

# 2018 Virginia Science Standards of Learning Curriculum Framework



Board of Education  
Commonwealth of Virginia

Copyright © 2019  
by the  
Virginia Department of Education  
P.O. Box 2120  
Richmond, Virginia 23218-2120  
<http://www.doe.virginia.gov>

All rights reserved. Reproduction of these materials for instructional purposes in public school classrooms in Virginia is permitted.

**Superintendent of Public Instruction**

James F. Lane, Ed.D.

**Assistant Superintendent of Learning**

Gena Keller

**Office of Science, Technology, Engineering, and Mathematics**

Tina Manglicmot, Ed.D., Director  
Anne Petersen, Ph.D., Science Coordinator  
Joshua Bearman, Science Specialist  
Myra Thayer, Science Specialist

**NOTICE**

The Virginia Department of Education does not discriminate on the basis of race, sex, color, national origin, religion, age, political affiliation, veteran status, or against otherwise qualified persons with disabilities in its programs and activities.

The *2018 Virginia Science Standards of Learning Curriculum Framework* can be found on the Virginia Department of Education's website at [http://www.doe.virginia.gov/testing/sol/standards\\_docs/science/index.shtml](http://www.doe.virginia.gov/testing/sol/standards_docs/science/index.shtml).

## *2018 Virginia Science Standards of Learning Curriculum Framework*

### **Introduction**

The *2018 Virginia Science Standards of Learning Curriculum Framework* amplifies the *Science Standards of Learning for Virginia Public Schools* (SOL) and defines the content knowledge, skills, and understandings that provide a foundation in science concepts and practices. The framework provides additional guidance to school divisions and their teachers as they develop an instructional program appropriate for their students. It assists teachers as they plan their lessons by identifying enduring understandings and defining the essential science and engineering practices students need to master. This framework delineates in greater specificity the minimum content requirements that all teachers should teach and all students should learn.

School divisions should use the framework as a resource for developing sound curricular and instructional programs. This framework should not limit the scope of instructional programs. Additional knowledge and skills that can enrich instruction and enhance students' understanding of the content identified in the SOL should be included in quality learning experiences.

The framework serves as a guide for SOL assessment development. Assessment items may not and should not be a verbatim reflection of the information presented in the framework. Students are expected to continue to apply knowledge and skills from the SOL presented in previous grades as they build scientific expertise.

The Board of Education recognizes that school divisions will adopt a K–12 instructional sequence that best serves their students. The design of the SOL assessment program, however, requires that all Virginia school divisions prepare students to demonstrate achievement of the standards for elementary and middle school by the time they complete the grade levels tested. The high school end-of-course SOL tests, for which students may earn verified units of credit, are administered in a locally determined sequence.

Each topic in the framework is developed around the SOL. The format of the framework facilitates teacher planning by identifying the enduring understandings and the scientific and engineering practices that should be the focus of instruction for each standard. The categories of scientific and engineering practices appear across all grade levels and content areas. Those categories are: asking questions and defining problems; planning and carrying out investigations; interpreting, analyzing, and evaluating data; constructing

and critiquing conclusions and explanations; developing and using models; and obtaining, evaluating, and communicating information. These science and engineering practices are embedded in instruction to support the development and application of science content.

## Science and Engineering Practices

Science utilizes observation and experimentation along with existing scientific knowledge, mathematics, and engineering technologies to answer questions about the natural world. Engineering employs existing scientific knowledge, mathematics, and technology to create, design, and develop new devices, objects, or technology to meet the needs of society. By utilizing both scientific and engineering practices in the science classroom, students develop a deeper understanding and competence with techniques at the heart of each discipline.

### *Engineering Design Practices*

Engineering design practices are similar to those used in an inquiry cycle; both use a system of problem solving and testing to come to a conclusion. However, unlike the inquiry cycle in which students ask a question and use the scientific method to answer it, in the engineering and design process, students use existing scientific knowledge to solve a problem. Both include research and experimentation; however, the engineering design process has a goal of solving a societal problem and may have multiple solutions. More information on the engineering and design process can be found at <https://www.eie.org/overview/engineering-design-process>.

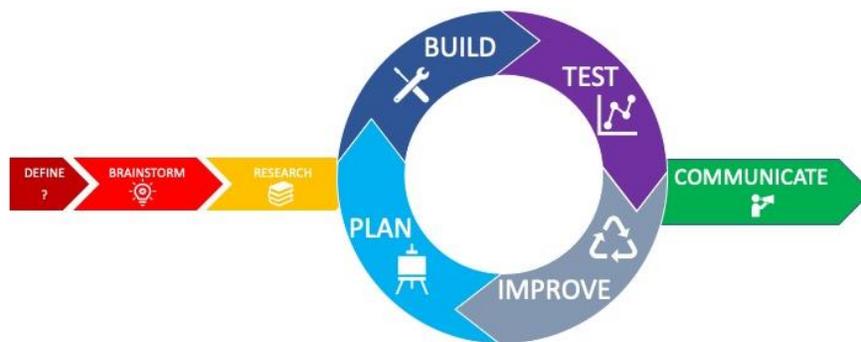


Figure 1: Engineering Design Process image based on the National Aeronautics and Space Administration (NASA) engineering design model.

