Amherst County Public Schools
Physical Science Curriculum Pacing Guide

REV: 8/15

1st 9 weeks	SOL Objectives	Vocabulary
PS.1	**The student will demonstrate an understanding of scientific reasoning, logic, and the nature of science by planning and conducting investigations in which** a) chemicals and equipment are used safely; b) length, mass, volume, density, temperature, weight, and force are accurately measured; c) conversions are made among metric units, applying appropriate prefixes; d) triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, probeware, and spring scales are used to gather data; e) numbers are expressed in scientific notation where appropriate; f) independent and dependent variables, constants, controls, and repeated trials are identified; g) data tables showing the independent and dependent variables, derived quantities, and the number of trials are constructed and interpreted; h) 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; i) frequency distributions, scatterplots, line plots, and histograms are constructed and interpreted; j) valid conclusions are made after analyzing data; k) research methods are used to investigate practical problems and questions; l) experimental results are presented in appropriate written form; m) models and simulations are constructed and used to illustrate and explain phenomena; and n) current applications of physical science concepts are used. **(~15 days and integrate with PS.2-11 throughout the year)** RESOURCES: PS.1	PS.1: volume, weight, mass, density, graduated cylinder, triple-beam balance, independent variable, dependent variable, constant, control, data table, metric system

PS.2 **The student will investigate and understand the nature of matter. Key concepts include** a) the particle theory of matter; b) elements, compounds, mixtures; c) solids, liquids, and gases; d) physical properties; e) chemical properties; and f) characteristics of types of matter based on physical and chemical properties. **6.6a** **(~20 days)** RESOURCES: PS.2 6.6A	PS.2: Particle Theory of Matter, solid, liquid, gas, elements, compounds, mixtures, solubility, acidity, basicity, combustibility, reactivity
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. **6.4a-g** **(~10 days)** RESOURCES: PS.3 6.4	PS.3: proton, neutron, electron, Bohr, Electron Cloud Model

2nd 9 Weeks	SOL Objectives	Vocabulary
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 numbers, atomic mass, chemical families (groups), and periods; b) classification of elements as metals, metalloids, and nonmetals; and c) formation of compounds through ionic and covalent bonding. **(~20 days)** RESOURCES: PS.4	PS.4: symbol, atomic number, atomic mass, family (group), period, metal, nonmetal, metalloid, ion, isotope, ionic bond, covalent bond, valence electrons
PS.5 **6.5a-b**	**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) chemical changes **(~18 days)** RESOURCES: PS.5 6.5	PS.5: Law of Conservation of Matter, physical change, chemical change, chemical reaction, chemical equation, reactants, products, exothermic, endothermic
PS.2	**The student will investigate and understand the nature of matter. Key concepts include** b) acids, bases, and salts **(~7 days)** RESOURCES: PS.2	PS.2b: acid, base, salt, neutralization reaction

3rd Nine weeks SOL Objectives	Vocabulary
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: c) nuclear reactions (products of fusion and fission and the effect of these products on human beings and the environment) **(~10 days)** RESOURCES: PS.5	PS.5: nuclear reaction, fusion, fission, renewable resource, nonrenewable resource,
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. **6.2a 6.2e** **(~10 days)** RESOURCES: PS.6	PS.6: Energy, potential, kinetic, mechanical (sound included), chemical, electrical, heat, light, nuclear, conservation of energy
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). **(~10 days)** RESOURCES: PS.7	PS.7: heat, temperature, conduction, convection, radiation, conductor, insulator, melting, freezing, boiling, condensation, sublimation
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). **(~15 days)** RESOURCES: PS.10	PS.10: speed, velocity, acceleration, transformation, force, work, power, efficiency, mechanical advantage, friction, gravity

<table>
<tr><th>4th Nine Weeks</th><th>SOL Objectives</th><th>Vocabulary</th></tr>
<tr><td colspan="2">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
(~10 days)

RESOURCES: PS.11</td><td>PS.11: electricity, charges, attraction, repulsion, magnetism, static, circuit, current, resistance, voltage, conductor, insulator, conduction, induction, friction</td></tr>
<tr><td colspan="2">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.
(~5 days)

RESOURCES: PS.8</td><td rowspan="2">PS.8, PS.9: wave, transverse, medium, electromagnetic, crest, trough, wavelength, amplitude, frequency, speed, reflection, refraction, diffraction, interference, longitudinal, compression, rarefaction, opaque, transparent, translucent, spectrum</td></tr>
<tr><td colspan="2">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.
(~10 days)

RESOURCES: PS.9</td></tr>
</table>

6.7 The student will investigate and understand the natural processes and human interactions that affect watershed systems. Key concepts include a) the health of ecosystems and the abiotic factors of a watershed; b) the location and structure of Virginia's regional watershed systems; c) divides, tributaries, river systems, and river and stream processes; d) wetlands; e) estuaries; f) major conservation, health, and safety issues associated with watersheds; and water monitoring and analysis using field equipment including hand-held technology. **RESOURCES 6.7**	Estuaries Conservation Watershed terrestrial ecosystem marine ecosystems
6.8 The student will investigate and understand the organization of the solar system and the interactions among the various bodies that comprise it. Key concepts include a) the sun, moon, Earth, other planets and their moons, dwarf planets, meteors, asteroids, and comets; b) relative size of and distance between planets; c) the role of gravity; d) revolution and rotation; e) the mechanics of day and night and the phases of the moon; f) the unique properties of Earth as a planet; g) the relationship of Earth's tilt and the seasons; h) the cause of tides; and i) the history and technology of space exploration. **RESOURCES 6.8**	solar system sun moon Earth dwarf planets meteors asteroids comets gravity revolution rotation phases tilt tides space exploration

6.9 The student will investigate and understand public policy decisions relating to the environment. Key concepts include a) management of renewable resources; b) management of nonrenewable resources; c) the mitigation of land-use and environmental hazards through preventive measures; and cost/benefit tradeoffs in conservation policies. **RESOURCES 6.9**	renewable resources nonrenewable resources mitigation environment
*****Remainder of the nine weeks is spent reviewing for and taking Grade 8 Science SOL. Other activities that encompass the entire year take place after the SOL test.**	

Science Standards of Learning

Curriculum Framework 2010

Physical Science

Virginia *Science Standards of Learning* Curriculum Framework 2010

Introduction

The *Science Standards of Learning* Curriculum Framework amplifies the *Science Standards of Learning for Virginia Public Schools* and defines the content knowledge, skills, and understandings that are measured by the Standards of Learning tests. The Science Curriculum 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 essential understandings and defining the essential content knowledge, skills, and processes students need to master. This supplemental framework delineates in greater specificity the minimum content that all teachers should teach and all students should learn.

