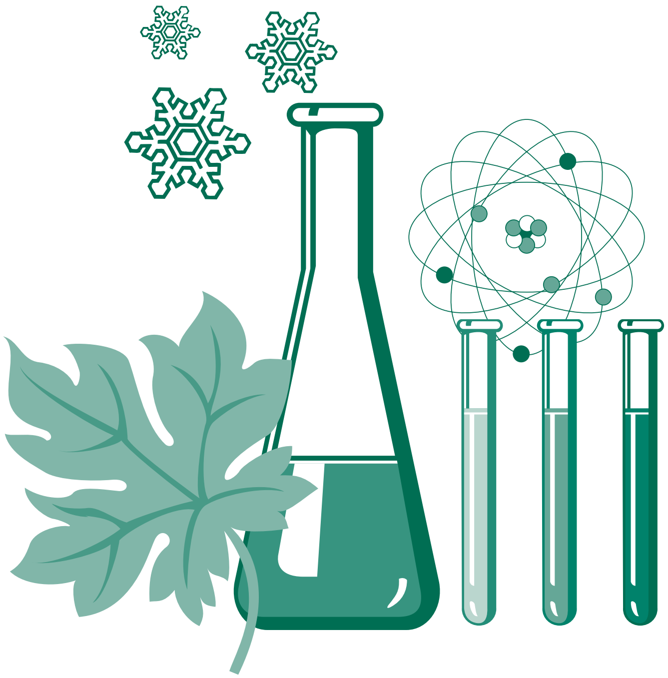

Science Standards of Learning Curriculum Framework

Physical Science

Commonwealth of Virginia
Board of Education
Richmond, Virginia
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Standard PS.1

The student will plan and conduct investigations in which

a) chemicals and equipment are used safely;
b) length, mass, volume, density, temperature, weight, and force are accurately measured and reported using metric units (SI — International System of Units);
c) conversions are made among metric units, applying appropriate prefixes;
d) triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, and spring scales are used to gather data;
e) numbers are expressed in scientific notation where appropriate;
f) research skills are utilized using a variety of resources;
g) independent and dependent variables, constants, controls, and repeated trials are identified;
h) data tables showing the independent and dependent variables, derived quantities, and the number of trials are constructed and interpreted;
i) data tables for descriptive statistics showing specific measures of central tendency, the range of the data set, and the number of repeated trials are constructed and interpreted;
j) frequency distributions, scattergrams, line plots, and histograms are constructed and interpreted;
k) valid conclusions are made after analyzing data;
l) research methods are used to investigate practical problems and questions;
m) experimental results are presented in appropriate written form; and
n) an understanding of the nature of science is developed and reinforced.

Understanding the Standard

The skills described in standard PS.1 are intended to define the “investigate” component of all of the other Physical Science standards (PS.2 – PS.11). The intent of standard PS.1 is that students will continue to develop a range of inquiry skills and achieve proficiency with those skills in the context of the concepts developed in the Physical Science curriculum. Standard PS.1 does not require a discrete unit on scientific investigation because the inquiry skills that make up the standard should be incorporated in all the other Physical Science standards. It is also intended that by developing these skills, students will achieve greater understanding of scientific inquiry and the nature of science, as well as more fully grasp the content-related SOL concepts.

Across the grade levels, kindergarten through high school, the skills in the first standards form a nearly continuous sequence. (Please note Appendix, “Science Skills Scope & Sequence.”) It is very important that the Physical Science teacher be familiar with the skills in the sequence leading up to standard PS.1 (LS.1, 6.1, 5.1, 4.1).

