---|---|---|---|---|
| **Kindergarten** | | | | |
| **K-PS2-1** | | 3.PS2.A, 3.PS2.B, 4.PS3.A | *K.MD.A.1*, K.MD.A.2, *MP.2* | W.K.7 |
| **K-PS2-2** | K.ETS1.A, K.ETS1.B | 2.ETS1.B, 3.PS2.A, 4.ETS1.A | | *RI.K.1*, *SL.K.3* |
| **K-PS3-1** | | 1.PS4.B, 3.ESS2.D | K.MD.A.2 | W.K.7 |
| **K-PS3-2** | K.ETS1.A, K.ETS1.B | 1.PS4.B, 2.ETS1.B, 4.ETS1.A | K.MD.A.2 | *W.K.7* |
| **K-LS1-1** | | 1.LS1.A, 2.LS2.A, 3.LS2.C, 3.LS4.B, 5.LS1.C, 5.LS2.A | *K.MD.A.2* | W.K.7 |
| **K-ESS2-1** | | 2.ESS2.A, 3.ESS2.D, 4.ESS2.A | MP.2, MP.4, K.CC.A, K.MD.A.1, K.MD.B.3 | W.K.7 |
| **K-ESS2-2** | | 4.ESS2.E, 5.ESS2.A | | RI.K.1, W.K.1, *W.K.2* |
| **K-ESS3-1** | | 1.LS1.A, 5.LS2.A, 5.ESS2.A | *MP.2*, *MP.4*, *K.CC* | *SL.K.5* |
| **K-ESS3-2** | K.ETS1.A | 2.ESS1.C, 3.ESS3.B, 4.ESS3.B | *MP.4*, *K.CC* | RI.K.1, SL.K.3 |
| **K-ESS3-3** | K.ETS1.A | 2.ETS1.B, 4.ESS3.A, 5.ESS3.C | | *W.K.2* |
| **Grade 1** | | | | |
| **1-PS4-1** | | | | W.1.7, W.1.8, *SL.1.1* |
| **1-PS4-2** | | 4.PS4.B | | *W.1.2*, W.1.7, W.1.8, *SL.1.1* |
| **1-PS4-3** | | 2.PS1.A | | W.1.7, W.1.8, *SL.1.1* |
| **1-PS4-4** | | K.ETS1.A, 2.ETS1.B, 4.PS4.C, 4.ETS1.A | *MP.5*, *1.MD.A.1*, *1.MD.A.2* | W.1.7 |
| **1-LS1-1** | | K.ETS1.A, 4.LS1.A, 4.LS1.D, 4.ETS1.A | | W.1.7 |
| **1-LS1-2** | | 3.LS2.D | *1.NBT.B.3*, *1.NBT.C.4*, *1.NBT.C.5*, *1.NBT.C.6* | RI.1.1, RI.1.2, RI.1.10 |
| **1-LS3-1** | | 3.LS3.A, 3.LS3.B | *MP.2*, *MP.5*, *1.MD.A.1* | RI.1.1, W.1.7, W.1.8 |
| **1-ESS1-1** | | | | W.1.7, W.1.8 |
| **1-ESS1-2** | | | *MP.2*, *MP.4*, *MP.5*, *1.OA.A.1*, *1.MD.C.4* | W.1.7, W.1.8 |

# Three-Dimensional Elements Integrated Into the Performance Expectations

The chart below identifies the elements of all three dimensions that are integrated into each performance expectation. Codes for elements of the disciplinary core idea that are in *blue italic* are considered to be secondary to the given performance expectation (PE). This simply means that the DCI element in question is affiliated with a different DCI than the PE. For example, the DCI element PS3.C-P1 is a secondary element to the PE K-PS2-1 because the DCI element is part of PS3: Energy but the PE is part of PS2: Motion and Stability: Forces and Interactions. DCI elements that are secondary to a particular PE are just as important as any other DCI elements of the PE.