School divisions should use the *Science Curriculum 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 Standards of Learning should be included as part of quality learning experiences.

The Curriculum Framework serves as a guide for Standards of Learning assessment development. Assessment items may not and should not be a verbatim reflection of the information presented in the Curriculum Framework. Students are expected to continue to apply knowledge and skills from Standards of Learning 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 Standards of Learning 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 Standards of Learning tests, for which students may earn verified units of credit, are administered in a locally determined sequence.

Each topic in the *Science Standards of Learning* Curriculum Framework is developed around the Standards of Learning. The format of the Curriculum Framework facilitates teacher planning by identifying the key concepts, knowledge and skills that should be the focus of instruction for each standard. The Curriculum Framework is divided into two columns: Understanding the Standard (K-5); Essential Understandings (middle and high school); and Essential Knowledge, Skills, and Processes. The purpose of each column is explained below.

Understanding the Standard (K-5)

This section includes background information for the teacher. It contains content that may extend the teachers' knowledge of the standard beyond the current grade level. This section may also contain suggestions and resources that will help teachers plan instruction focusing on the standard.

Essential Understandings (middle and high school)

This section delineates the key concepts, ideas and scientific relationships that all students should grasp to demonstrate an understanding of the Standards of Learning.

Essential Knowledge, Skills and Processes (K-12)

Each standard is expanded in the Essential Knowledge, Skills, and Processes column. What each student should know and be able to do in each standard is outlined. This is not meant to be an exhaustive list nor a list that limits what is taught in the classroom. It is meant to be the key knowledge and skills that define the standard.

Standard PS.1

PS.1	The student will demonstrate an understanding of scientific reasoning, logic and the nature of science by planning and conducting investigations in which a) chemicals and equipment are used safely; b) length, mass, volume, density, temperature, weight, and force are accurately measured; c) conversions are made among metric units, applying appropriate prefixes; d) triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, probeware, and spring scales are used to gather data; e) numbers are expressed in scientific notation where appropriate; f) independent and dependent variables, constants, controls, and repeated trials are identified; g) data tables showing the independent and dependent variables, derived quantities, and the number of trials are constructed and interpreted; h) 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; i) frequency distributions, scatterplots, line plots, and histograms are constructed and interpreted; j) valid conclusions are made after analyzing data; k) research methods are used to investigate practical problems and questions; l) experimental results are presented in appropriate written form; m) models and simulations are constructed and used to illustrate and explain phenomena; and n) current applications of physical science concepts are used.

Overview

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 Standards of Learning concepts. Models, simulations, and current applications are used throughout the course in order to learn and reinforce science concepts.

Across the grade levels, kindergarten through high school, the skills in the first standards form a nearly continuous 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

PS.1	The student will demonstrate an understanding of scientific reasoning, logic and the nature of science by planning and conducting investigations in which a) chemicals and equipment are used safely; b) length, mass, volume, density, temperature, weight, and force are accurately measured; c) conversions are made among metric units, applying appropriate prefixes; d) triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, probeware, and spring scales are used to gather data; e) numbers are expressed in scientific notation where appropriate; f) independent and dependent variables, constants, controls, and repeated trials are identified; g) data tables showing the independent and dependent variables, derived quantities, and the number of trials are constructed and interpreted; h) 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; i) frequency distributions, scatterplots, line plots, and histograms are constructed and interpreted; j) valid conclusions are made after analyzing data; k) research methods are used to investigate practical problems and questions; l) experimental results are presented in appropriate written form; m) models and simulations are constructed and used to illustrate and explain phenomena; and n) current applications of physical science concepts are used.

Essential Understandings	Essential Knowledge, Skills, and Processes
The critical scientific concepts developed in this standard include the following: • The nature of science refers to the foundational concepts that govern the way scientists formulate explanations about the natural world. The nature of science includes the following concepts of a) the natural world is understandable; b) science is based on evidence - both observational and experimental; c) science is a blend of logic and innovation; d) scientific ideas are durable yet subject to change as new data are collected; e) science is a complex social endeavor; and f) scientists try to remain objective and engage in peer review to help avoid bias.	In order to meet this standard, it is expected that students will • make connections between the components of the nature of science and their investigations and the greater body of scientific knowledge and research. • select appropriate equipment (probeware, 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,

Standard PS.1

PS.1 The student will demonstrate an understanding of scientific reasoning, logic and the nature of science by planning and conducting investigations in which

a) chemicals and equipment are used safely;
b) length, mass, volume, density, temperature, weight, and force are accurately measured;
c) conversions are made among metric units, applying appropriate prefixes;
d) triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, probeware, and spring scales are used to gather data;
e) numbers are expressed in scientific notation where appropriate;
f) independent and dependent variables, constants, controls, and repeated trials are identified;
g) data tables showing the independent and dependent variables, derived quantities, and the number of trials are constructed and interpreted;
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k) research methods are used to investigate practical problems and questions;
l) experimental results are presented in appropriate written form;
m) models and simulations are constructed and used to illustrate and explain phenomena; and
n) current applications of physical science concepts are used.

Essential Understandings	Essential Knowledge, Skills, and Processes
• Systematic investigations require standard measures and consistent and reliable tools. International System of Units (SI or 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, scatterplots, 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	degrees Celsius, and newtons. • recognize metric prefix units and make common metric conversions between the same base metric unit (for example, nanogram to milligram or kilometer to meter). • 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. • 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,

Standard PS.1

PS.1	The student will demonstrate an understanding of scientific reasoning, logic and the nature of science by planning and conducting investigations in which a) chemicals and equipment are used safely; b) length, mass, volume, density, temperature, weight, and force are accurately measured; c) conversions are made among metric units, applying appropriate prefixes; d) triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, probeware, and spring scales are used to gather data; e) numbers are expressed in scientific notation where appropriate; f) independent and dependent variables, constants, controls, and repeated trials are identified; g) data tables showing the independent and dependent variables, derived quantities, and the number of trials are constructed and interpreted; h) 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; i) frequency distributions, scatterplots, line plots, and histograms are constructed and interpreted; j) valid conclusions are made after analyzing data; k) research methods are used to investigate practical problems and questions; l) experimental results are presented in appropriate written form; m) models and simulations are constructed and used to illustrate and explain phenomena; and n) current applications of physical science concepts are used.