Standard PS.1

Overview	Essential Knowledge, Skills, and Processes
The critical scientific concepts developed in this standard include the following: • Systematic investigations require standard measures and consistent and reliable tools. SI (metric) measures, recognized around the world, are a standard way to make measurements. • Systematic investigations require organized reporting of data. The way the data are displayed can make it easier to see important patterns, trends, and relationships. Frequency distributions, scattergrams, line plots, and histograms are powerful tools for displaying and interpreting data. • Investigation not only involves the careful application of systematic (scientific) methodology, but also includes the review and analysis of prior research related to the topic. Numerous sources of information are available from print and electronic sources, and the researcher needs to judge the authority and credibility of the sources. • To communicate the plan of an experiment accurately, the independent variable, dependent variable, and constants must be explicitly defined. • The number of repeated trials needs to be considered in the context of the investigation. Often "controls" are used to establish a standard for comparing the results of manipulating the independent variable. Controls receive no experimental treatment. Not all experiments have a control, however.	In order to meet this standard, it is expected that students should be able to • select appropriate equipment (triple beam balances, thermometers, metric rulers, graduated cylinders, electronic balances, or spring scales) and utilize correct techniques to measure length, mass, density, weight, volume, temperature, and force. • design a data table that includes space to organize all components of an investigation in a meaningful way, including levels of the independent variable, measured responses of the dependent variable, number of trials, and mathematical means. • record measurements, using the following metric (SI) units: liter, milliliter (cubic centimeters), meter, centimeter, millimeter, grams, degrees Celsius, and newtons. • recognize metric prefix units and make common metric conversions between the same base metric unit (for example, milligram to gram or kilometer to meter).

Standard PS.1 (continued)

Overview	Essential Knowledge, Skills, and Processes
• The analysis of data from a systematic investigation may provide the researcher with a basis to reach a reasonable conclusion. Conclusions should not go beyond the evidence that supports them. Additional scientific research may yield new information that affects previous conclusions. • Different kinds of problems and questions require differing approaches and research. Scientific methodology almost always begins with a question, is based on observation and evidence, and requires logic and reasoning. Not all systematic investigations are experimental. • It is important to communicate systematically the design and results of an investigation so that questions, procedures, tools, results, and conclusions can be understood and replicated. • Scientists rely on creativity and imagination during all stages of their investigations.	• use a variety of graphical methods to display data; create an appropriate graph for a given set of data; and select the proper type of graph for a given set of data, identify and label the axes, and plot the data points. *(Note: Frequency distributions, scattergrams, line plots, and histograms are described in the Mathematics Curriculum Framework, standard 7.17, pp. 27–29.)* • gather, evaluate, and summarize information, using multiple and variable resources, and detect bias from a given source. • identify the key components of controlled experiments: hypotheses, independent and dependent variables, constants, controls, and repeated trials. • formulate conclusions that are supported by the gathered data. • apply the methodology of scientific inquiry: begin with a question, design an investigation, gather evidence, formulate an answer to the original question, and communicate the investigative process and results. • communicate in written form the following information about investigations: the purpose/problem of the investigation, procedures, materials, data and/or observations, graphs, and an interpretation of the results. • describe how creativity comes into play during various stages of scientific investigations.

Standard PS.2

The student will investigate and understand the basic nature of matter. Key concepts include

a) the particle theory of matter;
b) elements, compounds, mixtures, acids, bases, and salts;
c) solids, liquids, and gases;
d) characteristics of types of matter based on physical and chemical properties;
e) physical properties (shape, density, solubility, odor, melting point, boiling point, color); and
f) chemical properties (acidity, basicity, combustibility, reactivity).

Understanding the Standard

The concepts in PS.2 build upon several science standards from previous grades, including K.4, 1.3, 2.3, 3.3, 5.4, and 6.4. These standards introduce and develop basic ideas about the characteristics and structure of matter. In PS.2, the ideas and terminology continue to be expanded and treated in greater depth, including more mathematical application. It is intended that students will actively develop scientific investigation, reasoning, and logic skills (PS.1) in the context of the key concepts presented in this standard.