| Performance Expectation | Science and Engineering Practices | Crosscutting Concepts | Disciplinary Core Ideas | Connection to Engineering | Connection to Nature of Science |
|---|---|---|---|---|---|
| **Kindergarten** | | | | | |
| **K-PS2-1** | INV-P1 | CE-P1 | PS2.A-P1, PS2.A-P2, *PS3.C-P1* | | |
| **K-PS2-2** | DATA-P5 | CE-P1 | PS2.A-P1, PS2.A-P2, *ETS1.A-P1* | | |
| **K-PS3-1** | INV-P4 | CE-P2 | PS3.B-P1 | | VOM-P2 |
| **K-PS3-2** | CEDS-P2 | CE-P2 | PS3.B-P1 | | |
| **K-LS1-1** | DATA-P3 | PAT-P1 | LS1.C-P1 | | BEE-P1 |
| **K-ESS2-1** | DATA-P3 | PAT-P1 | ESS2.D-P1 | | BEE-P1 |
| **K-ESS2-2** | ARG-P6 | SYS-P2 | ESS2.E-P1, *ESS3.C-P1* | | |
| **K-ESS3-1** | MOD-P3 | SYS-P2 | ESS3.A-P1 | | |
| **K-ESS3-2** | AQDP-P1, INFO-P1 | CE-P2 | ESS3.B-P1, *ETS1.A-P2* | INTER-P1, INFLU-P3 | |
| **K-ESS3-3** | INFO-P4 | CE-P2 | ESS3.C-P1, *ETS1.B-P1* | | |
| **Grade 1** | | | | | |
| **1-PS4-1** | INV-P2 | CE-P1 | PS4.A-P1 | | VOM-P1, VOM-P2 |
| **1-PS4-2** | CEDS-P1 | CE-P1 | PS4.B-P1 | | |
| **1-PS4-3** | INV-P3 | CE-P1 | PS4.B-P2 | | |
| **1-PS4-4** | CEDS-P2 | | PS4.C-P1 | INFLU-P3 | |
| **1-LS1-1** | CEDS-P2 | SF-P1 | LS1.A-P1, LS1.D-P1 | INFLU-P1 | |
| **1-LS1-2** | INFO-P3 | PAT-P1 | LS1.B-P1 | | BEE-P1 |
| **1-LS3-1** | CEDS-P1 | PAT-P1 | LS3.A-P1, LS3.B-P1 | | |
| **1-ESS1-1** | DATA-P3 | PAT-P1 | ESS1.A-P1 | | AOC-P1, AOC-P2 |
| **1-ESS1-2** | INV-P4 | PAT-P1 | ESS1.B-P1 | | |
| **Grade 2** | | | | | |
| **2-PS1-1** | INV-P2 | PAT-P1 | PS1.A-P1 | | |
| **2-PS1-2** | DATA-P5 | CE-P1 | PS1.A-P2, | INFLU-P1 | |
| **2-PS1-3** | CEDS-P1 | EM-P1 | PS1.A-P2, PS1.A-P3 | | |
| **2-PS1-4** | ARG-P6 | CE-P2 | PS1.B-P1 | | ENP-P2 |
| **2-LS2-1** | INV-P2 | CE-P2 | LS2.A-P1 | | |
| **2-LS2-2** | MOD=P4 | SF-P1 | LS2.A-P2, *ETS1.B-P1* | | |
| **2-LS4-1** | INV-P4 | | LS4.D-P1 | | BEE-P1 |
| **2-ESS1-1** | CEDS-P1 | SC-P2 | ESS1.C-P1 | | |
| **2-ESS2-1** | CEDS-P3 | SC-P2 | ESS2.A-P1, *ETS1.C-P1* | INFLU-P2 | AQAW-P1 |
| **2-ESS2-2** | MOD-P3 | PAT-P1 | ESS2.B-P1 | | |
| **2-ESS2-3** | INFO-P3 | PAT-P1 | ESS2.C-P1 | | |

# Correspondence of Performance Expectations to Elements of the Disciplinary Core Ideas

This list of disciplinary core idea (DCI) elements indicates which performance expectations (PE) make use of the DCI element in question. If a PE is listed in *blue italic*, it means that the DCI element is considered to be secondary to the PE, which simply means that the DCI element in question is affiliated with a different DCI than the PE. For example, the DCI element PS1.A-H3 is a secondary element to the PE HS-PS2-6 because the DCI element is part of PS1: Matter and Its Interactions but the PE is part of PS2: Motion and Stability: Forces and Interactions. DCI elements that are secondary to a particular PE are just as important as any other DCI elements of the PE.

## Physical Science

### PS1: Matter and Its Interactions

**PS1.A-P1:** 2-PS1-1
**PS1.A-P2:** 2-PS1-3, 2-PS1-2
**PS1.A-P3:** 2-PS1-3
**PS1.A-E1:** 5-PS1-1, 5-PS1-4
**PS1.A-E2:** 5-PS1-2
**PS1.A-E3:** 5-PS1-3
**PS1.A-M1:** MS-PS1-1
**PS1.A-M2:** MS-PS1-2, MS-PS1-3
**PS1.A-M3:** MS-PS1-4
**PS1.A-M4:** MS-PS1-4
**PS1.A-M5:** MS-PS1-1
**PS1.A-M6:** MS-PS1-4
**PS1.A-H1:** HS-PS1-1
**PS1.A-H2:** HS-PS1-1, HS-PS1-2
**PS1.A-H3:** HS-PS1-3, *HS-PS2-6*
**PS1.A-H4:** HS-PS1-4

**PS1.B-P1:** 2-PS1-4
**PS1.B-E1:** 5-PS1-2
**PS1.B-E2:** MS-PS1-2, MS-PS1-3, MS-PS1-5
**PS1.B-M1:** MS-PS1-5
**PS1.B-M2:** MS-PS1-6
**PS1.B-M3:** HS-PS1-4, HS-PS1-5
**PS1.B-H1:** HS-PS1-6
**PS1.B-H2:** HS-PS1-7
**PS1.B-H3:** HS-PS1-8

