2018 Virginia Science Standards of Learning

Curriculum Framework

Board of Education

Commonwealth of Virginia

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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.

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 a 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.

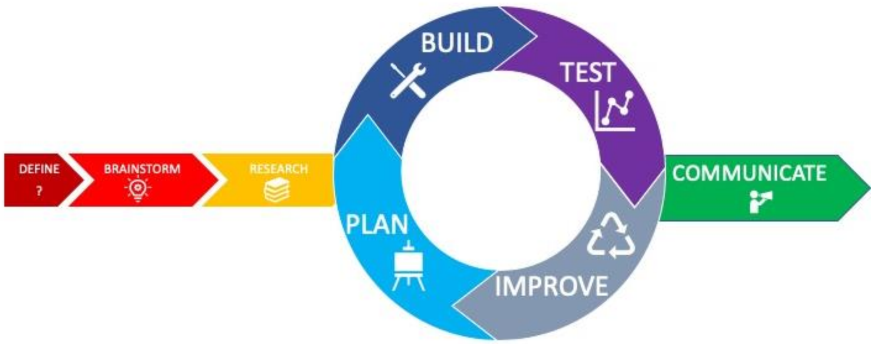

Figure 1: Engineering Design Process image based on the National Aeronautics and Space Administration (NASA) engineering design model.

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/).

Physical Science

Physical Science standards stress an in-depth understanding of the nature and structure of matter and the characteristics of energy. Major areas covered by the standards include the particle nature of matter; the organization and use of the periodic table; physical and chemical changes; energy transfer and transformations; properties of longitudinal and transverse waves; electricity and magnetism; and work, force, and motion. The standards build on skills of systematic investigation with a clear focus on variables and repeated trials. Validating conclusions with evidence and data becomes increasingly important at this level. Mathematics, computational thinking, and experiences in the engineering design process gain importance as students advance in their scientific thinking.

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.

PS.1 The student will demonstrate an understanding of scientific and engineering practices by

a) asking questions and defining problems
- **ask questions that require empirical evidence to answer**
- **develop hypotheses indicating relationships between 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 and include the safe use of chemicals and equipment**
- **evaluate the accuracy of various methods for collecting data**
- **take metric measurements using appropriate tools and technologies**
- **apply scientific ideas or principles to design, construct, and/or test a design of an object, tool, process, or system**

c) interpreting, analyzing, and evaluating data
- **construct and interpret data tables showing independent and dependent variables, repeated trials, and means**
- **construct, analyze, and interpret graphical displays of data and consider limitations of data analysis**

- **apply mathematical concepts and processes to scientific questions**
- **use data to evaluate and refine design solutions to best meet criteria**

d) constructing and critiquing conclusions and explanations

- **construct scientific explanations based on valid and reliable evidence obtained from sources (including the students' own investigations)**
- **construct arguments supported by empirical evidence and scientific reasoning**
- **generate and compare multiple solutions to problems based on how well they meet the criteria and constraints**
- **differentiate between a scientific hypothesis, theory, and law**

e) developing and using models

- **construct, develop, and use models and simulations to illustrate and/or explain observable and unobservable phenomena**
- **evaluate limitations of models**

f) obtaining, evaluating, and communicating information

- **read scientific texts, including those adapted for classroom use, to determine the central idea and/or 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**

Physical Science Content

PS.2 The student will investigate and understand that matter is composed of atoms. Key ideas include

a) our understanding of atoms has developed over time;
b) the periodic table can be used to predict the chemical and physical properties of matter; and
c) the kinetic molecular theory is used to predict and explain matter interactions.

Central Idea: Atoms are composed of subatomic particles, each with its own location and characteristics. Atomic structure and properties are reflected in the periodic table.

Vertical Alignment: Students are introduced to the atom and elements in sixth grade (6.5). In Physical Science, the subatomic particles are introduced, along with general information that can be found in the periodic table. More detailed information about atomic structure and periodic trends are investigated in Chemistry (CH.2, CH.6).

Enduring Understanding	Essential Knowledge and Practices
The nature of science refers to the foundational concepts that govern the way scientists formulate explanations about the natural world (refer to LS.2). • A series of contributions and discoveries has led to the development of the atomic theory. The atomic theory encapsulates our current understanding of the atom and its structure. The development of this theory illustrates the nature of science (PS.2 a). *Students are not responsible for describing the contributions of specific scientists.* • The electron cloud model best represents our current understanding of the atomic structure. The electron cloud model describes the atom as containing a dense nucleus of protons and neutrons surrounded by regions of space (clouds) where electrons are most likely to be found (PS.2 a). (Note: the Bohr model is an inaccurate model and does not depict the 3-D nature of the atom; it implies that electrons are in static orbits.) *Students do not need to know electron configurations and the quantum mechanical model.* Matter consists of atoms held together by electromagnetic forces; matter exists as different substances which can be utilized based on their properties. Different substances with different properties are suited to different uses. • Atoms are the basic building blocks of all matter. The properties of an atom are based on the number and arrangement of its parts (PS.2 a). • The atom consists of subatomic particles (protons, neutrons, and electrons) that differ in location, charge, and relative mass (PS.2 a).	In order to meet this standard, it is expected that students will • provide examples to demonstrate how the development of atomic theory illustrates the nature of science (PS.2 a) • construct and use models and simulations to represent the structure of atoms; evaluate the limitations of models used (PS.2 a) • differentiate among scientific hypotheses, theories, and laws (PS.2 a) • interpret data in the periodic table to predict the chemical and physical properties of main group elements (PS.2 b) • construct and use models and simulations to represent and/or explain the atom and phases of matter; evaluate the limitations of models used, when appropriate (PS.2 c) • develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed (PS.2 c) • interpret diagrams representing different phases of matter (PS.2 c) • compose evidence-based conclusions, explanations, and arguments to identify changes in matter when thermal energy is added or taken away (PS.2 c).