## The Engineering Design Process:

- Define: Define the problem, ask a question
- Imagine: Brainstorm possible solutions
- Research: Research the problem to determine the feasibility of possible solutions
- Plan: Plan a device/model to address the problem or answer the question
- Build: Build a device/model to address the problem or answer the question
- Test: Test the device/model in a series of trials
  - Does the design meet the criteria and constraints defined in the problem?
    - Yes? Go to Share (#8)
    - No? Go to Improve (#7)
- Improve: Using the results of the test, brainstorm improvements to the device/model; return to #3
- Share: Communicate your results to stakeholders and the public

## Computational Thinking

The term *computational thinking* is used throughout this framework. Computational thinking is a way of solving problems that involves logically organizing and classifying data and using a series of steps (algorithms). Computational thinking is an integral part of Virginia’s computer science standards and is explained as such in the *Computer Science Standards of Learning*:

*Computational thinking is an approach to solving problems that can be implemented with a computer. It involves the use of concepts, such as abstraction, recursion, and iteration, to process and analyze data, and to create real and virtual artifacts. Computational thinking practices such as abstraction, modeling, and decomposition connect with computer science concepts such as algorithms, automation, and data visualization. [Computer Science Teachers Association & Association for Computing Machinery]*

Students engage in computational thinking in the science classroom when using both inquiry and the engineering design process. Computational thinking is used in laboratory experiences as students develop and follow procedures to conduct an investigation.

## ***Structure of the 2018 Virginia Science Standards of Learning Curriculum Framework***

The framework is divided into two columns: Enduring Understandings and Essential Knowledge and Practices. The purpose of each column is explained below.

### *Enduring Understandings*

The Enduring Understandings highlight the key concepts and the big ideas of science that are applicable to the standard. These key concepts and big ideas build as students advance in their scientific and engineering understanding. The bullets provide the context of those big ideas at that grade or content level.

### *Essential Knowledge and Practices*

Each standard is expanded in the Essential Knowledge and Practices column. What each student should know and be able to do as evidence of understanding of the standard is identified here. This is not meant to be an exhaustive list nor is a list that limits what is taught in the classroom. It is meant to be the key knowledge and practices that define the standard. Science and engineering practices are highlighted with a leaf bullet (see footer).

The *2018 Virginia Science Standards of Learning Curriculum Framework* is informed by the Next Generation Science Standards (<https://www.nextgenscience.org/>).



## Grade Six

### *Our world; our responsibility*

In sixth grade, students are transitioning from elementary to middle school. The science standards support that transition as students examine more abstract concepts, providing a foundation in the disciplines of science. They explore the characteristics of their world, from the Earth's placement in the solar system to the interactions of water, energy, air, and ecosystems on the Earth. As students more closely examine the use of resources, they also consider how their actions and choices affect future habitability of Earth. Students continue to develop scientific skills and processes as they pose questions and predict outcomes, plan and conduct investigations, collect and analyze data, construct explanations, and communicate information about the natural world. Mathematics and computational thinking gain importance as students advance in their scientific thinking. Students continue to use the engineering design process to apply their scientific knowledge to solve problems.

### **Scientific and Engineering Practices**

Engaging in the practices of science and engineering helps students understand how scientific knowledge develops; such direct involvement gives them an appreciation of the many ways to investigate, model, and explain the world. These scientific and engineering practices include the use of scientific skills and processes to explore the content of science as outlined in the *Science Standards of Learning*. The engineering design practices are the application of science content to solve a problem or design an object, tool, process, or system. These scientific and engineering practices are critical to science instruction and are to be embedded throughout the year.

#### **6.1 The student will demonstrate an understanding of scientific and engineering practices by**

##### **a) asking questions and defining problems**

- **ask questions to determine relationships between independent and dependent variables**
- **develop hypotheses and identify independent and dependent variables**
- **offer simple solutions to design problems**

##### **b) planning and carrying out investigations**

- **independently and collaboratively plan and conduct observational and experimental investigations; identify variables, constants, and controls where appropriate, including the safe use of chemicals and equipment**
- **evaluate the accuracy of various methods for collecting data**
- **take metric measurements using appropriate tools**
- **use tools and/materials to design and/or build a device to solve a specific problem**

- c) **interpreting, analyzing, and evaluating data**
  - **organize data sets to reveal patterns that suggest relationships**
  - **construct, analyze, and interpret graphical displays of data**
  - **compare and contrast data collected by different groups and discuss similarities and differences in findings**
  - **use data to evaluate and refine design solutions**
- d) **constructing and critiquing conclusions and explanations**
  - **construct explanations that include qualitative or quantitative relationships between variables**
  - **construct scientific explanations based on valid and reliable evidence obtained from sources (including the students' own investigations)**
  - **generate and compare multiple solutions to problems based on how well they meet the criteria and constraints**
- e) **developing and using models**
  - **use scale models to represent and estimate distance**
  - **use, develop, and revise models to predict and explain phenomena**
  - **evaluate limitations of models**
- f) **obtaining, evaluating, and communicating information**
  - **read scientific texts, including those adapted for classroom use, to obtain scientific and/or technical information**
  - **gather, read, and synthesize information from multiple appropriate sources and assess the credibility, accuracy, and possible bias of each publication**
  - **construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning**

## **Grade Six Science Content**

- 6.2 The student will investigate and understand that the solar system is organized and the various bodies in the solar system interact. Key ideas include**
- a) **matter is distributed throughout the solar system;**
  - b) **planets have different sizes and orbit at different distances from the sun;**
  - c) **gravity contributes to orbital motion; and**
  - d) **the understanding of the solar system has developed over time.**

**Central Idea:** The solar system is a set of interrelated and interdependent elements that are seamlessly connected through the flow of matter and energy.