Essential Understandings	Essential Knowledge, Skills, and Processes
comparing the results of manipulating the independent variable. Controls receive no experimental treatment. Not all experiments have a control, however. • 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. • Some useful applications of physical science concepts are in the area of materials science (e.g., metals, ceramics, and semiconductors).	design an investigation, gather evidence, formulate an answer to the original question, communicate the investigative process and results, and realize this methodology does not always follow a prescribed sequence. • 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. • use current technologies to model and simulate experimental conditions. • recognize examples of the use of nanotechnology and its applications.

Standard PS.1

PS.1	The student will demonstrate an understanding of scientific reasoning, logic and the nature of science by planning and conducting investigations in which a) chemicals and equipment are used safely; b) length, mass, volume, density, temperature, weight, and force are accurately measured; c) conversions are made among metric units, applying appropriate prefixes; d) triple beam and electronic balances, thermometers, metric rulers, graduated cylinders, probeware, and spring scales are used to gather data; e) numbers are expressed in scientific notation where appropriate; f) independent and dependent variables, constants, controls, and repeated trials are identified; g) data tables showing the independent and dependent variables, derived quantities, and the number of trials are constructed and interpreted; h) 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; i) frequency distributions, scatterplots, line plots, and histograms are constructed and interpreted; j) valid conclusions are made after analyzing data; k) research methods are used to investigate practical problems and questions; l) experimental results are presented in appropriate written form; m) models and simulations are constructed and used to illustrate and explain phenomena; and n) current applications of physical science concepts are used.

Essential Understandings	Essential Knowledge, Skills, and Processes
• Nanotechnology is the study of materials at the molecular (atomic) scale. Items at this scale are so small they are no longer visible with the naked eye. Nanotechnology has shown that the behavior and properties of some substances at the nanoscale (a nanometer is one-billionth of a meter) contradict how they behave and what their properties are at the visible scale. • New discoveries based on nanoscience investigations have allowed the production of superior new materials with improved properties (e.g., computers, cell phones).	

Standard PS.2

PS.2	The student will investigate and understand the 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) physical properties; e) chemical properties; and f) characteristics of types of matter based on physical and chemical properties.

Overview

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, and the nature of science (PS.1) in the context of the key concepts presented in this standard.

Standard PS.2

PS.2 The student will investigate and understand the 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) physical properties;
e) chemical properties; and
f) characteristics of types of matter based on physical and chemical properties.

Essential Understandings	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, a gas, or plasma. • 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. • Matter can be described by its physical properties, which include shape, density, solubility, odor, melting point, boiling point, and color. Some	In order to meet this standard, it is expected that students will • describe the particle theory of matter. • describe how to determine whether a substance is an element, compound, or mixture. • define compounds as inorganic or organic. (All organic compounds contain carbon). • describe what a salt is and explain how salts form. • describe the properties of solids, liquids, gases, and plasma. • 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. • determine the identity of an unknown substance by comparing its properties to those of known substances. • 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

Standard PS.2

PS.2	The student will investigate and understand the 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) physical properties; e) chemical properties; and f) characteristics of types of matter based on physical and chemical properties.

Essential Understandings	Essential Knowledge, Skills, and Processes
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.	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

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.

Overview

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, and the nature of science (PS.1) in the context of the key concepts presented in this standard.

Standard PS.3

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.

Essential Understandings	Essential Knowledge, Skills, and Processes
The critical scientific concepts developed in this standard include the following: • Many scientists have contributed to our understanding of atomic structure. • The atom is the basic building block of matter and consists of subatomic particles (proton, neutron, electron, and quark) that differ in their location, charge, and relative mass. Protons and neutrons are made up of smaller particles called quarks. • Size at the atomic level is measured on the nanoscale. • 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 will • describe the historical development of the concept of the atom and the contributions of Dalton, Thomson, Rutherford, Bohr and other scientists (Schrödinger). • 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 its ability to represent accurately the three-dimensional structure of the atom.

Standard PS.4

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) formation of compounds through ionic and covalent bonding.

Overview

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 obtain information from it. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (PS.1) in the context of the key concepts presented in this standard.

Standard PS.4

<table>
<tr><td colspan="2">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) formation of compounds through ionic and covalent bonding.</td></tr>
<tr><th>Essential Understandings</th><th>Essential Knowledge, Skills, and Processes</th></tr>
<tr><td>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 vertical columns in the table are called groups or families. 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.

• 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</td><td>In order to meet this standard, it is expected that students will

• 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.

• recognize that an atom's identity is related to the number of protons in its nucleus.

• categorize a given element as metal, nonmetal, 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.

• describe the difference between ionic and covalent bonding.

• predict what kind of bond (ionic or covalent) will likely form when metals and nonmetals are chemically combined.</td></tr>
</table>

Standard PS.4

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) formation of compounds through ionic and covalent bonding.

Essential Understandings	Essential Knowledge, Skills, and Processes
across the table. Along the stair-step line are the metalloids, which have properties of both metals and nonmetals. • 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. • 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

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) chemical changes; and c) nuclear reactions.

Overview

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, and the nature of science (PS.1) in the context of the key concepts presented in this standard.

Standard PS.5

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) chemical changes; and
c) nuclear reactions.

Essential Understandings	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. Chemical changes are often affected by the surface area/volume ratio of the materials involved in the change. • 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.) • 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.	In order to meet this standard, it is expected that students will • compare and contrast physical, chemical, and nuclear changes. • identify the reactants and products in a given chemical equation formula. • 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.6

PS.6	The student will investigate and understand forms of energy and how energy is transferred and transformed. Key concepts include a) potential and kinetic energy; and b) mechanical, chemical, electrical, thermal, radiant and nuclear energy.

Overview

The concepts in PS.6 build upon several science standards from previous grades, including 4.2, 4.3, 6.2, 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, and the nature of science (PS.1) in the context of the key concepts presented in this standard.