Enduring Understanding	Essential Knowledge and Practices
• The organization of the periodic table can be used to predict the metallic character and tendency of main group elements to form ionic or covalent bonds (PS.2 b). *Students do not need to know the properties of transition elements.* • Elements in the same vertical column or group of the periodic table contain the same number of electrons in their outer energy levels. These electrons are called *valence electrons* and give rise to similar chemical properties (PS.2 b). *Students do not need to determine the number of valence electrons*. • Elements in the same row of the periodic table contain the same number of energy levels (PS.2 b). *Students do not need to determine principle energy levels or electron configurations*. The kinetic molecular theory states that atoms and molecules are perpetually in motion and have kinetic energy. • The relative amount of kinetic energy in a group of atoms or molecules is an important factor in determining its physical state (PS.2 c). • The changes of state that occur with variations in temperature or pressure can be described and predicted using the kinetic molecular theory (PS.2 c).	

PS.3 The student will investigate and understand that matter has properties and is conserved in chemical and physical processes. Key ideas include

a) pure substances can be identified based on their chemical and physical properties;

b) pure substances can undergo physical and chemical changes that may result in a change of properties;

c) compounds form through ionic and covalent bonding; and

d) balanced chemical equations model the conservation of matter.

Central Idea: During a chemical reaction, atoms stay the same, but rearrange to form new molecules or compounds. The new substances that results from the reaction have different physical properties from the original substances.

Vertical Alignment: In sixth grade, students learn that all matter is composed of atoms and these atoms may interact to form new substances. These substances are held together by electrostatic forces called *bonds* (6.5). Although students learn in sixth grade that chemical equations model chemical changes, they do not write or balance chemical reactions until grade eight. The chemistry standards reflect a greater depth of understanding as students study the electron's role in bonding and create models to show electrons within the bonds. Students also will classify balanced reactions based on reactants and products (CH.3).

Enduring Understanding	**Essential Knowledge and Practices**
Matter consists of atoms held together by electromagnetic forces. Matter exists as different substances which can be utilized based on their properties. Different substances with different properties are suited to different uses. • Matter exists in different physical states (phases) as a solid, liquid, gas, or plasma (PS.3 a). • Measurements of a variety of properties can be used to identify matter (PS.3 a). • Physical properties of matter include temperature, state, color, hardness, texture, odor, mass, volume, density, conductivity, luster, malleability, boiling point, melting point, and solubility (PS.3 a). *Students are not expected to know or apply the terms* buoyancy *or* viscosity. • Density represents the relationship between the mass of the substance and its volume (PS.3 a). • Some physical properties, such as density, melting point, and boiling point are characteristic of a pure substance and do not depend on the size of the sample. These physical	In order to meet this standard, it is expected that students will • distinguish between physical properties and chemical properties of matter (PS.3 a) • generate, analyze, and interpret data in tables, graphs, charts, diagrams, and/or other displays related to physical and chemical properties of matter (PS.3 a) • apply mathematical and computational thinking to calculate and compare the densities of substances (PS.3 a) • identify and describe a pure substance based on its physical and/or chemical properties (PS.3 a) • provide examples of the specific uses of matter that are suited to their physical or chemical properties (PS.3 a) • plan and conduct investigations to explore the relationship among mass, volume, and density, collecting and analyzing data in metric units and the International System of Units (SI units) (PS.3 a) • generate, analyze, and interpret data in tables, graphs, charts, and/or other displays related to mass, volume, and density (PS.3 a)

Enduring Understanding	Essential Knowledge and Practices
properties can be used to identify unknown pure substances (i.e., matter that consists only of one type of atom, molecule, or compound) (PS.3 a). • Chemical properties of matter include reactivity, combustibility, flammability, and acidity/basicity (PS.3 a). *Students are not expected to identify heat of combustion, chemical stability, preferred oxidation state, toxicity, or half-life.* • Matter can undergo physical and chemical changes (PS.3 b). • No new substances are created during a physical change, although matter may take a different form. The size, shape, state, and color of matter may be modified. Examples of physical changes include (but are not limited to) ice cream melting, a diamond forming from carbon, and salt dissolving in water (PS.3 b). • Mixtures consist of two or more substances; however, the substances are not chemically combined. They can be separated by physical means (PS.3 b). • Attraction and repulsion among electric charges at the atomic level explains the structure, properties, and transformations of matter (PS.3 b). • Elements combine in many ways to produce compounds that make up all other substances on Earth (PS.3 b). • Chemical changes include a rearrangement of the atoms of one or more substances, leading to the formation of at least one new substance with different chemical properties. Examples of chemical changes include (but are not limited	• distinguish between physical and chemical changes (PS.3 b) • compose evidence-based conclusions, explanations, and arguments from data obtained in an investigation related to chemical changes in matter (PS.3 b) • analyze and interpret diagrams and/or other displays to determine if a chemical or physical change has occurred (PS.3 b) • analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical change has occurred (PS.3 b) • use evidence and scientific reasoning to differentiate between a chemical reaction that requires an input of energy (endothermic) and one that releases energy (exothermic) (PS.3 b) • apply scientific principles and the engineering process to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes (PS.3 b) • differentiate among elements, compounds, and mixtures (PS.3 b) • apply scientific principles to develop a plan to separate a mixture (PS.3 b) • compare ionic and covalent bonding (PS.3 c) • apply scientific principles to predict if an ionic or covalent bond will form when main group metals and non-metals are chemically combined (PS.3 c) • identify the reactants and products in a given chemical equation (PS.3 d)