**Vertical Alignment:** Students are introduced to the solar system, to include characteristics and position of planets in fourth grade (4.5). Students will extend the concept of change over time of the universe, the size and spatial relationships of matter (including celestial bodies), and the nature of science and discovery through human and technological exploration in Earth Science (ES.2).

| <b>Enduring Understanding</b>   | <b>Essential Knowledge and Practices</b>  |
|---|---|
| <p>The solar system is a set of interrelated and interdependent elements that are seamlessly connected through the flow of matter and energy. Characteristics of these elements within the solar system are determined by their composition.</p> <ul style="list-style-type: none"> <li>• The solar system consists of the sun, moon, Earth, other planets and their moons, meteors, asteroids, and comets. Each body has its own characteristics and features (6.2 a, b).</li> <li>• The distance between planets and the sizes of the planets vary greatly. The outer gas planets are very large, and the four inner planets are comparatively small and rocky (6.2 b).</li> </ul> <p>Gravitational interactions are attractive and depend on the masses of interacting objects. Gravity is the force that keeps the planets in motion around the sun. Gravity acts everywhere in the universe (6.2 c).</p> <p>Technological advances, breakthroughs in interpretation, and new observations continuously refine our understanding of the Earth and solar system.</p> <ul style="list-style-type: none"> <li>• The invention of the telescope provided powerful and confounding observations that rapidly challenged the Earth-centered model. The development of mathematical physics provided a scientific explanation for the motion of the nearby planets (6.2 d).</li> </ul> | <p>In order to meet this standard, it is expected that students will</p> <ul style="list-style-type: none"> <li>• name the components of the solar system and describe their characteristics (6.2 a, b)</li> <li>• describe the planets and their relative positions from the sun (6.2 b)</li> <li>• identify characteristics of other components of the solar system including dwarf planets, meteors, asteroids, and comets (6.2a, b)</li> <li>• design, construct, and interpret a scale model of the Earth-moon-sun system and the solar system to Jupiter (6.2 b)</li> <li>• explain the role of gravity in the formation of the solar system and in orbital motion (6.2 c)</li> <li>• evaluate changes in the understanding of the solar system over time as changes in technology provided more information (6.2 d)</li> <li>• interpret a timeline of major developments in understanding the organization and workings of the solar system and assess the role of technology and mathematics in that development (6.2 d).</li> </ul> |

| Enduring Understanding  | Essential Knowledge and Practices |
|---|-----------------------------------|
| <ul style="list-style-type: none"> <li>With the development of new technology over the last half-century (e.g., manned and robotic space craft, powerful Earth-based and space telescopes, and computer analyses of huge data sets), our knowledge of the solar system has increased substantially (6.2 d). <i>Students are not responsible for memorizing specific missions or contributions.</i></li> </ul> |                                   |

**6.3 The student will investigate and understand that there is a relationship between the sun, Earth, and the moon. Key ideas include**

- a) Earth has unique properties;
- b) the rotation of Earth in relationship to the sun causes day and night;
- c) the movement of Earth and the moon in relationship to the sun causes phases of the moon;
- d) Earth’s tilt as it revolves around the sun causes the seasons; and
- e) the relationship between Earth and the moon is the primary cause of tides.

**Central Idea:** Earth’s position in the solar system resulted in characteristics that support life.

**Vertical Alignment:** Students learn about the relationships among the Earth, moon, and sun and how these lead to day and night, the seasons, and the phases of the moon in fourth grade (4.6). Students will extend the cause-and-effect relationship within the sun-Earth-moon system and the stability and outcomes created by the Earth-moon relationship in Earth Science (ES.2).

| Enduring Understanding  | Essential Knowledge and Practices   |
|---|---|
| <p>The proximity of the Earth to the sun and moon in our solar system influences Earth systems and enables life to exist on Earth.</p> <ul style="list-style-type: none"> <li>Earth is a rocky planet, extensively covered with large oceans of liquid water, with ice caps in its polar regions. Earth has a protective atmosphere consisting predominantly of nitrogen and oxygen and has a magnetic field. The atmosphere and the</li> </ul> | <p>In order to meet this standard, it is expected that students will</p> <ul style="list-style-type: none"> <li>describe the unique properties of Earth that enable it to support life (6.3 a)</li> <li>model and describe how day and night and the phases of the moon occur (6.3 b, c)</li> </ul> |