Standard PS.6

PS.6	The student will investigate and understand forms of energy and how energy is transferred and transformed. Key concepts include a) potential and kinetic energy; and b) mechanical, chemical, electrical, thermal, radiant and nuclear energy.

Essential Understandings	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 radiant, thermal, chemical, electrical, mechanical, and nuclear energy. Visible light is a form of radiant energy and 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 thermal energy.	In order to meet this standard, it is expected that students will • 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

PS.7	The student will investigate and understand temperature scales, heat, and thermal energy 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 thermal energy transfer.

Overview

This standard focuses on how thermal energy 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, and the nature of science (PS.1) in the context of the key concepts presented in this standard.

Standard PS.7

PS.7	The student will investigate and understand temperature scales, heat, and thermal energy 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 thermal energy transfer.

Essential Understandings	Essential Knowledge, Skills, and Processes
The critical scientific concepts developed in this standard include the following: • Heat and temperature are not the same thing. Heat is the transfer of thermal energy between substances of different temperature. As thermal energy is added, the temperature of a substance increases. • Temperature is a measure of the average kinetic energy of the molecules of a substance. Increased temperature means greater average kinetic energy of the molecules in the substance being measured, and most substances expand when heated. The temperature of absolute zero (–273^{o}C/0 K) is the theoretical point at which molecular motion stops. • Atoms and molecules are perpetually in motion. • The transfer of thermal energy occurs in three ways: by conduction, by convection, and by radiation. • As thermal 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, evaporating, 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 will • distinguish between heat and temperature. • compare and contrast Celsius and Kelvin temperature scales and describe absolute zero. • illustrate and explain the effect of the addition or subtraction of thermal energy on the motion of molecules. • 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 methods of thermal energy transfer (conduction, convection, and radiation) and provide and explain common examples. • explain, in simple terms, how the principle of thermal energy transfer applies to heat engines, thermostats, refrigerators, heat pumps, and geothermal systems. • design an investigation from a testable question related to thermal energy 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

PS.8	The student will investigate and understand the characteristics of sound waves. Key concepts include a) wavelength, frequency, speed, amplitude, rarefaction, and compression; b) resonance; c) the nature of compression waves; and d) technological applications of sound.

Overview

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, and the nature of science (PS.1) in the context of the key concepts presented in this standard.

Standard PS.8

PS.8	The student will investigate and understand the characteristics of sound waves. Key concepts include a) wavelength, frequency, speed, amplitude, rarefaction, and compression; b) resonance; c) the nature of compression waves; and d) technological applications of sound.

Essential Understandings	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. • The speed of sound depends on two things: the medium through which the waves travel and the temperature of the medium. • Resonance is the tendency of a system to vibrate at maximum amplitude at certain frequencies. • 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 or the distance from one rarefaction to the next rarefaction. • 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 will • 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. • identify examples illustrating resonance (e.g., musical instruments, Tacoma Narrows Bridge, crystal stemware). • model a compression (longitudinal) wave and diagram, label, and describe the basic components: wavelength, compression, rarefaction, and frequency. • 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.

Standard PS.9

PS.9	The student will investigate and understand the characteristics of transverse waves. Key concepts include a) wavelength, frequency, speed, amplitude, crest, and trough; b) the wave behavior of light; c) images formed by lenses and mirrors; d) the electromagnetic spectrum; and e) technological applications of light.

Overview

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, and the nature of science (PS.1) in the context of the key concepts presented in this standard.

Standard PS.9

PS.9	The student will investigate and understand the characteristics of transverse waves. Key concepts include a) wavelength, frequency, speed, amplitude, crest, and trough; b) the wave behavior of light; c) images formed by lenses and mirrors; d) the electromagnetic spectrum; and e) technological applications of light.

Essential Understandings	Essential Knowledge, Skills, and Processes
The critical scientific concepts developed in this standard include the following: • Visible light is a form of radiant energy that moves in transverse waves. • All transverse waves exhibit certain characteristics: wavelength, crest, trough, frequency, and amplitude. As wavelength increases, frequency decreases. There is an inverse relationship between frequency and wavelength. • Radiant energy travels in straight lines until it strikes an object where it can be reflected, absorbed, or transmitted. As visible light travels through different media, it undergoes a change in speed that may result in refraction. • 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. • Plane, concave, and convex mirrors all reflect light. Convex mirrors diverge light and produce a smaller, upright image. Concave mirrors converge light and produce an upright, magnified image if close and an	In order to meet this standard, it is expected that students will • model a transverse wave and draw and label the basic components. Explain wavelength, amplitude, frequency, crest, and trough. • describe the wave behavior of visible light (refraction, reflection, diffraction, and interference). • design an investigation to illustrate the behavior of visible light – reflection and refraction. Describe how reflection and refraction occur. • identify the images formed by lenses and mirrors. • 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.9

PS.9	The student will investigate and understand the characteristics of transverse waves. Key concepts include a) wavelength, frequency, speed, amplitude, crest, and trough; b) the wave behavior of light; c) images formed by lenses and mirrors; d) the electromagnetic spectrum; and e) technological applications of light.

Essential Understandings	Essential Knowledge, Skills, and Processes
inverted, smaller image if far away. • Concave and convex lenses refract light. Convex lenses converge light. Concave lenses diverge light. • Diffraction is when light waves strike an obstacle and new waves are produced. • Interference takes place when two or more waves overlap and combine as a result of diffraction.	

Standard PS.10

PS.10	The student will investigate and understand the scientific principles 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) technological applications of work, force, and motion.

Overview

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, and the nature of science (PS.1) in the context of the key concepts presented in this standard.

Standard PS.10

PS.10 The student will investigate and understand the scientific principles 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) technological applications of work, force, and motion.

Essential Understandings	Essential Knowledge, Skills, and Processes
The critical scientific concepts developed in this standard include the following: • 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. • Newton's three laws of motion describe the motion of all common objects. • 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. • 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. • Work is done when an object is moved through a distance in the direction of the applied force. • 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	In order to meet this standard, it is expected that students will • make measurements to calculate the speed of a moving object. • apply the concepts of speed, velocity, and acceleration when describing motion. • differentiate between mass and weight. • identify situations that illustrate each Law of Motion. • explain how force, mass, and acceleration are related. • 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. • 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 ($P = W/t$). • explain how the concepts of work, force, and motion apply to everyday uses and current technologies.