Enduring Understanding	Essential Knowledge and Practices
to) rust forming on an iron nail, burning wood, cooking an egg (PS.3 b). • Chemical changes involve the breaking and making of chemical bonds. If the total energy required to break bonds in the reactants is more than the total energy released when new bonds are formed in the products, the reaction is endothermic. If the total energy required to break bonds in the reactants is less than the total energy released when new bonds are formed in the products, the reaction is exothermic (PS.3 b). *Students are not expected to indicate the type of reaction (synthesis, decomposition, and replacement reactions).* • To become chemically stable, the atoms of elements gain, lose, or share electrons (PS.3 c). • Compounds consist of two or more elements that are chemically combined in a fixed ratio (PS.3 c). • A chemical formula is a mathematical model that displays the number of atoms of each element that form a chemical compound (e.g., H_2O_2, $C_6H_{12}O_6$) (PS.3 c). • Compounds can be classified as ionic or covalent based on the type of chemical bonds they contain (PS.3 c). • When a metallic element reacts with a non-metallic element, their atoms gain and lose electrons respectively, forming ionic bonds. Generally, when two nonmetals react, atoms share electrons, forming covalent (molecular) bonds (PS.3 c). • A chemical equation represents the changes that take place in a chemical reaction. The chemical formulas of the	• apply the law of conservation of matter to balance simple chemical equations (PS.3 d).

Enduring Understanding	Essential Knowledge and Practices
reactants are written on the left, an arrow indicates a change to new substances, and the chemical formulas of the products are written on the right (PS.3 d). • The law of conservation of matter (mass) states that regardless of how substances within a closed system are changed, the total mass remains the same (PS.3 d).	

PS.4 The student will investigate and understand that the periodic table is a model used to organize elements based on their atomic structure. Key uses include

a) symbols, atomic numbers, atomic mass, chemical groups (families), and periods are identified on the periodic table; and

b) elements are classified as metals, metalloids, and nonmetals.

Central Idea: The periodic table is a foundational organizational tool that outlines knowledge about matter in the discipline of chemistry. Memorizing information is not nearly as important as being able to use the tool to understand the interactions and nature of the elements that make up the natural world.

Vertical Alignment: Students begin their study of the atom in sixth grade. Included in the introduction to the atom are subatomic particles, elements, the fundamentals of bonding, and the chemical equations to model a chemical reaction (6.5). In Chemistry, students use the periodic table to predict trends within groups and periods and to predict bonding (CH.2).

Enduring Understandings	Essential Knowledge and Practices
Predictable properties emerge when elements are arranged according to the number of protons. The periodic table models these patterns and can be used to predict properties of elements.	In order to meet this standard, it is expected that students will • compare the location, charge, and relative mass of protons, neutrons, and electrons in a single atom (PS.4 a) • differentiate between atoms of an element and its isotopes (PS.4 a)

Enduring Understandings	**Essential Knowledge and Practices**
• All atoms of an element contain the same number of protons and cannot be broken down into simpler substances using chemical reactions (PS.4 a). • Each element is distinguished by the number of protons in the nuclei of its atoms (atomic number). The number of protons never changes in an atom during chemical or physical changes (PS.4 a). • There are more than 118 known elements. Elements with an atomic number greater than 92 are not found naturally in measurable quantities on Earth. These elements are artificially produced in a laboratory setting (PS.4 a). • The periodic table is a tool used to organize information about the elements. The boxes in the periodic table are arranged in increasing order of atomic number (PS.4 a). • Although an element's atoms all have the same number of protons, they can have different numbers of neutrons (PS.4 a). • Atomic mass is equivalent to the number of protons and neutrons in the atom of an element (PS.4 a). • Atoms of an element with differing numbers of neutrons are known as *isotopes*, which leads to a different atomic mass; however, the chemical properties of the isotopes are the same. The atomic mass presented in the periodic table represents a population-weighted average of naturally occurring isotopes (PS.4 a).	• recognize that an atom's identity is related to the number of protons in its nucleus (PS.4 a) • use the periodic table to obtain the following information about the atom of an element: symbol, atomic number, and atomic mass (PS.4 a) • describe the organization of the periodic table in terms of atomic number, metals vs. nonmetals, and groups vs. periods (PS.4 a) • use basic information provided for an element (atomic mass, atomic number, symbol, and name) to determine its place on the periodic table (PS.4 a) • recognize that the number of electrons in the outermost energy level determines an element's chemical properties or chemical reactivity (PS.4 a) • classify a given element as metal, nonmetal, or metalloid based on its position in the periodic table (PS.4 b) • given a chemical formula of a compound, identify the elements and the number of atoms of each that comprise the compound (PS.4 b).

Enduring Understandings	Essential Knowledge and Practices
• Gaining or losing electrons makes an atom an ion. An ion has different chemical properties than the original atom (PS.4 a). • Elements in the same column (group or family) of the periodic table have similar properties because they contain the same number of electrons in their outer energy level (valence) (PS.4 a). *Students are not expected to indicate the number of valence of electrons of any atom*. • The horizontal rows of the periodic table are called *periods* (PS.4 a). *Students are not expected to indicate the number of principal energy levels.* • The vertical columns in the table are called *groups*. They are also commonly referred to as *families*. Elements in the same group share many physical and chemical properties because they contain the same number of electrons in their outer energy level (valence) (PS.4 a). • Elements on the left side of the periodic table are metals (PS.4 b). • Elements have fewer metallic properties as one reads from left to right across the periodic table (PS.4 b). • The nonmetals are located to the right of the stair-step line on the periodic table (PS.4 b). • Metalloids, which occur along the stair-step line, have both metallic and non-metallic properties (PS.4 b).	