Standard PS.2

Overview	Essential Knowledge, Skills, and Processes
The critical scientific concepts developed in this standard include the following: • *Matter* is anything that has mass and occupies space. All matter is made up of small particles called atoms. Matter can exist as a solid, a liquid, or a gas. • Matter can be classified as elements, compounds, and mixtures. The atoms of any element are alike but are different from atoms of other elements. Compounds consist of two or more elements that are chemically combined in a fixed ratio. Mixtures also consist of two or more substances, but the substances are not chemically combined. • Compounds can be classified in several ways, including: - acids, bases, salts - inorganic and organic compounds. • Acids make up an important group of compounds that contain hydrogen ions. When acids dissolve in water, hydrogen ions (H^+) are released into the resulting solution. A base is a substance that releases hydroxide ions (OH^-) into solution. pH is a measure of the hydrogen ion concentration in a solution. The pH scale ranges from 0–14. Solutions with a pH lower than 7 are acidic; solutions with a pH greater than 7 are basic. A pH of 7 is neutral. When an acid reacts with a base, a salt is formed, along with water.	In order to meet this standard, it is expected that students should be able to • describe the particle theory of matter. • describe the properties of the states of matter (solid, liquid, and gas). • describe how to determine whether a substance is an element, compound, or mixture. • define compounds as inorganic or organic. (All organic compounds contain carbon.) • distinguish between physical properties (i.e., shape, density, solubility, odor, melting point, boiling point, and color) and chemical properties (i.e., acidity, basicity, combustibility, and reactivity). • find the mass and volume of substances and calculate and compare their densities. • analyze the pH of a solution and classify it as acidic, basic, or neutral. • describe what a salt is and explain how salts form. • determine the identity of an unknown substance by comparing its properties to those of known substances.

Standard PS.2 (continued)

Overview	Essential Knowledge, Skills, and Processes
• Matter can be described by its physical properties, which include shape, density, solubility, odor, melting point, boiling point, and color. Some physical properties, such as density, boiling point, and solubility, are characteristic of a specific substance and do not depend on the size of the sample. Characteristic properties can be used to identify unknown substances. • Equal volumes of different substances usually have different masses. • Matter can also be described by its chemical properties, which include acidity, basicity, combustibility, and reactivity. A chemical property indicates whether a substance can undergo a chemical change.	• design an investigation from a testable question related to physical and chemical properties of matter. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis. (Students should be able to use the inquiry skills represented in PS.1 and LS.1 to compose a clear hypothesis, create an organized data table, identify variables and constants, record data correctly, construct appropriate graphs, analyze data, and draw reasonable conclusions.)

Standard PS.3

The student will investigate and understand the modern and historical models of atomic structure. Key concepts include

a) the contributions of Dalton, Thomson, Rutherford, and Bohr in understanding the atom; and
b) the modern model of atomic structure.

Understanding the Standard

PS.3 builds upon science standards 3.3, 5.4, and 6.4, which introduce basic concepts and terminology related to the atom. PS.3 focuses more specifically on the basic structure of the atom and how models have been and are used to explain atomic structure. It is intended that students will actively develop scientific investigation, reasoning, and logic skills (PS.1) in the context of the key concepts presented in this standard.

Standard PS.3

Overview	Essential Knowledge, Skills, and Processes
The critical scientific concepts developed in this standard include the following: • The atom is the basic building block of matter and consists of subatomic particles (proton, neutron, and electron) that differ in their location, charge, and relative mass. • Scientists use models to help explain the structure of the atom. Their understanding of the structure of the atom continues to evolve. Two models commonly used are the Bohr and the "electron cloud" (Quantum Mechanics) models. The Bohr model does not depict the three-dimensional aspect of an atom, and it implies that electrons are in static orbits. The "electron cloud" model better represents our current understanding of the structure of the atom.	In order to meet this standard, it is expected that students should be able to • describe the historical development of the concept of the atom and the contributions of Dalton, Thomson, Rutherford, and Bohr. • use the Bohr model to differentiate among the three basic particles in the atom (proton, neutron, and electron) and their charges, relative masses, and locations. • compare the Bohr atomic model to the electron cloud model with respect to their ability to represent accurately the three-dimensional structure of the atom.

Standard PS.4

The student will investigate and understand the organization and use of the periodic table of elements to obtain information. Key concepts include

a) symbols, atomic number, atomic mass, chemical families (groups), and periods;
b) classification of elements as metals, metalloids, and nonmetals; and
c) simple compounds (formulas and the nature of bonding).

Understanding the Standard

PS.4 formally introduces the periodic table of elements. This standard builds upon concepts of the atom presented in science standard 6.4. Standard PS.4 focuses on a student's ability to look at the organization of the periodic table and learn what information can be obtained from it. It is intended that students will actively develop scientific investigation, reasoning, and logic skills (PS.1) in the context of the key concepts presented in this standard.