Standard PS.10

PS.10	The student will investigate and understand the scientific principles 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) technological applications of work, force, and motion.

Essential Understandings	Essential Knowledge, Skills, and Processes
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

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) relationship between a magnetic field and an electric current; c) electromagnets, motors, and generators and their uses; and d) conductors, semiconductors, and insulators.

Overview

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, and the nature of science (PS.1) in the context of the key concepts presented in this 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) relationship between a magnetic field and an electric current;
c) electromagnets, motors, and generators and their uses.; and
d) conductors, semiconductors, and insulators.

Essential Understandings

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 of 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.
- A conductor is a material that transfers an electric current well. An insulator is material that does not transfer an electric current. A semiconductor is in-between a conductor and an insulator.
- The diode is a semiconductor device that acts like a one way valve to control the flow of electricity in electrical circuits. Solar cells are made

Essential Knowledge, Skills, and Processes

In order to meet this standard, it is expected that students will

- 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.
- explain the relationship between a magnetic field and an electric current.
- 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.
- provide examples of materials that are good conductors, semiconductors, and insulators.
- identify current applications of semiconductors and their uses (e.g., diodes and transistors).

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) relationship between a magnetic field and an electric current;
c) electromagnets, motors, and generators and their uses.; and
d) conductors, semiconductors, and insulators.

Essential Understandings	Essential Knowledge, Skills, and Processes
of semiconductor diodes that produce direct current (DC) when visible light, infrared light (IR), or ultraviolet (UV) energy strikes them. Light emitting diodes (LED) emit visible light or infrared radiation when current passes through them. An example is the transmitter in an infrared TV remote or the lighting course behind the screen in an LED TV or notebook computer screen. • Transistors are semiconductor devices made from silicon, and other semiconductors. They are used to amplify electrical signals (in stereos, radios, etc.) or to act like a light switch turning the flow of electricity on and off.	

Grade Six
Science Strand

Force, Motion, and Energy

The strand focuses on student understanding of what force, motion, and energy are and how the concepts are connected. The major topics developed in this strand include magnetism; types of motion; simple machines; and energy forms and transformations, especially electricity, sound, and light. This strand includes science standards K.3, 1.2, 2.2, 3.2, 4.2, 4.3, 5.2, 5.3, 6.2, and 6.3.

6.2	The student will investigate and understand basic sources of energy, their origins, transformations, and uses. Key concepts include a) potential and kinetic energy; b) the role of the sun in the formation of most energy sources on Earth; c) nonrenewable energy sources; d) renewable energy sources; and e) energy transformations.

Overview

Many sources of energy on Earth are the result of solar radiation. This can be energy Earth is currently receiving or energy that has been stored as fossil fuels. All energy exists in two basic forms — kinetic and potential. Understanding the forms of energy and their transformations will provide the foundation for students to investigate the transfer of energy within living and Earth systems as well as to understand chemical reactions, force, and motion. This standard builds upon concepts of energy sources introduced in science standard 3.11. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and an understanding of the nature of science (6.1) in the context of the key concepts presented in this standard.

6.2 The student will investigate and understand basic sources of energy, their origins, transformations, and uses. Key concepts include

a) potential and kinetic energy;
b) the role of the sun in the formation of most energy sources on Earth;
c) nonrenewable energy sources;
d) renewable energy sources; and
e) energy transformations.

Essential Understandings	Essential Knowledge, Skills, and Processes
The concepts developed in this standard include the following: • Potential energy is energy that is not "in use" and available to do work. Kinetic energy is energy that is "in use" — the energy a moving object has due to its motion. For example, moving water and wind have kinetic energy. The chemical energy in fossil fuels is potential energy until it is released. • Solar energy from the ancient past is stored in fossil fuels, such as coal, petroleum, and natural gas. Fossil fuels are rich in the elements carbon and hydrogen. These sources of energy take very long periods of time to form and once depleted, are essentially nonrenewable. Nuclear power is also a source of nonrenewable energy. • Many of Earth's energy resources are available on a perpetual basis. These include solar, wind, water (hydropower, tidal and waves), biofuels and geothermal energy. Some energy sources can be replenished over relatively short periods of time. These include wood and other biomass. All are considered renewable. • Secondary sources of energy, such as electricity, are used to store, move, and deliver energy easily in usable form. Hydrogen is also a secondary source of energy, also called an energy carrier. • Thermal and radiant energy can be converted into mechanical energy, chemical energy, and electrical energy and back again.	In order to meet this standard, it is expected that students will • compare and contrast potential and kinetic energy through common examples found in the natural environment. • analyze and describe the transformations of energy involved with the formation and burning of coal and other fossil fuels. • compare and contrast renewable (solar, wind, water [hydropower, tidal and waves], biofuels, geothermal, and biomass) and nonrenewable energy sources (coal, petroleum, natural gas, nuclear power). • explain that hydrogen is not an energy source, but a means of storing and transporting energy. • design an application of the use of solar and wind energy. • chart and analyze the energy a person uses during a 24-hour period and determine the sources. • compare and contrast energy sources in terms of their origins, how they are utilized, and their availability. • analyze the advantages and disadvantages of using various energy sources and their impact on climate and the environment. • analyze and describe how the United States' energy use has changed over time. • analyze and describe sources of energy used in Virginia related to energy use nationally and globally.

6.2 The student will investigate and understand basic sources of energy, their origins, transformations, and uses. Key concepts include

a) potential and kinetic energy;
b) the role of the sun in the formation of most energy sources on Earth;
c) nonrenewable energy sources;
d) renewable energy sources; and
e) energy transformations.

Essential Understandings	Essential Knowledge, Skills, and Processes
	• predict the impact of unanticipated energy shortages. • comprehend and apply basic terminology related to energy sources and transformations. • create and interpret a model or diagram of an energy transformation. • design an investigation that demonstrates how light energy (radiant energy) can be transformed into other forms of energy (mechanical, chemical and electrical).

Grade Six
Science Strand

Matter

This strand focuses on the description, physical properties, and basic structure of matter. The major topics developed in this strand include concepts related to the basic description of objects, phases of matter (solids, liquids, and gases – especially water), phase changes, mass and volume, and the structure of classification of matter. This strand includes science standards K.4, K.5, 1.3, 2.3, 3.3, 5.4, 6.4, 6.5, and 6.6.