PS.5 The student will investigate and understand that energy is conserved. Key ideas include

a) energy can be stored in different ways;

b) **energy is transferred and transformed; and**
c) **energy can be transformed to meet societal needs.**

Central Idea: Energy is a quantifiable property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called *energy* is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another between various forms.

Vertical Alignment: Students investigate energy and energy transformations in fifth grade (5.2). The study of these transformation is continued in sixth grade as students focus on sun as the primary source of energy (6.4). Mathematical processes will be applied to matter and energy interactions in Physics (PH.4).

Enduring Understandings	**Essential Knowledge and Practices**
Energy is the ability to cause change. Energy can be transferred between components in a system and transformed from one form to another. • Energy exists in two states: potential and kinetic (PS.5 a). • Potential energy is energy based on position or chemical composition. Potential energy can be in the form of chemical energy (energy in bonds), nuclear energy (the energy that holds the nucleus of an atom together), elastic energy (energy in objects that have a restorative force, such as springs or rubber bands) and gravitational potential energy (energy of place or position) (PS.5 a). • Kinetic energy is energy of motion. Kinetic is the motion of waves, electrons, molecules, or an object (PS.5 a). • When the motion energy of an object changes, there is inevitably some other change in energy at the same time (PS.5 a). • Important forms of energy include radiant, thermal, chemical, electrical, mechanical, and nuclear (PS.5 a).	In order to meet this standard, it is expected that students will • identify and give examples of common forms of energy (PS.5 a) • recognize examples of energy causing change (PS.5 a) • differentiate between kinetic and potential energy (PS.5 a) • plan and conduct observational and/or experimental investigations related to transformations of kinetic and potential energy (PS.5 a) • generate, analyze, and interpret data in tables, graphs, charts, diagrams, and/or other displays to compare relative amounts of potential and kinetic energy (PS.5 a) • construct and use models to show that different amounts of potential energy are stored in the system when the arrangement of objects interacting at a distance changes (PS.5 a) • plan and conduct experimental and/or observational investigations to provide evidence that energy can be transferred and transformed between its different forms (PS.5 b)

Enduring Understandings	Essential Knowledge and Practices
• Visible light is a form of radiant energy and sound is a form of mechanical energy (PS.5 a). • The law of conservation of energy states that energy cannot be created or destroyed but only changed from one form to another (PS.5 b). • In any energy transfer and transformation, some of the energy goes into the environment as thermal energy (PS.5 b). • Thermal energy is transferred by conduction, by convection, and by radiation (PS.5 b). • The amount of kinetic energy in a substance is directly proportional to its Kelvin temperature (PS.5 b). • Heat is the transfer of thermal energy between substances due to a difference in temperature. As thermal energy is added, the temperature of a substance increases. The exception is when a phase change occurs (PS.5 b). • A change in state (phase change) occurs when thermal energy is added or taken away from a system. There is no change in temperature during a phase change (freezing, melting, condensing, evaporating, boiling, and vaporizing) as this energy is being used to make or break bonds between molecules (PS.5 b). • Energy is spontaneously transferred out of hotter regions or objects and into colder ones (PS.5 b). • Temperature is the average kinetic energy of molecules of a substance. Increased temperature means greater kinetic energy of the molecules in the substance being measured,	• identify the energy transformations that occur when energy is used to run a device in the home or school (PS.5 b) • identify the energy transformations that occur between radiant energy in sunlight and the food we eat (PS.5 b) • plan and conduct an investigation related to energy transfer through conduction, convection, and radiation (PS.5 b) • generate, analyze, and interpret data in graphs, charts, diagrams, and/or other displays related to thermal energy transfer through conduction, convection, and radiation (PS.5 b) • apply scientific principles to design, construct, and test a device that either minimizes or maximizes thermal energy transfer (PS.5 b) • compare Celsius and Kelvin temperature scales and use them to describe absolute zero (PS.5 b) • explain absolute zero in terms of molecular movement (kinetic energy) (PS.5 b) • use scientific principles to explain the function of a thermometer (PS.5 b) • analyze a time/temperature graph of a phase change to determine the temperature at which the phase change occurs (freezing point, melting point, or boiling point) (PS.5 b) • ask questions and define problems related to electrical energy production in Virginia (PS.5 c) • describe energy systems, to include transformations in nature and those that are used to meet societal needs (PS.5 c) • evaluate and use credible, accurate, and unbiased sources of print and electronic media to gather and summarize scientific and technical information to describe how energy and fuels

Enduring Understandings	Essential Knowledge and Practices
and most substances expand when heated. The temperature of absolute zero (-273°C/0 K) is the theoretical temperature at which molecular motion stops (PS.5 b). • The amount of energy transfer needed to change the temperature of a matter sample by a given amount depends on the nature of the matter, the size of the sample, and the environment (PS.5 b). Energy and fuels that humans use derive from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time and others are not. • 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 geological processes. Renewable energy resources, and the technologies to exploit them, are being rapidly developed (PS.5 c). • Electrical energy is produced through a series of energy transformations from a variety of original forms which include coal, oil, solar, nuclear, wind, biomass, and natural gas (PS.5 c). • Nuclear energy is the energy stored in the nucleus of an atom. This energy can be released by joining nuclei together (fusion) or by splitting nuclei (fission), resulting in the conversion of minute amounts of matter into energy. In nuclear reactions, a small amount of matter produces a large amount of energy. However, there are potential negative	(fossil, renewable, and nuclear) are derived from natural resources and how their uses affect the environment (PS.5 c).

Enduring Understandings	Essential Knowledge and Practices
effects of using nuclear energy, including the dangers of radioactive nuclear waste storage and disposal (PS.5 c).	