| Enduring Understanding   | Essential Knowledge and Practices   |
|--|---|
| <p>magnetic field help shield Earth’s surface from harmful solar radiation (6.3 a).</p> <ul style="list-style-type: none"> <li>Scientific evidence indicates that Earth is about 4.5 billion years old (6.3 a).</li> </ul> <p>The interactions and orientations of the sun, Earth, and moon lead to patterns that are evidenced in seasons, eclipses, and the phases of the moon.</p> <ul style="list-style-type: none"> <li>As Earth rotates, different sides of Earth face toward or away from the sun, causing day and night, respectively (6.3 b).</li> <li>The relative positions of the moon, Earth, and sun give rise to moon phases (6.3 c).</li> <li>Seasons are caused by a combination of the tilt of Earth on its axis, the curvature of Earth’s surface, and the angle at which sunlight strikes the surface of Earth during its annual revolution around the sun (6.3 d).</li> <li>Tides are the result of the gravitational pull of the moon and sun on the surface waters of Earth (6.3 e).</li> </ul> | <ul style="list-style-type: none"> <li>model and explain the effect of Earth’s axial tilt and its annual orbit around the sun on the seasons (6.3 d)</li> <li>explain and illustrate the relationship between the gravitational pull of the moon and the cycle of tides (6.3 e).</li> </ul> |

**6.4 The student will investigate and understand that there are basic sources of energy and that energy can be transformed.**

**Key ideas include**

- a) the sun is important in the formation of most energy sources on Earth;
- b) Earth’s energy budget relates to living systems and Earth’s processes;
- c) radiation, conduction, and convection distribute energy; and
- d) energy transformations are important in energy usage.

**Central Idea:** The major source of energy on Earth is solar radiation.

**Vertical Alignment:** Students learn that energy can occur in different forms and can be transformed from one form to another in fifth grade (5.4). This energy cannot be created or destroyed within a closed system. The study of energy transfer and transformation continues into Life Science as students learn about photosynthesis and cellular respiration (LS.4).

| Enduring Understanding   | Essential Knowledge and Practices  |
|--|--|
| <p>All Earth’s processes are the result of energy flowing and mass cycling within and among Earth’s systems. The energy is derived from the sun and from Earth’s hot interior.</p> <ul style="list-style-type: none"> <li>• Solar radiation is made up of different types of radiation (including infrared, visible light, and ultraviolet) (6.4 a).</li> <li>• Earth receives only a very small portion of the sun’s energy, yet this energy is responsible for powering the motion of the atmosphere, the oceans, and many processes at Earth’s surface. Earth’s surface is heated unequally (6.4 b).</li> <li>• Earth’s energy budget refers to the tracking of how much energy is flowing into and out of the Earth’s climate, where the energy is going, and if the energy coming in balances with the energy going out (6.4 b).</li> <li>• The Earth’s energy budget includes the solar energy entering and exiting Earth’s atmosphere. Excess carbon dioxide and other gases affect the energy budget, creating a greenhouse effect (6.4 b).</li> <li>• When air or water is heated, the molecules move faster and farther apart, reducing their density and causing them to rise. Cooler air or water molecules move more slowly and are denser than warm air or water. Warm air or water rising coupled with cooler air or water descending forms a cyclic rising/falling pattern called convection (6.4 c).</li> </ul> | <p>In order to meet this standard, it is expected that students will</p> <ul style="list-style-type: none"> <li>• explain the importance of the sun in the formation of most energy sources on Earth (6.4 a)</li> <li>• analyze and interpret a chart or diagram showing Earth’s energy budget (6.4 b)</li> <li>• explain and illustrate how convection currents distribute thermal energy in the atmosphere and oceans (6.4 c)</li> <li>• explain the role of radiation, conduction, and convection in the distribution of Earth’s energy through the atmosphere (6.4 c)</li> <li>• model and identify energy transformations from the sun to energy sources on Earth (6.4 d)</li> <li>• create and interpret a model or diagram of an energy transformation (6.4 d)</li> <li>• describe the transformations of energy involved with the formation and burning of coal and other fossil fuels (6.4 d)</li> <li>• investigate how light energy (radiant energy) can be transformed into other forms of energy (e.g., mechanical, chemical, and electrical) (6.4 d).</li> </ul> |

| Enduring Understanding   | Essential Knowledge and Practices |
|--|-----------------------------------|
| <ul style="list-style-type: none"> <li>• Radiation and convection from Earth’s surface transfer thermal energy. This energy powers the global circulation of the atmosphere and the oceans on our planet (6.4 c).</li> </ul> <p>Energy is continuously transferred from one place to another and transformed among various forms.</p> <ul style="list-style-type: none"> <li>• Secondary sources of energy, such as electricity, are used to store, move, and deliver energy easily in usable form (6.4 d).</li> <li>• Thermal and radiant energy can be converted into mechanical energy, chemical energy, and electrical energy and back again (6.4 d).</li> </ul> |                                   |

- 6.5 The student will investigate and understand that all matter is composed of atoms. Key ideas include**
- a) atoms consist of particles, including electrons, protons, and neutrons;**
  - b) atoms of a particular element are similar but differ from atoms of other elements;**
  - c) elements may be represented by chemical symbols;**
  - d) two or more atoms interact to form new substances, which are held together by electrical forces (bonds);**
  - e) compounds may be represented by chemical formulas;**
  - f) chemical equations can be used to model chemical changes; and**
  - g) a few elements comprise the largest portion of the solid Earth, living matter, the oceans, and the atmosphere.**