Standard PS.4

Overview	Essential Knowledge, Skills, and Processes
The critical scientific concepts developed in this standard include the following: • There are more than 110 known elements. No element with an atomic number greater than 92 is found naturally in measurable quantities on Earth. The remaining elements are artificially produced in a laboratory setting. Elements combine in many ways to produce compounds that make up all other substances on Earth. • The periodic table of elements is a tool used to organize information about the elements. Each box in the periodic table contains information about the structure of an element. • An atom's identity is directly related to the number of protons in its nucleus. This is the basis for the arrangement of atoms on the periodic table of elements. • The periodic table of elements is an arrangement of elements according to atomic number and properties. The information can be used to predict chemical reactivity. The boxes for all of the elements are arranged in increasing order of atomic number. The elements have an increasing nonmetallic character as one reads from left to right across the table. Along the stair-step line are the metalloids, which have properties of both metals and nonmetals.	In order to meet this standard, it is expected that students should be able to • use the periodic table to obtain the following information about the atom of an element: - symbol - atomic number - atomic mass - state of matter at room temperature - number of outer energy level (valence) electrons. • describe the organization of the periodic table in terms of - atomic number - metals, metalloids, and nonmetals - groups/families vs. periods. • categorize a given element as metal, non-metal, or metalloid. • given a chemical formula of a compound, identify the elements and the number of atoms of each that comprise the compound. • recognize that the number of electrons in the outermost energy level determines an element's chemical properties or chemical reactivity. • predict what kind of bond (ionic or covalent) will likely form when metals and nonmetals combined chemically.

Standard PS.4 (continued)

Overview	Essential Knowledge, Skills, and Processes
• The nonmetals are located to the right of the stair-step line on the periodic table. • Metals tend to lose electrons in chemical reactions, forming positive ions. Nonmetals tend to gain electrons in chemical reactions, forming negative ions. • Gaining or losing electrons makes an atom an ion. Gaining or losing neutrons makes an atom an isotope. However, gaining or losing a proton makes an atom into a completely different element. • The vertical columns in the table are called groups or families. Elements in each group have similar properties because they have the same number of electrons in the outermost energy level. The horizontal rows are called periods. • Elements in the same column (family) of the periodic table contain the same number of electrons in their outer energy levels. This gives rise to their similar properties and is the basis of periodicity — the repetitive pattern of properties such as boiling point across periods on the table.	• describe the difference between ionic and covalent bonding. • recognize that an atom's identity is related to the number of protons in its nucleus.

Standard PS.4 (continued)

Overview	Essential Knowledge, Skills, and Processes
• Atoms react to form chemically stable substances that are held together by chemical bonds and are represented by chemical formulas. To become chemically stable, atoms gain, lose, or share electrons. • Compounds are formed when elements react chemically. When a metallic element reacts with a nonmetallic element, their atoms gain and lose electrons respectively, forming ionic bonds. Generally, when two nonmetals react, atoms share electrons, forming covalent (molecular) bonds.	

Standard PS.5

The student will investigate and understand changes in matter and the relationship of these changes to the Law of Conservation of Matter and Energy. Key concepts include

a) physical changes;
b) nuclear reactions (products of fusion and fission and the effect of these products on human beings and the environment); and
c) chemical changes (types of reactions, reactants, and products; and balanced equations).

Understanding the Standard

This standard focuses on the concept that matter and energy can be changed in different ways, but the total amount of mass and energy is conserved. Students have previously investigated physical and chemical changes. It is intended that students will actively develop scientific investigation, reasoning, and logic skills (PS.1) in the context of the key concepts presented in this standard.

Standard PS.5

Overview	Essential Knowledge, Skills, and Processes
The critical scientific concepts developed in this standard include the following: • Matter can undergo physical and chemical changes. In physical changes, the chemical composition of the substances does not change. In chemical changes, different substances are formed. • 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. The Law of Conservation of Energy states that energy cannot be created or destroyed but only changed from one form to another. • A chemical equation represents the changes that take place in a chemical reaction. The chemical formulas of the 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. Chemical reactions are classified into two broad types: ones in which energy is released (exothermic) and ones in which energy is absorbed (endothermic). (The study of synthesis, decomposition, and replacement reactions can be reserved for high school Chemistry.)	In order to meet this standard, it is expected that students should be able to • compare and contrast physical, chemical, and nuclear changes. • design an investigation that illustrates physical and chemical changes. • given chemical formulas, write and balance simple chemical equations. • analyze experimental data to determine whether it supports the Law of Conservation of Mass. • recognize that some types of chemical reactions require continuous input of energy (endothermic) and others release energy (exothermic). • describe, in simple terms, the processes that release nuclear energy (i.e., nuclear fission and nuclear fusion). Create a simple diagram to summarize and compare and contrast these two types of nuclear energy. • evaluate the positive and negative effects of using nuclear energy.