PS.6 The student will investigate and understand that waves are important in the movement of energy. Key ideas include
a) energy may be transferred in the form of longitudinal and transverse waves;
b) mechanical waves need a medium to transfer energy;
c) waves can interact; and
d) energy associated with waves has many applications.

Central Idea: Waves transfer energy and can exist in the form of longitudinal and transverse waves. Wave interactions include reflection, refraction, diffraction, and interference.

Vertical Alignment: Students are introduced to the concept of waves in fifth grade through the study of sound and visible light (5.5). In Physics, the concept of waves is extended to include all waves and their role in transferring energy (PH.5).

Enduring Understandings	Essential Knowledge and Practices
Waves transmit energy from one place to another without a permanent transfer of mass. • One wavelength is measured from any point on a wave to the corresponding point on the next wave (PS.6 a). • The amplitude of a wave depends on the type of wave and will be described for two types below. As the energy carried by a wave increases, the amplitude of the wave increases (PS.6 a). • Wave frequency is the number of waves produced over a given period. There is an inverse relationship between frequency and wavelength. As the frequency of a wave increases, wavelength decreases. A wave with a higher	In order to meet this standard, it is expected that students will • describe the role of waves in transferring energy (PS.6 a) • explain the relationship between frequency and wavelength (PS.6 a) 🍃 construct and use models and simulations to represent waves, including how the amplitude of a wave is related to its energy (PS.6 a) 🍃 model a longitudinal (compression) wave and diagram, label, and describe the components (wavelength, compression, and frequency) (PS.6 a)

Enduring Understandings	Essential Knowledge and Practices
frequency (shorter wavelength) carries more energy than a wave with a lower frequency (longer wavelength) (PS.6 a). • The speed of a wave is defined as the distance a point on a wave travels over time. It is expressed in units of meters/second (m/s). Waves can reflect, refract, and diffract (PS.6 a). • Refraction occurs when a wave passes through different materials, resulting in a change in the speed of the wave (PS.6 a). • Reflection occurs when a wave bounces from a surface back toward its source (PS.6 a). • Diffraction is a characteristic of all wave types and occurs when a wave encounters irregular surfaces. This causes the waves to change direction and be scattered. Diffraction is the bending of longitudinal waves around small obstacles or the spreading out of waves beyond openings (PS.6 a). • Longitudinal waves are caused by vibrations carried through a substance, sometimes referred to as a *medium* (solid, liquid. or gas) (PS.6 a). • When energy is being transferred through a medium by a longitudinal wave, the particles of the medium vibrate back and forth along the same path that the wave travels. The particles in a longitudinal wave do not move along the wave—only energy travels from one place to another (PS.6 a). • A compression (longitudinal) wave consists of a repeating pattern of compressions and rarefactions. Wavelength is measured as the distance from one compression to the next compression (PS.6 a).	• model a transverse wave and diagram, label and describe the components (wavelength, amplitude, frequency, crest, and trough) (PS.6 a) • compare longitudinal and transverse waves and their characteristics (PS.6 a) • plan and conduct investigations related to the refraction, reflection, and diffraction of longitudinal and transverse waves (PS.6 a) • develop and use a model to describe mechanical waves being reflected, absorbed, or transmitted through various materials (PS.6 b) • plan and conduct an investigation related to sound (the investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis) (PS.6 b) • interpret graphs and charts to determine factors that determine the speed of sound through various materials (PS.6 b) • identify the property of a sound wave that corresponds to its loudness (PS.6 b) • apply scientific principles to compose an argument as to which of several wires of different lengths would produce the highest-pitch sound (PS.6 b) • identify examples illustrating interference and/or resonance of transverse or longitudinal waves (PS.6 c) • evaluate and use credible, accurate, unbiased sources of print and electronic media to gather and summarize scientific and technical information about technological applications of

Enduring Understandings	Essential Knowledge and Practices
• The amplitude of a longitudinal wave is the largest distance the particles vibrate from their rest (starting) positions. A wave with greater amplitude carries more energy. For example, a longitudinal sound wave with greater amplitude will be louder than one with less amplitude (PS.6 a). • When energy passes through a medium (matter) in a transverse wave, particles vibrate in an up-and-down motion. The particles move across, or at right angles to, the direction the wave is going. A wave moving on a rope is an example of a transverse wave. Radiant energy travels in transverse waves (PS.6 a). • A wavelength on a transverse wave is the distance from one point to the next corresponding point (e.g., from the tip of one crest to the tip of the next crest) (PS.6 a). • The amplitude of a transverse wave is the distance from the rest position to the crest of a wave or to the trough of a wave. It is the maximum distance the particles of a medium vibrate from their rest position. A wave with a high amplitude carries more energy than a wave with a small amplitude carries (PS.6 a). • Mechanical waves (also called compression or longitudinal waves) are caused by vibrations carried through a substance, sometimes referred to as a medium (solid, liquid. or gas). When energy is being transferred through a medium by a longitudinal wave, the particles of the medium vibrate back and forth along the same path that the wave travels (e.g., vocal chords of a person, the vibrating string and sound board of a guitar or violin, the vibrating prongs of a tuning fork, or the vibrating diaphragm of a radio speaker) (PS.6 b). • The speed of a longitudinal wave depends on several factors, including the medium through which it travels. For example,	sound and water waves and how each application functions (PS.6 d).