**Central Idea:** Atoms are the basic building blocks of all matter.

**Vertical Alignment:** Students are introduced to the atom in fifth grade (5.7). Sixth grade is the first time students are introduced to subatomic particles. Knowledge of basic chemistry concepts is fundamental to understanding the physical sciences, life processes, and earth and environmental science ideas. In Physical Science, students will learn more about the different types of bonding and how to balance simple equations. Students are introduced to the periodic table in Physical Science (PS.4).

| Enduring Understandings   | Essential Knowledge and Practices  |
|---|--|
| <p>Atoms are the basic building blocks of all matter. The properties of an atom are based on the number and arrangement of its subatomic particles.</p> <ul style="list-style-type: none"> <li>• The basic structural components of a typical atom are electrons, protons, and neutrons. Protons and neutrons comprise the nucleus of an atom (6.5 a).</li> <li>• An element is a form of matter made up of one type of atom. The atoms of an element have the same number of protons and electrons, although the number of neutrons may vary (6.5 b).</li> <li>• The atoms of one element differ from those of another element in the number of protons (6.5 b).</li> <li>• Elements can be represented by chemical symbols (6.5 c).</li> </ul> <p>In a chemical process, the atoms that make up the original substance (<i>reactants</i>) are regrouped into different molecules and the new substances (<i>products</i>) have different properties from the properties of the reactants.</p> <ul style="list-style-type: none"> <li>• Two or more atoms of different elements may combine to form a compound (6.5 d).</li> <li>• Chemical bonds are the forces that hold atoms together to form new substances. These bonds are formed with electrons (6.5 d).</li> <li>• Compounds can be represented by chemical formulas. Each element in the compound is represented by its unique symbol. The number of each type of element in the compound (other than one) is represented by a small number (the subscript) to the right of the element symbol (6.5 e).</li> </ul> | <p>In order to meet this standard, it is expected that students will</p> <ul style="list-style-type: none"> <li>• create and interpret a simplified, modern model of the structure of an atom (6.5 a)</li> <li>• compare the atomic structure of two elements (6.5 b)</li> <li>• explain that elements are represented by symbols (6.5 c)</li> <li>• describe the role of bonding in the formation of new substances (6.5 d)</li> <li>• identify the name and number of each element present in a simple molecule or compound (6.5 e)</li> <li>• model a simple chemical change with an equation and account for all atoms (6.5 e)</li> <li>• distinguish the types of elements and number of each element in the chemical equation (6.5 f)</li> <li>• interpret data to identify the predominant elements found in the atmosphere, the oceans, living matter, and Earth's crust (6.5 g).</li> </ul> |

| Enduring Understandings   | Essential Knowledge and Practices |
|---|-----------------------------------|
| <p>Matter is conserved because atoms are conserved in chemical and physical processes.</p> <ul style="list-style-type: none"> <li>• Chemical equations can be used to model chemical changes, illustrating how elements become rearranged in a chemical reaction (6.5 f). <i>Students are not responsible for balancing equations.</i></li> <li>• A limited number of elements form the largest portion of Earth’s crust, living matter, the oceans, and the atmosphere (6.5 g).</li> </ul> |                                   |

- 6.6 The student will investigate and understand that water has unique physical properties and has a role in the natural and human-made environment. Key ideas include**
- a) water is referred to as the universal solvent;**
  - b) water has specific properties;**
  - c) thermal energy has a role in phase changes;**
  - d) water has a role in weathering;**
  - e) large bodies of water moderate climate; and**
  - f) water is important for agriculture, power generation, and public health.**

**Central Idea:** Due to water’s properties, it is a fundamental compound necessary for Earth’s processes.

**Vertical Alignment:** Students are introduced to the water cycle (3.7) and water conservation (4.8) in elementary science. The role of water in biological processes continue in Life Science (LS.4, LS.5).

| Enduring Understanding  | Essential Knowledge and Practices  |
|---|--|
| <p>Water has unique properties that are essential to Earth processes.</p> | <p>In order to meet this standard, it is expected that students will</p> <ul style="list-style-type: none"> <li>• plan an investigation to demonstrate the ability of water to dissolve materials (6.6 a)</li> </ul> |