Standard PS.5 (continued)

Overview	Essential Knowledge, Skills, and Processes
• Another type of change occurs in nuclear reactions. 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 effects of using nuclear energy, including radioactive nuclear waste storage and disposal.	

Standard PS.6

The student will investigate and understand states and forms of energy and how energy is transferred and transformed. Key concepts include

a) potential and kinetic energy;
b) mechanical, chemical, and electrical energy; and
c) heat, light, and sound.

Understanding the Standard

The concepts in PS.6 build upon several science standards from previous grades, including 4.2, 4.3, 5.3, 6.3, and 6.4. These standards introduce and develop basic ideas about states and forms of energy. At the sixth grade level, this sequence culminates with the idea about energy transformations. In PS.6, concepts about energy forms, energy transformations, and potential and kinetic energy continue to be expanded and treated in greater depth, including more mathematical application. It is intended that students will actively develop scientific investigation, reasoning, and logic skills (PS.1) in the context of the key concepts presented in this standard.

Standard PS.6

Overview	Essential Knowledge, Skills, and Processes
The critical scientific concepts developed in this standard include the following: • *Energy* is the ability to do work. • Energy exists in two states. *Potential energy* is stored energy based on position or chemical composition. *Kinetic energy* is energy of motion. Students should know that the amount of potential energy associated with an object depends on its position. The amount of kinetic energy depends on the mass and velocity of the moving object. • Important forms of energy include light, heat, chemical, electrical, mechanical, and nuclear energy. Sound is a form of mechanical energy. • Energy can be transformed from one type to another. In any energy conversion, some of the energy is lost to the environment as heat.	In order to meet this standard, it is expected that students should be able to • differentiate between potential and kinetic energy. • use diagrams or concrete examples to compare relative amounts of potential and kinetic energy. • identify and give examples of common forms of energy. • design an investigation or create a diagram to illustrate energy transformations.

Standard PS.7

The student will investigate and understand temperature scales, heat, and heat transfer. Key concepts include

a) Celsius and Kelvin temperature scales and absolute zero;
b) phase change, freezing point, melting point, boiling point, vaporization, and condensation;
c) conduction, convection, and radiation, and
d) applications of heat transfer (heat engines, thermostats, refrigeration, and heat pumps).

Understanding the Standard

This standard focuses on how heat affects matter and how heat is transferred. Concepts introduced in previous grades and related to the states of matter are presented in standards 2.3 and 5.4. More complex concepts and terminology related to phase changes are introduced in PS.7, including the distinction between heat and temperature. It is intended that students will actively develop scientific investigation, reasoning, and logic skills (PS.1) in the context of the key concepts presented in this standard.

Standard PS.7

Overview	Essential Knowledge, Skills, and Processes
The critical scientific concepts developed in this standard include the following: • Atoms and molecules are perpetually in motion. • Increased temperature means greater average kinetic energy of the substance being measured, and most substances expand when heated. The temperature of absolute zero (–273^{o}C/0^{o}K) is the theoretical point at which molecular motion stops. • The transfer of heat occurs in three ways: by conduction, by convection, and by radiation. • Heat and temperature are not the same thing. As heat energy is added to or taken away from a system, the temperature does not always change. There is no change in temperature during a phase change (freezing, melting, condensing, boiling, and vaporizing) as this energy is being used to make or break bonds between molecules.	In order to meet this standard, it is expected that students should be able to • illustrate and explain the effect of the addition or subtraction of heat energy on the motion of molecules. • distinguish between heat and temperature. • compare and contrast Celsius and Kelvin temperature scales and describe absolute zero. • analyze a time/temperature graph of a phase change experiment to determine the temperature at which the phase change occurs (freezing point, melting point, or boiling point). • compare and contrast conduction, convection, and radiation and provide and explain common examples. • explain, in simple terms, how the principle of heat transfer applies to heat engines, thermostats, and refrigerators and heat pumps. • design an investigation from a testable question related to heat transfer. The investigation may be a complete experimental design or may focus on systematic observation, description, measurement, and/or data collection and analysis.