Enduring Understandings	Essential Knowledge and Practices
the speed of sound is slowest in a gas, faster in liquids, and fastest in solids. Sound does not go through empty space (a vacuum). Temperature also affects the speed of a longitudinal wave. For example, the warmer the medium, the faster sound travels (PS.6 b). • Sound, a form of mechanical energy, is propagated through longitudinal waves and needs a medium through which it is transmitted (PS.6 b). • Sound is caused when something vibrates, making particles vibrate back and forth in the direction of the wave. Loudness (of sounds) is related to the amplitude of the mechanical wave. Greater amplitudes equate with louder sounds. Pitch (of sounds) is related to the frequency of the mechanical wave. Higher frequencies equate with higher pitches (PS.6 b). • Interference is the addition of two or more waves, resulting in a new wave pattern. Interference can be constructive or destructive. Waves of the same type that encounter each other pass through each other and exhibit interference (PS.6 c). • Resonance is the tendency of a system to vibrate at maximum amplitude at certain frequencies. For instance, when several musical instruments of the same kind play the same notes, the waves may combine to produce a louder sound (PS.6 c). • Wave-based technology has many applications. Examples include (but are not limited to) sonar, ultrasonography, vehicle parking sensors, and wave power generators (PS.6 d).	

PS.7 The student will investigate and understand that electromagnetic radiation has characteristics. Key ideas include
a) electromagnetic radiation, including visible light, has wave characteristics and behavior; and
b) regions of the electromagnetic spectrum have specific characteristics and uses.

Central Idea: All electromagnetic waves travel at the speed of light and exhibit the behavior and properties of waves. Due to the amazing range of frequencies and wavelengths, diffraction and reflection vary greatly.

Vertical Alignment: Students are introduced to the concept of waves in fifth grade through the study of sound and visible light (5.5, 5.6). In Physics, the concept of visible light is expanded to include all forms of electromagnetic radiation (PH.5).

Enduring Understandings	**Essential Knowledge and Practices**
Radiant energy travels through space in transverse waves of varying lengths and frequencies. The different wavelengths and frequencies of radiant energy are referred to as *electromagnetic radiation*. • Electromagnetic radiation consists of changing electric and magnetic fields (PS.7 a). • All types of electromagnetic radiation travel at the speed of light but differ in frequency (PS.7 a). • The sun gives off radiant energy of all frequencies in the electromagnetic spectrum. The energy transmitted by various wavelengths of radiant energy (electromagnetic radiation) may be converted to other forms of energy only after it is absorbed by matter (PS.7 a). • Scientists have divided the wavelengths of electromagnetic radiation (radiant energy) into a spectrum. Electromagnetic waves are arranged on the electromagnetic spectrum according to wavelength and frequency (PS.7 a). • The electromagnetic spectrum includes gamma rays, X-rays, ultraviolet, visible light, infrared, microwaves, and radio waves (PS.7 a).	In order to meet this standard, it is expected that students will • describe the wave behavior of visible light (PS.7 a) • compare the various types of electromagnetic waves in terms of wavelength, frequency, and energy (PS.7 a) 🍃 construct and use models and simulations to represent how waves are reflected, absorbed, or transmitted through various materials (PS.7 a) • apply an understanding of the law of reflection to explain why objects appear as specific colors (PS.7 a) • identify the images formed by concave, convex, and plane mirrors (PS.7 a) 🍃 plan and conduct investigations related to the reflection of visible light (PS.7 a) • identify the images formed by concave and convex lenses (PS.7 a) 🍃 plan and conduct investigations related to the refraction of visible light (PS.7 a)

Enduring Understandings	Essential Knowledge and Practices
• Radio waves are the lowest-energy waves and have the longest wavelength and the lowest frequency. Gamma rays are the highest energy waves and have the shortest wavelength and the highest frequency. Visible light lies in between and makes up only a small portion of the electromagnetic spectrum (PS.7 a). • Radiant energy travels in straight lines until it strikes an object where it can be reflected, absorbed, or transmitted (PS.7 a). • When a wave encounters a new material, the new material may absorb the energy of the wave by transforming it to another form of energy, usually thermal energy. The material may reflect the wave or the material may transmit the wave, allowing it to pass through (PS.7 a). • When visible light shines on an object, it is reflected, absorbed, or transmitted through the object, depending on the object's material and the frequency (color) of the light (PS.7 a). • The color of an object is due to the wavelengths of reflected visible light coming from the object to the viewer's eye. For example, when a ball looks blue, it is because it reflects blue light wavelengths; other wavelengths of visible light are absorbed by the ball. A black object absorbs all wavelengths of visible light (PS.7 a). • Mirrors reflect light. The direction of the reflected light rays is predicted by the law of reflection (PS.7 a).	• identify and explain in general terms the uses of mirrors and lenses in everyday life (PS.7 b) • compare the various types of electromagnetic waves in terms of wavelength, frequency, and energy (PS.7 b) • describe an everyday application of each of the major forms of electromagnetic energy (PS.7 b).

Enduring Understandings	Essential Knowledge and Practices
• The law of reflection states that the incident light ray, the reflected light ray, and the normal surface of the mirror all lie on the same plane. Furthermore, the angle of reflection is equal to the angle of incidence (PS.7 a). • A concave mirror focuses light rays to a point and produces an upright, magnified image if the mirror is close to the object (e.g., make-up mirrors). If the concave mirror is far from the object, the image is inverted and smaller than the object (PS.7 a). • A convex mirror spreads light rays and produces only upright, smaller images (PS.7 a). • The path that light travels can be traced as straight lines, except at surfaces between different transparent materials (e.g., air and water, air and glass) where the light path bends (PS.7 a). • As visible light travels through different media, it undergoes a change in speed that may result in refraction (PS.7 a). • Refraction occurs when a wave passes through different materials which results in a change in the speed of the wave (PS.7 a). • Lenses refract visible light rays. When visible light enters a lens, it bends toward the thickest part of the lens (PS.7 a). • Optical instruments such as cameras, telescopes, binoculars, and microscopes use lenses and combinations of lenses to change the path of light rays and produce a specific type of image (PS.7 a). • A concave lens spreads light rays, forming a smaller, upright image (PS.7 a).	