| Enduring Understanding   | Essential Knowledge and Practices  |
|--|--|
| <ul style="list-style-type: none"> <li>• Due to water’s structure, many substances will dissolve in water. For this reason, water is often called the <i>universal solvent</i> (6.6 a).</li> <li>• Water is the only compound that commonly exists in all three states (solid, liquid, gas) on Earth (6.6 b).</li> <li>• The structure of water molecules allows for the attraction of these molecules to each other, leading to <i>cohesion</i>. Their structure also allows water molecules to stick to other surfaces, leading to <i>adhesion</i> (6.6 b).</li> <li>• Surface tension is the property of the surface of a liquid that allows it to resist an external force. This property is due to the cohesive nature of water molecules (6.6 b).</li> <li>• Solid water is less dense than liquid water (6.6 b).</li> </ul> <p>Thermal energy added to a system increases the kinetic energy of molecules and results in temperature and phase changes.</p> <ul style="list-style-type: none"> <li>• Water can absorb thermal energy without showing relatively large changes in temperature (6.6 c, e).</li> <li>• Large bodies of water act to moderate the climate of surrounding areas by absorbing thermal energy in summer and slowly releasing that energy in the winter. For this reason, the climate near large bodies of water is slightly milder than in areas without large bodies of water (6.6 c, e).</li> </ul> <p>Water shapes landscapes and is a powerful agent in weathering and erosion.</p> <ul style="list-style-type: none"> <li>• Water (rain, ice, snow) has shaped our environment by physically and chemically weathering rock and soil and</li> </ul> | <ul style="list-style-type: none"> <li>• describe the properties of water and identify examples of cohesion, adhesion, and surface tension (6.6 b)</li> <li>• compare the effects of adding or subtracting thermal energy to the states of water (6.6 c)</li> <li>• relate the three states of water to the water cycle (6.6 c)</li> <li>• model the action of freezing water on rocks (6.6 d)</li> <li>• plan and conduct an investigation to determine the action of acidified water on building materials such as concrete, limestone, or marble (6.6 d)</li> <li>• chart, record, and describe evidence of chemical and physical weathering in the local environment (6.6 d)</li> <li>• analyze and explain the difference in average winter temperatures among areas in central and western Virginia and cities and counties along the Chesapeake Bay and Atlantic coast (6.6 e)</li> <li>• explain the role of water in power generation (6.6 f)</li> <li>• describe the importance of careful management of water resources (6.6 f).</li> </ul> |

| Enduring Understanding  | Essential Knowledge and Practices |
|---|-----------------------------------|
| <p>transporting sediments. Freezing water can break rock without any change in the minerals that form the rock (physical weathering). This usually produces small particles and sand. Water, along with dissolved gases and other chemicals, causes the minerals in rocks to be changed, leading to the deterioration of the rock (chemical weathering). Erosion is the movement of the materials by water or wind (6.6 d).</p> <p>Humans affect the quality, availability, and distribution of Earth's water.</p> <ul style="list-style-type: none"> <li>• Most of Earth's water (97 percent) is salt water in the oceans. Available fresh water, used by humans and other organisms, makes up less than one percent of the water on Earth (6.6 f).</li> <li>• Water is essential for agriculture and in power generation (6.6 f).</li> <li>• Accessibility of clean, fresh water is critical in maintaining public health (6.6 f).</li> </ul> |                                   |

- 6.7 The student will investigate and understand that air has properties and that Earth's atmosphere has structure and is dynamic. Key ideas include**
- a) air is a mixture of gaseous elements and compounds;**
  - b) the atmosphere has physical characteristics;**
  - c) properties of the atmosphere change with altitude;**
  - d) there is a relationship between air movement, thermal energy, and weather conditions;**
  - e) atmospheric measures are used to predict weather conditions; and**
  - f) weather maps give basic information about fronts, systems, and weather measurements.**

**Central Idea:** The Earth's atmosphere is a dynamic system that changes in response to inputs and outflows of energy and matter.

**Vertical Alignment:** Students learn about weather and climate in fourth grade (4.4). Although the students have been introduced to weather throughout their elementary years, the concept of the atmosphere and the interactions that occur to affect both the biotic and abiotic portions of Earth is new to students. Students will study the atmosphere as a complex, dynamic system in Earth Science (ES.11).

| Enduring Understandings   | Essential Knowledge and Practices   |
|---|---|
| <p>Earth’s atmosphere is comprised of interacting and interdependent elements that are subject to change in response to inputs and outflows of energy and matter.</p> <ul style="list-style-type: none"> <li>• Air is a mixture of gaseous elements and compounds. These include nitrogen, oxygen, water, argon, and carbon dioxide. Nitrogen makes up the largest proportion of air (6.7 a).</li> <li>• The atmosphere is made up of layers (troposphere, stratosphere, mesosphere, and thermosphere) that have distinct characteristics (6.7c). <i>Students are not expected to know specific altitudes or temperatures at each layer.</i></li> <li>• Naturally occurring ozone is also found in the atmosphere and helps to shield Earth from ultraviolet radiation (6.7 c).</li> </ul> <p>The atmosphere is dynamic because of the number of factors that affect it, such as pressure and temperature, which change with altitude and latitude.</p> <ul style="list-style-type: none"> <li>• Air exerts pressure. Air pressure decreases as altitude increases (6.7 b).</li> <li>• Moisture in the air is called <i>humidity</i> (6.7 b).</li> <li>• Temperature decreases as altitude increases in the lowest layer of the atmosphere (6.7 b).</li> <li>• Data on characteristics such as barometric pressure, temperature, wind speed and direction, humidity, and dew</li> </ul> | <p>In order to meet this standard, it is expected that students will</p> <ul style="list-style-type: none"> <li>• identify the composition and physical characteristics of the atmosphere (6.7 a)</li> <li>• analyze and interpret charts and graphs of the atmosphere in terms of temperature and pressure (6.7 b)</li> <li>• measure and record air temperature, air pressure, and humidity, using appropriate units of measurement and tools (6.7 b)</li> <li>• predict weather conditions based on air temperature, barometric pressure, and humidity (6.7 b, e)</li> <li>• differentiate among the layers of the atmosphere in terms of general characteristics and changes in altitude (6.7 c)</li> <li>• explain the impact of the addition of thermal energy on air movement (6.7 d)</li> <li>• compare types of precipitation (6.7 e)</li> <li>• compare weather-related phenomena, including thunderstorms, tornadoes, hurricanes, and drought (6.7 e)</li> <li>• interpret basic weather maps, including the identification of warm and cold fronts (6.7 f)</li> <li>• map the movement of cold and warm fronts and interpret their effects on observable weather conditions (6.7 f).</li> </ul> |