**PS1.C-H1:** *HS-ESS1-5*
**PS1.C-H2:** *HS-ESS1-6*

### PS2: Motion and Stability: Forces and Interactions

**PS2.A-P1:** 3-PS2-1
**PS2.A-P2:** 3-PS2-2
**PS2.A-E1:** K-PS2-1, K-PS2-2
**PS2.A-E2:** K-PS2-1, K-PS2-2
**PS2.A-M1:** MS-PS2-1
**PS2.A-M2:** MS-PS2-2
**PS2.A-M3:** MS-PS2-2
**PS2.A-H1:** HS-PS2-1
**PS2.A-H2:** HS-PS2-2
**PS2.A-H3:** HS-PS2-2, HS-PS2-3

**PS2.B-P1:** K-PS2-1
**PS2.B-E1:** 3-PS2-1
**PS2.B-E2:** 3-PS2-1, 3-PS2-3, 3-PS2-4
**PS2.B-E3:** 5-PS2-1
**PS2.B-M1:** MS-PS2-3
**PS2.B-M2:** MS-PS2-4
**PS2.B-M3:** MS-PS2-5
**PS2.B-H1:** HS-PS2-4
**PS2.B-H2:** HS-PS2-4, HS-PS2-5
**PS2.B-H3:** HS-PS2-6, HS-PS1-1, HS-PS1-3

### PS3: Energy

**PS3.A-E1:** 4-PS3-1
**PS3.A-E2:** 4-PS3-2, 4-PS3-3
**PS3.A-M1:** MS-PS3-1
**PS3.A-M2:** MS-PS3-2
**PS3.A-M3:** *MS-PS1-4*
**PS3.A-M4:** MS-PS3-3, MS-PS3-4, MS-PS1-4
**PS3.A-H1:** HS-PS3-1, HS-PS3-2
**PS3.A-H2:** HS-PS3-2, HS-PS3-3
**PS3.A-H3:** *HS-PS2-5*
**PS3.A-H4:** HS-PS3-2

**PS3.B-P1:** K-PS3-1, K-PS3-2
**PS3.B-E1:** 4-PS3-2, 4-PS3-3
**PS3.B-E2:** 4-PS3-2
**PS3.B-E3:** 4-PS3-2, 4-PS3-4
**PS3.B-M1:** MS-PS3-3, MS-PS3-5
**PS3.B-M2:** MS-PS3-4
**PS3.B-M3:** MS-PS3-3
**PS3.B-H1:** HS-PS3-1
**PS3.B-H2:** HS-PS3-1, HS-PS3-4
**PS3.B-H3:** HS-PS3-1
**PS3.B-H4:** HS-PS3-1
**PS3.B-H5:** HS-PS3-4

**PS3.C-P1:** *K-PS2-1*
**PS3.C-E1:** 4-PS3-3, 4-PS4-1
**PS3.C-M1:** MS-PS3-2
**PS3.C-H1:** HS-PS3-5

**PS3.D-E1:** 4-PS3-4
**PS3.D-E2:** 5-PS3-1
**PS3.D-M1:** *MS-LS1-6*
**PS3.D-M2:** *MS-LS1-7*
**PS3.D-H1:** *HS-ESS1-1*
**PS3.D-H2:** *HS-LS2-5*
**PS3.D-H3:** *HS-PS4-5*
**PS3.D-H4:** HS-PS3-3, HS-PS3-4

### PS4: Waves and Their Applications in Technologies for Information Transfer

**PS4.A-P1:** 1-PS4-1
**PS4.A-E1:** 4-PS4-1
**PS4.A-E2:** 4-PS4-1
**PS4.A-M1:** MS-PS4-1
**PS4.A-M2:** MS-PS4-2
**PS4.A-H1:** HS-PS4-3
**PS4.A-H2:** HS-PS4-1
**PS4.A-H3:** HS-PS4-2, HS-PS4-5
**PS4.A-H4:** *HS-ESS2-3*

**PS4.B-P1:** 1-PS4-2
**PS4.B-P2:** 1-PS4-3
**PS4.B-E1:** 4-PS4-2
**PS4.B-M1:** MS-PS4-2
**PS4.B-M2:** MS-PS4-2
**PS4.B-M3:** MS-PS4-2
**PS4.B-M4:** MS-PS4-2
**PS4.B-H1:** HS-PS4-3
**PS4.B-H2:** HS-PS4-4
**PS4.B-H3:** HS-PS4-5
**PS4.B-H4:** *HS-ESS1-2*

**PS4.C-P1:** 1-PS4-4
**PS4.C-E1:** 4-PS4-3
**PS4.C-M1:** MS-PS4-3
**PS4.C-H1:** HS-PS4-5