Standard PS.8

The student will investigate and understand characteristics of sound and technological applications of sound waves. Key concepts include

a) wavelength, frequency, speed, and amplitude;
b) resonance;
c) the nature of mechanical waves; and
d) technological applications of sound.

Understanding the Standard

The focus of this standard is the mechanical wave-like nature of sound and some examples of its application. Sound is introduced in science standard 5.2, and it is expected that standard PS.8 will build upon and expand the concepts of the earlier standard. It is intended that students will actively develop scientific investigation, reasoning, and logic skills (PS.1) in the context of the key concepts presented in this standard.

Standard PS.8

Overview	Essential Knowledge, Skills, and Processes
The critical scientific concepts developed in this standard include the following: • Sound is produced by vibrations and is a type of mechanical energy. Sound travels in compression waves and at a speed much slower than light. It needs a medium (solid, liquid, or gas) in which to travel. In a compression wave, matter vibrates in the same direction in which the wave travels. • All waves exhibit certain characteristics: wavelength, frequency, and amplitude. As wavelength increases, frequency decreases. • A longitudinal wave consists of a repeating pattern of compressions and rarefactions. Wavelength is measured as the distance from one compression to the next compression or the distance from one rarefaction to the next rarefaction. • The speed of sound depends on two things: the medium through which the waves travel and the temperature of the medium. • Reflection and interference patterns are used in ultrasonic technology, including sonar and medical diagnosis.	In order to meet this standard, it is expected that students should be able to • model a compression (longitudinal) wave and diagram, label, and describe the basic components: wavelength, compression, rarefaction, and frequency. • determine the relationship between frequency and wavelength. • analyze factors that determine the speed of sound through various materials and interpret graphs and charts that display this information. • describe technological applications of sound waves and generally how each application functions. • design an investigation from a testable question 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. (Students should be able to use the inquiry skills represented in PS.1 and LS.1 to compose a clear hypothesis, create an organized data table, identify variables and constants, record data correctly, construct appropriate graphs, analyze data, and draw reasonable conclusions.)

Standard PS.9

The student will investigate and understand the nature and technological applications of light. Key concepts include

a) the wave behavior of light (reflection, refraction, diffraction, and interference);
b) images formed by lenses and mirrors; and
c) the electromagnetic spectrum.

Understanding the Standard

This standard focuses on the nature of light and its applications. It builds upon standard 5.3, in which students investigate the characteristics of visible light. Standard PS.9 introduces students to the wave behavior of light. The speed of light in a vacuum is a constant. Light can change speed and direction as a result of moving from one medium to another. It is intended that students will actively develop scientific investigation, reasoning, and logic skills (PS.1) in the context of the key concepts presented in this standard.

Standard PS.9

Overview	Essential Knowledge, Skills, and Processes
The critical scientific concepts developed in this standard include the following: • Light travels in straight lines until it strikes an object where it can be reflected, absorbed, or transmitted. As light waves travel through different media, they undergo a change in speed that may result in refraction. • Light is a form of radiant energy that moves in transverse waves. • There is an inverse relationship between frequency and wavelength. • Electromagnetic waves are arranged on the electromagnetic spectrum by wavelength. All types of electromagnetic radiation travel at the speed of light, but differ in wavelength. The electromagnetic spectrum includes gamma rays, X-rays, ultraviolet, visible light, infrared, and radio and microwaves. • 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.	In order to meet this standard, it is expected that students should be able • design an investigation to illustrate the behavior of visible light – reflection and refraction. Describe how reflection and refraction occur. • describe the wave theories of light. • model a transverse wave and draw and label the basic components. Explain wavelength, amplitude, and frequency. • compare the various types of electromagnetic waves in terms of wavelength, frequency, and energy. • describe an everyday application of each of the major forms of electromagnetic energy.