| Enduring Understandings   | Essential Knowledge and Practices |
|---|-----------------------------------|
| <p>point can be collected, analyzed, and used to predict weather (6.7 b, d).</p> <p>Thermal energy transfer from the sun or from other geosystems influences air movement and weather conditions.</p> <ul style="list-style-type: none"> <li>The amounts of thermal energy and water vapor in the air and the pressure of the air largely determine weather conditions (6.7 d, e).</li> </ul> <p>Models constructed based on patterns in atmospheric conditions are used to predict weather.</p> <ul style="list-style-type: none"> <li>Most of the air that makes up the atmosphere is found in the troposphere (the lowest layer). Virtually all weather takes place there (6.7 c, e).</li> <li>Weather maps show useful information about air measurements, observations, and boundaries between air masses (fronts). The curved lines showing areas of equal air pressure and temperature are key features of weather maps. Weather maps are important for understanding and predicting the weather (6.7 f).</li> </ul> |                                   |

- 6.8 The student will investigate and understand that land and water have roles in watershed systems. Key ideas include**
- a) a watershed is composed of the land that drains into a body of water;**
  - b) Virginia is composed of multiple watershed systems which have specific features;**
  - c) the Chesapeake Bay is an estuary that has many important functions; and**
  - d) natural processes, human activities, and biotic and abiotic factors influence the health of a watershed system.**

**Central Idea:** Watershed systems are dynamic and complex; interactions within these systems may influence the overall health of the watershed.

**Vertical Alignment:** Students are introduced to the interactions among the biotic and abiotic factors within ecosystems in fourth grade (4.3). Watersheds as natural resources and the conservation of watersheds is emphasized at that time (4.8). Dynamics within ecosystems are investigated in Life Science, although watersheds are not explicitly covered again until Earth Science (ES.8).

| Enduring Understanding  | Essential Knowledge and Practices  |
|---|--|
| <p>All ecosystems, including watershed ecosystems, are affected by complex biotic and abiotic interactions involving exchanges of matter and energy.</p> <ul style="list-style-type: none"> <li>• An ecosystem is made up of the biotic (living) community and the abiotic (nonliving) factors that affect it. The health of an ecosystem is directly related to water quality (6.8 a).</li> <li>• A watershed is the land that water flows across or through on its way to a stream, lake, wetland, or other body of water (6.8 a).</li> <li>• Abiotic factors determine ecosystem type and its distribution of plants and animals, as well as the usage of land by people. Abiotic factors include water supply, topography, landforms, geology, soils, sunlight, and air quality/O<sub>2</sub> availability (6.8 a).</li> <li>• Water-quality monitoring is the collection of water samples to analyze chemical and/or biological parameters. Simple parameters include pH, temperature, salinity, dissolved oxygen, turbidity, and the presence of macroinvertebrate organisms (6.8 a).</li> <li>• Areas of higher elevations, such as ridgelines and divides, separate watersheds (6.8 b).</li> <li>• The watershed systems in Virginia lead to three main bodies of water. These are the Chesapeake Bay, the North Carolina sounds, or the Gulf of Mexico (6.8 b).</li> </ul> | <p>In order to meet this standard, it is expected that students will</p> <ul style="list-style-type: none"> <li>• identify abiotic and biotic features in the students’ local watershed (6.8 a, b)</li> <li>• use maps to determine the location and size of Virginia’s regional watershed systems (6.8 b)</li> <li>• locate the local watershed and the rivers and streams associated with it (6.8 b)</li> <li>• explain the importance of the Virginia watersheds (6.8 c)</li> <li>• explain and appraise the value of wetlands to ecosystems, including humans (6.8 d)</li> <li>• explain the importance of estuaries, including their importance to people (6.8 d)</li> <li>• propose ways to maintain water quality within a watershed (6.8 d)</li> <li>• explain the factors that affect water quality in a watershed and how those factors can affect an ecosystem (6.8 d)</li> <li>• forecast potential water-related issues that may become important in the future (6.8 d)</li> <li>• locate and critique a media article or editorial (print or electronic) concerning water use or water quality and analyze and evaluate the science concepts involved (6.8 d)</li> </ul> |

| Enduring Understanding   | Essential Knowledge and Practices   |
|--|---|
| <ul style="list-style-type: none"> <li>• Wetlands form the transition zone between dry land and bodies of water such as rivers, lakes, or bays. Both tidal and non-tidal wetlands perform important water-quality functions, including regulating runoff by storing flood waters; reducing erosion by slowing down run-off; maintaining water quality by filtering sediments, trapping nutrients, and breaking down pollutants; and recharging groundwater. Wetlands also provide food and shelter for wildlife and fish and nesting and resting areas for migratory birds (6.8 b).</li> <li>• Estuaries perform important functions, such as providing habitat for many organisms (including serving as nurseries for their young) (6.8 c).</li> <li>• The Chesapeake Bay is an estuary where fresh and saltwater meet and are mixed by tides. It is the largest estuary in the contiguous United States and one of the most productive (6.8 c).</li> </ul> <p>Human actions and geologic processes affect the availability of freshwater resources.</p> <ul style="list-style-type: none"> <li>• Human activities can alter abiotic components and thus accelerate or decelerate natural processes (6.8 d).</li> </ul> | <ul style="list-style-type: none"> <li>• argue for and against commercially developing a parcel of land containing a large wetland area (6.8 d)</li> <li>• design and defend a land-use model that minimizes negative impact (6.8 d)</li> <li>• measure, record, and analyze a variety of water quality indicators and describe what these mean to the health of an ecosystem (6.8 d).</li> </ul> |