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

Overview

Standard 6.4 focuses on an understanding of the basic structure of the atom, including electrons, protons, and neutrons. The concepts defined in standard 6.4 build on students' basic understanding of the concept of matter as introduced in science standards 3.3 and 5.4. Knowledge of basic chemistry concepts is fundamental to understanding the physical sciences, life processes, and Earth and environmental science ideas. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and the nature of science (6.1) in the context of the key concepts presented in this standard.

6.4 The student will investigate and understand that all matter is made up of atoms. Key concepts include

a) atoms consist of particles, including electrons, protons, and neutrons;
b) atoms of a particular element are alike but are different from atoms of other elements;
c) elements may be represented by chemical symbols;
d) two or more atoms interact to form new substances, which are held together by electrical forces (bonds);
e) compounds may be represented by chemical formulas;
f) chemical equations can be used to model chemical changes; and
g) a limited number of elements comprise the largest portion of the solid Earth, living matter, the oceans, and the atmosphere.

Essential Understandings	Essential Knowledge, Skills, and Processes
The concepts developed in this standard include the following: • The basic structural components of a typical atom are electrons, protons, and neutrons. Protons and neutrons comprise the nucleus of an atom. • An element is a form of matter made up of one type of atom. The atoms of an element are basically alike, though the number of neutrons may vary. • The atoms of one element differ from those of another element in the number of protons. • Elements can be represented by chemical symbols. • Two or more atoms of different elements may combine to form a compound. • Compounds can be represented by chemical formulas. Each different element in the compound is represented by its unique symbol. The number of each type of element in the compound (other than 1) is represented by a small number (the subscript) to the right of the element symbol. • Chemical equations can be used to model chemical changes, illustrating how elements become rearranged in a chemical reaction. • A limited number of elements, including silicon, aluminum, iron, sodium, calcium, potassium, magnesium, hydrogen, oxygen, nitrogen, and carbon, form the largest portion of Earth's crust, living matter, the	In order to meet this standard, it is expected that students will • create and interpret a simplified modern model of the structure of an atom. • compare and contrast the atomic structure of two different elements. • explain that elements are represented by symbols. • identify the name and number of each element present in a simple molecule or compound, such as O_2, H_2O, CO_2, or $CaCO_3$. • model a simple chemical change with an equation and account for all atoms. Distinguish the types of elements and number of each element in the chemical equation. (Balancing equations will be further developed in Physical Science.) • name some of the predominant elements found in the atmosphere, the oceans, living matter, and Earth's crust.

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

Essential Understandings	Essential Knowledge, Skills, and Processes
oceans, and the atmosphere.	

6.5	The student will investigate and understand the unique properties and characteristics of water and its roles in the natural and human-made environment. Key concepts include a) water as the universal solvent; b) the properties of water in all three phases; c) the action of water in physical and chemical weathering; d) the ability of large bodies of water to store thermal energy and moderate climate; e) the importance of water for agriculture, power generation, and public health; and f) the importance of protecting and maintaining water resources.

Overview

Standard 6.5 is intended to develop student understanding of the unique properties of water and the importance of protecting and managing water resources. Understanding the structure, properties, and behavior of the water molecule is fundamental to understanding more complex environmental systems. Concepts like solubility, surface tension, cohesion, adhesion, density, condensation, and evaporation can be investigated to appreciate why the properties of water are critical to life processes and living things. This standard also introduces the concept of the ability of large bodies of water to moderate the climate on land. The connections between water resources and agriculture, power generation, and public health are also investigated. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and an understanding of the nature of science (6.1) in the context of the key concepts presented in this standard.

6.5	The student will investigate and understand the unique properties and characteristics of water and its roles in the natural and human-made environment. Key concepts include a) water as the universal solvent; b) the properties of water in all three phases; c) the action of water in physical and chemical weathering; d) the ability of large bodies of water to store thermal energy and moderate climate; e) the importance of water for agriculture, power generation, and public health; and f) the importance of protecting and maintaining water resources.

Essential Understandings	Essential Knowledge, Skills, and Processes
The concepts developed in this standard include the following: • Among water's unique properties is that one side of each water molecule is slightly negative and the other is slightly positive. Individual water molecules, therefore, attract other water molecules like little magnets as the slightly positive portion of a water molecule is attracted to the slightly negative portion of an adjacent water molecule. In this way, water molecules "stick together." • Due to water's polar nature, a large number of substances will "dissolve" in water. For this reason, water is often called the universal solvent. • Water is the only compound that commonly exists in all three states (solid, liquid, gas) on Earth. The unique properties of water are a major factor in the ability of our planet to sustain life. • Additional properties of water are its high surface tension and the large range of temperature (0–100 degrees Celsius) in which it can be found in the liquid state, as well as the fact that, unlike other substances, solid water is less dense than liquid water. • Water is able to absorb thermal energy without showing relatively large changes in temperature. Large bodies of water act to moderate the climate of surrounding areas by absorbing thermal energy in summer and slowly releasing that energy in the winter. For this reason, the climate near large bodies of water is slightly milder than areas without large bodies of water.	In order to meet this standard, it is expected that students will • comprehend and apply key terminology related to water and its properties and uses. • model and explain the shape and composition of a water molecule. • design an investigation to demonstrate the ability of water to dissolve materials. • comprehend the adhesive and cohesive properties of water. • compare the effects of adding thermal energy to the states of water. • explain why ice is less dense than liquid water. • relate the three states of water to the water cycle. • design an investigation to model the action of freezing water on rock material. • design an investigation to determine the presence of water in plant material (e.g., a fruit). • infer how the unique properties of water are key to the life processes of organisms. • design an investigation to model the action of acidified water on building materials such as concrete, limestone, or marble. • chart, record, and describe evidence of chemical weathering in the

6.5	The student will investigate and understand the unique properties and characteristics of water and its roles in the natural and human-made environment. Key concepts include a) water as the universal solvent; b) the properties of water in all three phases; c) the action of water in physical and chemical weathering; d) the ability of large bodies of water to store thermal energy and moderate climate; e) the importance of water for agriculture, power generation, and public health; and f) the importance of protecting and maintaining water resources.