Standard PS.10

The student will investigate and understand scientific principles and technological applications of work, force, and motion. Key concepts include

a) speed, velocity, and acceleration;
b) Newton's laws of motion;
c) work, force, mechanical advantage, efficiency, and power; and
d) applications (simple machines, compound machines, powered vehicles, rockets, and restraining devices).

Understanding the Standard

PS.10 builds upon the concepts of simple machines, force, and work introduced in science standards 3.2 and 4.2. Standard PS.10 reviews and expands these basic ideas and introduces students to more mathematical concepts of motion. It is intended that students will actively develop scientific investigation, reasoning, and logic skills (PS.1) in the context of the key concepts presented in this standard.

Standard PS.10

Overview	Essential Knowledge, Skills, and Processes
The critical scientific concepts developed in this standard include the following: • A force is a push or pull. Force is measured in newtons. Force can cause objects to move, stop moving, change speed, or change direction. *Speed* is the change in position of an object per unit of time. Velocity may have a positive or a negative value depending on the direction of the change in position, whereas speed always has a positive value and is nondirectional. • Newton's three laws of motion describe the motion of all common objects. • *Acceleration* is the change in velocity per unit of time. An object moving with constant velocity has no acceleration. A decrease in velocity is negative acceleration or *deceleration*. A distance-time graph for acceleration is always a curve. Objects moving with circular motion are constantly accelerating because direction (and hence velocity) is constantly changing. • 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. • Work is done when an object is moved through a distance in the direction of the applied force.	In order to meet this standard, it is expected that students should be able to • make measurements to calculate the speed of a moving object. • apply the concepts of speed, velocity, and acceleration when describing motion. • explain how force, mass, and acceleration are related. • differentiate between mass and weight. • identify situations that illustrate each Law of Motion. • apply the concept of mechanical advantage to test and explain how a machine makes work easier. • make measurements to calculate the work done on an object. • make measurements to calculate the power of an object. • explain how the concepts of work, force, and motion apply to car safety technology, machines, and rockets. • solve basic problems given the following formulas: Speed = distance/time ($s = d/t$) Force = mass × acceleration ($F = ma$) Work = force × distance ($W = Fd$) Power = work/time ($P = W/t$).

Standard PS.10 (continued)

Overview	Essential Knowledge, Skills, and Processes
• A simple machine is a device that makes work easier. Simple machines have different purposes: to change the effort needed (mechanical advantage), 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. The ratio of work output to work input is called *efficiency*. • Mathematical formulas are used to calculate speed, force, work, and power.	

Standard PS.11

The student will investigate and understand basic principles of electricity and magnetism. Key concepts include

a) static electricity, current electricity, and circuits;
b) magnetic fields and electromagnets; and
c) motors and generators.

Understanding the Standard

Science standards 4.3 provide students with a strong foundation in the characteristics of electricity and simple circuits. Students in fourth grade construct series and parallel circuits and make electromagnets. Standard PS.11 is intended to provide a more in-depth and mathematical focus on circuits, current, static electricity, and the relationship between electricity and magnetism. It is intended that students will actively develop scientific investigation, reasoning, and logic skills (PS.1) in the context of the key concepts presented in this standard.

Standard PS.11

Overview	Essential Knowledge, Skills, and Processes
The critical scientific concepts developed in this standard include the following: • Several factors affect how much electricity can flow through a system. Resistance is a property of matter that affects the flow electricity. Some substances have more resistance than others. • Friction can cause electrons to be transferred from one object to another. These static electrical charges can build up on an object and be discharged slowly or rapidly. This is often called static electricity. • Electricity is related to magnetism. Magnetic fields can produce electrical current in conductors. Electricity can produce a magnetic field and cause iron and steel objects to act like magnets. • *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. • A *generator* is a device that converts mechanical energy into electrical energy. Most of the electrical energy we use comes from generators. 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.	In order to meet this standard, it is expected that students should be able to • explain the relationship between a magnetic field and an electric current. • design an investigation to illustrate the effects of static electricity. • construct and compare series and parallel circuits. • create an electromagnet and explain how it works. • construct simple circuits to determine the relationship between voltage, resistance, and current. • compare and contrast generators and motors and how they function. • identify situations in everyday life in which motors and generators are used.