Enduring Understandings	Essential Knowledge and Practices
• A convex lens focuses light rays to a point. When the object is far from the lens, the image formed is smaller and inverted. When the object is close to the convex lens, the image is larger than the object and is upright (PS.7 a). • Electromagnetic radiation has many practical uses in everyday life, such as in medicine, security, and telecommunications (PS.7 b). • Electromagnetic radiation is used for communications and transmission of information. The waves that are used in this way are radio waves, microwaves, infrared radiation, and visible light. Digitized signals encode and transmit information more reliably than analog signals (PS.7 b).	

PS.8 The student will investigate and understand that work, force, and motion are related. Key ideas include
a) motion can be described using position and time; and
b) motion is described by Newton's laws.

Central Idea: Newton's laws of motion describe the relationship between a body and the forces acting upon it, and its motion in response to those forces.

Vertical Alignment: The concept of force is interwoven throughout elementary science instruction. Fifth grade science lays a foundation for motion depending on position and time and how forces, both of contact and at a distance, can affect motion (5.3). In Physics, Newton's laws continue to be a focus as students study velocity, acceleration, and linear, circular, and projectile motion (PH.2).

Enduring Understanding	Essential Knowledge and Practices
Object positions, force directions, and motions are compared using a chosen reference frame and chosen units of size. • Speed is the change in position of an object per unit of time. Speed always has a positive value and is non-directional (PS.8 a). • Velocity is the speed an object moves. Velocity may have a positive or a negative value depending on the direction of the change in position (PS.8 a). • Acceleration is the change in velocity per unit of time. An object moving with constant velocity has no acceleration. A decrease or increase in velocity are considered acceleration. A distance-time graph for an accelerating object is always a curve. Objects moving with circular motion are constantly accelerating because direction (and hence velocity) is constantly changing (PS.8 a).	In order to meet this standard, it is expected that students will • apply the concept of frame of reference to motion scenarios (PS.8 a) • apply the concepts of speed, velocity, and acceleration when describing motion (PS.8 a) • compare the speed of two or more objects (PS.8 a) • develop hypotheses, identify constants, variables, and apply repeated trials when conducting experimental investigations related to motion (PS.8 a) • make measurements and apply mathematical and computational thinking to calculate and analyze speed, velocity, and acceleration (PS.8 a) • generate, analyze, and interpret data in tables, graphs, charts, diagrams, models, equations, and/or other displays related to motion (PS.8 a) • construct and use models and simulations to represent and/or explain motion (PS.8 a)

Enduring Understanding	**Essential Knowledge and Practices**
• Formulas (mathematical models) are used to calculate speed, velocity, and acceleration (PS.8 a). *Students are not expected to memorize formulas.* • Graphs (2-D models) are constructed to better understand relationships and patterns of motion (PS.8 a). *Students are not responsible for describing more complex curves, only simple linear relationships.* Forces cause motion. Forces can cause objects to move, stop moving, change speed, or change direction. Newton's laws describe the motion of all common objects. Force is measured in Newtons (PS.8 b). • The motion of an object is determined by the sum of the forces acting on it; if the total force on the object is not zero, its motion will change. The greater the mass of the object, the greater the force needed to achieve the same change in motion. For any given object, a larger force causes a larger change in motion (PS.8 b). • Mass and weight are not equivalent. Mass is the amount of matter in a given substance. Weight is a measure of the force due to gravity acting on a mass. Weight is measured in Newtons and mass in kilograms (PS.8 b). • A variety of models can be used to illustrate Newton's laws of motion (PS.8 b). • Newton's first law states that an object at rest will remain at rest and an object in motion will remain in constant straight motion unless acted on by an external force (PS.8 b). • Newton's second law states that force equals mass times acceleration. Net force and acceleration are directly	• critique and improve an investigation about forces (PS.8 b) • plan and conduct an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object (PS.8 b) • differentiate between mass and weight (PS.8 b) • plan and conduct investigations related to mass and weight, collecting and analyzing data in metric and SI units where appropriate (PS.8 b) • identify situations that illustrate each of Newton's laws of motion (PS.8 b) • apply an understanding of scientific principles and laws to describe and predict motion (PS.8 b) • construct and use models and simulations to represent and/or explain Newton's laws of motion (PS.8 b) • plan and conduct an investigate regarding Newton's second law of motion to show the relationship among force, mass, and acceleration (PS.8 b) • explain how force, mass, and acceleration are related (PS.8 b) • apply Newton's third law of motion to design a solution to a problem involving the motion of two colliding objects (PS.8 b) • state the direction of motion after the interaction of two objects (PS.8 b) • explain how the concept of work, force, and motion apply to everyday uses and current technologies (PS.8 b) • recognize the direction of the force of friction (PS.8 b)

Enduring Understanding	Essential Knowledge and Practices
proportional. As the net force increases, the acceleration increases by the same proportion. Acceleration and mass are inversely proportional (PS.8 b). • Newton's third law states that for every force there is an equal and opposite force. Forces always occur in pairs (PS.8 b). • For any pair of interacting objects, the force exerted by the first object on the second object is equal in strength to the force that the second object exerts on the first, but in the opposite direction (Newton's third law) (PS.8 b). • Work is done when an object is moved through a distance in the direction of the applied force (PS.8 b). • Friction impedes motion when two surfaces are in contact (PS.8 b). • Power is the rate at which work is done (PS.8 b). • A simple machine is a device that makes work easier. Simple machines have different purposes: to change the effort needed, to change the direction or distance through which the force is applied, to change the speed at which the resistance moves, or a combination of these. Due to friction, the work put into a machine is always greater than the work output (PS.8 b).	• explain why force must be exerted continually to keep an object sliding across a carpeted surface (PS.8 b) • recognize examples of mechanical work (PS.8 b) • apply mathematical and computational thinking to solve basic problems related to work (PS.8 b) • make measurements and apply mathematical and computational thinking to calculate the power of an object (PS.8 b) • use models to illustrate and explain concepts related to work and power (PS.8 b).