- 6.9 The student will investigate and understand that humans impact the environment and individuals can influence public policy decisions related to energy and the environment. Key ideas include**
- a) natural resources are important to protect and maintain;**
  - b) renewable and nonrenewable resources can be managed;**
  - c) major health and safety issues are associated with air and water quality;**
  - d) major health and safety issues are related to different forms of energy;**
  - e) preventive measures can protect land-use and reduce environmental hazards; and**

**f) there are cost/benefit tradeoffs in conservation policies.**

**Central Idea:** Natural resource management and health and safety issues related to the use of resources should be considered in the development of public policy.

**Vertical Alignment:** Students continue building an understanding of the importance of Earth’s natural resources in fourth grade. (4.9). The complexity of resource use is further explored in Earth Science (ES.6).

| Enduring Understanding  | Essential Knowledge and Practices  |
|---|--|
| <p>Natural resources have different properties, making them suitable for different uses. Natural resources are limited and are distributed unevenly around the planet.</p> <ul style="list-style-type: none"> <li>• People, as well as other living organisms, are dependent upon the availability of clean water and air and a healthy environment (6.9 a, c).</li> <li>• Local, state, and federal governments have significant roles in managing and protecting air, water, plant, and wildlife resources (6.9 b).</li> <li>• Modern industrial society is dependent upon energy. Fossil fuels are the major sources of energy in developed and industrialized nations and should be managed to minimize adverse impacts (6.9 d).</li> <li>• Renewable resources should be managed so that they produce continuously. Sustainable development focuses decisions about long-term use of the land and natural resources on maximum community benefit for the longest time with the least environmental damage (6.9 b).</li> <li>• Preventing pollutants from entering the air and water can protect the health of living things. Water pollutants such as pesticides, fertilizers, and chemicals affect the limited</li> </ul> | <p>In order to meet this standard, it is expected that students will</p> <ul style="list-style-type: none"> <li>• construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources affect Earth’s systems (e.g., climate, oceans, rainforest) (6.9 a)</li> <li>• differentiate between renewable and nonrenewable resources (6.9 b)</li> <li>• describe the role of local and state conservation professionals in managing natural resources, including wildlife protection; forestry and waste management; and air, water, and soil conservation (6.9 b)</li> <li>• analyze resource-use options in everyday activities and determine how personal choices have costs and benefits related to the generation of waste (6.9 f)</li> <li>• analyze how renewable and nonrenewable resources are used and managed within the home, school, and community (6.9 b)</li> <li>• describe ways that water and air pollution affect human health and safety (6.9 c)</li> <li>• compare energy sources and their effects on human health and safety (6.9 d)</li> </ul> |

| <b>Enduring Understanding</b>  | <b>Essential Knowledge and Practices</b>   |
|--|--|
| <p>amount of fresh water available for living things to maintain life processes. These pollutants may also lead to an increase in bacterial, viral, and parasitic diseases (6.9 c).</p> <ul style="list-style-type: none"> <li>• Conservation of resources and environmental protection include individual acts of stewardship (6.9 f).</li> <li>• Human use of resources has a cause-and-effect impact on Earth systems and on the global economy (6.9 f).</li> <li>• There are advantages and disadvantages to using any energy source. These advantages and disadvantages may affect the environment and have economic implications (6.9 d).</li> <li>• Human health can be affected when pollutants, in the form of particulates and thermal energy released into the atmosphere, disrupt the natural balance in the system (6.9 c, d).</li> </ul> <p>Earth scientists and engineers develop new technologies to extract resources while reducing the pollution, waste, and ecosystem degradation caused by extraction.</p> <ul style="list-style-type: none"> <li>• Preventive measures, such as pollution prevention or thoughtfully planned and enforced land-use restrictions, can reduce future damage (6.9 e).</li> <li>• Regulations, incentives, and voluntary efforts help conserve resources and protect environmental quality (6.9 f).</li> <li>• Use of renewable (water, air, soil, plant life, animal life) and nonrenewable resources (coal, oil, natural gas, nuclear power, and mineral resources) must be considered in terms of their cost/benefit tradeoffs (6.9 f).</li> <li>• Pollution prevention and waste management are less costly than cleanup (6.9 f).</li> </ul> | <ul style="list-style-type: none"> <li>● investigate practices that can reduce environmental hazards or improve land use (6.9 e)</li> <li>● analyze reports, media articles, and other narrative materials related to waste management and resource use to determine various perspectives concerning the costs and benefits in real-life situations (6.9 f)</li> <li>● evaluate the effects of resource use, waste management, and pollution prevention in the school and home environment (6.9 f).</li> </ul> |