Essential Understandings	Essential Knowledge, Skills, and Processes
• Water (rain, ice, snow) has shaped our environment by physically and chemically weathering rock and soil and transporting sediments. Freezing water can break rock without any change in the minerals that form the rock (physical weathering). This usually produces small particles and sand. Water with dissolved gases and other chemicals causes the minerals in rocks to be changed, leading to the deterioration of the rock (chemical weathering). • Most of Earth's water is salt water in the oceans (97 percent). Nonfrozen, fresh water makes up less than 1 percent of the water on Earth. • Water is essential for agriculture. Crops watered by reliable irrigation systems are more productive and harvests more dependable. • Water is an important resource used in power generation. Hydroelectric power plants make use of the kinetic energy of water as it flows through turbines. Water is also heated in power plants and turned to steam. The steam is used to turn turbines, which generate electricity. • In the past, streams and rivers were often used to dispose of human waste, and open sewers were common. During the mid-1800s, public health officials recognized the connection between disease outbreaks and contamination of public wells and drinking water. Advances in water treatment and sanitary sewers have helped eliminate diseases associated with human waste. • Due to water's importance in power generation, agriculture, and human health, it is important to conserve water resources.	local environment. • analyze and explain the difference in average winter temperatures among areas in central and western Virginia and cities and counties along the Chesapeake Bay and Atlantic coast. • explain the role of water in power generation. • describe the importance of careful management of water resources.

6.5	The student will investigate and understand the unique properties and characteristics of water and its roles in the natural and human-made environment. Key concepts include a) water as the universal solvent; b) the properties of water in all three phases; c) the action of water in physical and chemical weathering; d) the ability of large bodies of water to store thermal energy and moderate climate; e) the importance of water for agriculture, power generation, and public health; and f) the importance of protecting and maintaining water resources.

Essential Understandings	Essential Knowledge, Skills, and Processes

6.6	The student will investigate and understand the properties of air and the structure and dynamics of Earth's atmosphere. Key concepts include a) air as a mixture of gaseous elements and compounds; b) pressure, temperature, and humidity; c) atmospheric changes with altitude; d) natural and human-caused changes to the atmosphere and the importance of protecting and maintaining air quality; e) the relationship of atmospheric measures and weather conditions; and f) basic information from weather maps, including fronts, systems, and basic measurements.

Overview

Standard 6.6 is intended to provide students with a basic understanding of the properties of air, the structure of the atmosphere, weather, and air quality. Students need to understand there are both natural and human-caused changes to the atmosphere and that the results of these changes are not yet fully known. A basic understanding of weather and weather prediction builds on the key concepts in standard 4.6. Standard 6.6 also focuses on student understanding of air quality as an important parameter of human and environmental health. It is important to make the obvious connections between this standard and the other sixth-grade standards. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and an understanding of the nature of science (6.1) in the context of the key concepts presented in this standard.

6.6 The student will investigate and understand the properties of air and the structure and dynamics of Earth's atmosphere. Key concepts include
a) air as a mixture of gaseous elements and compounds;
b) pressure, temperature, and humidity;
c) atmospheric changes with altitude;
d) natural and human-caused changes to the atmosphere and the importance of protecting and maintaining air quality;
e) the relationship of atmospheric measures and weather conditions; and
f) basic information from weather maps, including fronts, systems, and basic measurements.

Essential Understandings

The concepts developed in this standard include the following:

- Air is a mixture of gaseous elements and compounds. These include nitrogen, oxygen, water, argon and carbon dioxide. Nitrogen makes up the largest proportion of air.
- Air exerts pressure. Air pressure decreases as altitude increases.
- Moisture in the air is called humidity.
- The atmosphere is made up of layers (troposphere, stratosphere, mesosphere, and thermosphere) that have distinct characteristics.
- Temperature decreases as altitude increases in the lowest layer of the atmosphere.
- Most of the air that makes up the atmosphere is found in the troposphere (the lowest layer). Virtually all weather takes place there.
- Forest fires and volcanic eruptions are two natural processes that affect Earth's atmosphere. Many gaseous compounds and particles are released into the atmosphere by human activity. All of the effects of these materials are not yet fully understood.
- The amounts of thermal energy and water vapor in the air and the pressure of the air largely determine what the weather conditions are.
- Clouds are important indicators of atmospheric conditions. Clouds are found at various levels within the troposphere. Three major types of clouds are cumulus, stratus, and cirrus.
- Ozone, a form of oxygen, can form near the surface when exhaust

Essential Knowledge, Skills, and Processes

In order to meet this standard, it is expected that students will

- comprehend and apply basic terminology related to air and the atmosphere.
- identify the composition and physical characteristics of the atmosphere.
- analyze and interpret charts and graphs of the atmosphere in terms of temperature and pressure.
- measure and record air temperature, air pressure, and humidity, using appropriate units of measurement and tools.
- analyze and explain some of the effects that natural events and human activities may have on weather, atmosphere, and climate.
- evaluate their own roles in protecting air quality.
- design an investigation to relate temperature, barometric pressure, and humidity to changing weather conditions.
- compare and contrast cloud types and relate cloud types to weather conditions.
- compare and contrast types of precipitation.
- compare and contrast weather-related phenomena, including thunderstorms, tornadoes, hurricanes, and drought.
- interpret basic weather maps and make forecasts based on the information presented.

6.6 The student will investigate and understand the properties of air and the structure and dynamics of Earth's atmosphere. Key concepts include
a) air as a mixture of gaseous elements and compounds;
b) pressure, temperature, and humidity;
c) atmospheric changes with altitude;
d) natural and human-caused changes to the atmosphere and the importance of protecting and maintaining air quality;
e) the relationship of atmospheric measures and weather conditions; and
f) basic information from weather maps, including fronts, systems, and basic measurements.

Essential Understandings	Essential Knowledge, Skills, and Processes
pollutants react with sunlight. This pollutant can cause health problems. Naturally occurring ozone is also found in the upper atmosphere and helps to shield Earth from ultraviolet radiation. • Maintaining good air quality is a crucial goal for modern society, and it is everyone's responsibility to work toward it. • Weather maps show much useful information about descriptive air measurements, observations, and boundaries between air masses (fronts). The curved lines showing areas of equal air pressure and temperature are key features of weather maps. Weather maps are important for understanding and predicting the weather.	• map the movement of cold and warm fronts and interpret their effects on observable weather conditions.