PS.9 The student will investigate and understand that there are basic principles of electricity and magnetism. Key ideas include

a) an imbalance of charge generates static electricity;
b) materials have different conductive properties;
c) electric circuits transfer energy;
d) magnetic fields cause the magnetic effects of certain materials;

- e) **electric current and magnetic fields are related; and**
- f) **many technologies use electricity and magnetism.**

Central Idea: Electricity is a form of energy resulting from the existence of charged particles (such as electrons or protons), either statically as an accumulation of charge or dynamically as a current. In the majority of applications, it is the electron that is in motion to transfer charge and thus create a flow of electrical current. Changing electric fields are the cause of magnetic fields and changing magnetic fields can cause electrical charge to move.

Vertical Alignment: Students are introduced to the concept of electricity as a means of transmitting energy in fifth grade. This energy is then transformed by devices into other forms of energy. Terminology concerning circuits are used as students build simple circuits. Electromagnets are also introduced and constructed in fifth grade (5.4). In Physics, students will build on Physical Science standards to include calculations using Ohm's law as applied to series and parallel circuits (PH.8).

Enduring Understandings	**Essential Knowledge and Practices**
Electric charge is a property of an object or system that affects its interactions with other objects or systems containing charge. • Friction can cause electrons to be transferred from one object to another. The resulting imbalance in static electrical charges can build up on an object and be discharged slowly or rapidly. This is often called *static electricity* (PS.9 a). • A conductor is a material that transfers an electric current. An insulator is material that does not transfer an electric current. A semiconductor is a material that is in between a conductor and an insulator in terms of transferring electric current (PS.9 b). • Several factors affect how much electricity can flow through a system. Resistance is a property of matter that affects the flow of electricity. Some substances have more resistance than others (PS.9 b).	In order to meet this standard, it is expected that students will • model the transfer of electrons that results in a static charge (PS.9 a) • provide examples of materials that are good electrical conductors, semiconductors, and insulators (PS.9 b) • apply scientific principles and the engineering process to use a battery, several wires, and a bulb to determine if an object is an electrical conductor or insulator and create a model to help explain your solution (PS.9 b) • define and recognize examples of voltage, current, and resistance in electric circuits (PS.9 c) • construct simple series and parallel circuits to determine the relationship among voltage, resistance, and current (PS.9 c) • describe the energy flow and transformation in a circuit containing a power source and no more than three loads (PS.9 c)

Enduring Understandings	**Essential Knowledge and Practices**

• Voltage is the potential difference in charge between two points (PS.9 c).
• Current is the uniform flow of electrons through a circuit (PS.9 c).
• Resistance is a measure of the degree to which an object opposes the passage of an electric current (PS.9 c).
• Basic principles applicable to circuits include
  o electrons need a complete, conducting pathway (circuit)
  o electrons must receive energy (voltage) from a source
  o electrons move around the circuit, traveling from high to low potential through a device (current)
  o electrons transfer energy to perform some useful function (work)
  o thermal energy is transferred to the surroundings (PS.9 c).
• An electronic circuit is composed of individual electronic components, such as transistors and diodes, connected by conductive wires through which electric current can flow. Many common devices utilize electronic circuits (PS.9 c). *Students are not responsible for describing other components of electronic circuits such as capacitors, inductors, and resistors.*
• Electronic circuits have advantages over electric circuits, providing transfer of data and miniaturization (PS.9 c).
• Transistors are semiconductor devices made from silicon, and other semiconductor materials. These are used to amplify electrical signals (in stereos or radios) or to act like a light switch, turning the flow of electricity on and off (PS.9 c).
	• discuss the advantages of electronic over electrical circuits (PS.9 c)
	• evaluate and use credible, accurate, and unbiased sources of print and electronic media to gather and summarize scientific and technical information about current applications of semiconductors (e.g., diodes and transistors) (PS.9 c)
	• conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other, even though the objects are not in contact (PS.9 d)
	• identify technologies that utilize electromagnetism (PS.9 e)
	• apply an understanding of electromagnetic induction to explain the current produced when a coil of wire is moved through a magnetic field (PS.9 e)
	• plan and conduct an investigation to determine the factors that affect the strength of electric and magnetic forces (PS.9 e)
	• compare generators and motors and how they function (PS.9 f)
	• identify everyday appliances and technologies that utilize motors and generators (PS.9 f).

Enduring Understandings	Essential Knowledge and Practices
• Forces that act at a distance can be explained by fields that extend through space and can be mapped by their effect on a test object (PS.9 d). Electric and magnetic (electromagnetic) forces can be attractive or repulsive. The sizes of these forces depend on the magnitudes of the charges, currents, or magnetic strengths involved and on the distances between the interacting objects. Many technologies use principles of electromagnetism to operate. • Moving electricity can produce a magnetic field and cause iron and steel objects to act like magnets (PS.9 e). • Electromagnets are temporary magnets that lose their magnetism when the electric current is removed. Both a motor and a generator have magnets (or electromagnets) and a coil of wire that creates another magnetic field (PS.9 e). • Changing magnetic fields can produce electrical current in conductors. This phenomenon is called *electromagnetic induction* (PS.9 e). • A generator is a device that converts mechanical energy into electrical energy. Most of the electrical energy we use comes from generators (PS.9 f). • Electric motors convert electrical energy into mechanical energy that is used to do work. Examples of motors include those in many household appliances, such as blenders and washing machines (PS.9 f).	