6.7 The student will investigate and understand the natural processes and human interactions that affect watershed systems. Key concepts include **the health of ecosystems and the abiotic factors of a watershed;** **the location and structure of Virginia's regional watershed systems;** **divides, tributaries, river systems, and river and stream processes;** **wetlands;** **estuaries;** **major conservation, health, and safety issues associated with watersheds; and** **water monitoring and analysis using field equipment including hand-held technology.**
Overview **Standard 6.7 is intended to provide students with a basic understanding of how natural processes and human interactions impact watershed systems. This includes an understanding of the physical geography of Virginia's portions of the three major watershed systems (the Chesapeake Bay, the North Carolina sounds, and the Gulf of Mexico) and the various features associated with moving water (surface and groundwater). Wetlands have become an important focus of scientists as we learn their role in flood and erosion control as well as their importance as habitat for many species of living things. Students are introduced to major safety and conservation issues associated with watersheds and become familiar with the testing parameters and tools used in the field. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and an understanding of the nature of science (6.1) in the context of the key concepts presented in this standard.**

6.7 The student will investigate and understand the natural processes and human interactions that affect watershed systems. Key concepts include **the health of ecosystems and the abiotic factors of a watershed;** **the location and structure of Virginia's regional watershed systems;** **divides, tributaries, river systems, and river and stream processes;** **wetlands;** **estuaries;** **major conservation, health, and safety issues associated with watersheds; and** **water monitoring and analysis using field equipment including hand-held technology.**	
Essential Understandings	**Essential Knowledge, Skills, and Processes**
The concepts developed in this standard include the following: An ecosystem is made up of the biotic (living) community and the abiotic (nonliving) factors that affect it. The health of an ecosystem is directly related to water quality. Abiotic factors determine ecosystem type and its distribution of plants and animals as well as the usage of land by people. Abiotic factors include water supply, topography, landforms, geology, soils, sunlight, and air quality/O2 availability. Human activities can alter abiotic components and thus accelerate or decelerate natural processes. For example, people can affect the rate of natural erosion. Plowing cropland can cause greater erosion, while planting trees can prevent it. Flood protection/wetland loss is another example. A watershed is the land that water flows across or through on its way to a stream, lake, wetland, or other body of water. Areas of higher elevations, such as ridgelines and divides, separate watersheds.	In order to meet this standard, it is expected that students will comprehend and apply basic terminology related to watersheds. use topographic maps to determine the location and size of Virginia's regional watershed systems. locate their own local watershed and the rivers and streams associated with it. design an investigation to model the effects of stream flow on various slopes. analyze and explain the functioning of wetlands and appraise the value of wetlands to humans. explain what an estuary is and why it is important to people. propose ways to maintain water quality within a watershed. explain the factors that affect water quality in a watershed and how those factors can affect an ecosystem. forecast potential water-related issues that may become important in the future.

6.7 The student will investigate and understand the natural processes and human interactions that affect watershed systems. Key concepts include the health of ecosystems and the abiotic factors of a watershed; the location and structure of Virginia's regional watershed systems; divides, tributaries, river systems, and river and stream processes; wetlands; estuaries; major conservation, health, and safety issues associated with watersheds; and water monitoring and analysis using field equipment including hand-held technology.	
Essential Understandings	**Essential Knowledge, Skills, and Processes**
The three major regional watershed systems in Virginia lead to the Chesapeake Bay, the North Carolina sounds, or the Gulf of Mexico. River systems are made up of tributaries of smaller streams that join along their courses. Rivers and streams generally have wide, flat, border areas, called flood plains, onto which water spills out at times of high flow. Rivers and streams carry and deposit sediment. As water flow decreases in speed, the size of the sediment it carries decreases. Wetlands form the transition zone between dry land and bodies of water such as rivers, lakes, or bays. Both tidal and nontidal wetlands perform important water quality functions, including regulating runoff by storing flood waters; reducing erosion by slowing down run-off; maintaining water quality by filtering sediments, trapping nutrients, and breaking down pollutants; and recharging groundwater. They also provide food and shelter for wildlife and fish and nesting and resting areas for migratory birds. Estuaries perform important functions, such as	locate and critique a media article or editorial (print or electronic) concerning water use or water quality. Analyze and evaluate the science concepts involved. argue for and against commercially developing a parcel of land containing a large wetland area. Design and defend a land-use model that minimizes negative impact. measure, record, and analyze a variety of water quality indicators and describe what they mean to the health of an ecosystem.

6.7 The student will investigate and understand the natural processes and human interactions that affect watershed systems. Key concepts include
the health of ecosystems and the abiotic factors of a watershed;
the location and structure of Virginia's regional watershed systems;
divides, tributaries, river systems, and river and stream processes;
wetlands;
estuaries;
major conservation, health, and safety issues associated with watersheds; and
water monitoring and analysis using field equipment including hand-held technology.

Essential Understandings	Essential Knowledge, Skills, and Processes
providing habitat for many organisms and serving as nurseries for their young. The Chesapeake Bay is an estuary where fresh and salt water meet and are mixed by tides. It is the largest estuary in the contiguous United States and one of the most productive. Water quality monitoring is the collection of water samples to analyze chemical and/or biological parameters. Simple parameters include pH, temperature, salinity, dissolved oxygen, turbidity, and the presence of macroinvertebrate organisms.	

Grade Six
Science Strand

Interrelationships in Earth/Space Systems

The strand focuses on student understanding of how Earth systems are connected and how Earth interacts with other members of the solar system. The topics developed include shadows; relationships between the sun and Earth; weather types, patterns, and instruments; properties of soil; characteristics of the ocean environment; and organization of the solar system. This strand includes science standards K.7, 1.6, 2.6, 3.7, 4.6, 4.7, 4.8, 5.6, and 6.8.

6.8 The student will investigate and understand the organization of the solar system and the interactions among the various bodies that comprise it. Key concepts include **the sun, moon, Earth, other planets and their moons, dwarf planets, meteors, asteroids, and comets;** **relative size of and distance between planets;** **the role of gravity;** **revolution and rotation;** **the mechanics of day and night and the phases of the moon;** **the unique properties of Earth as a planet;** **the relationship of Earth's tilt and the seasons;** **the cause of tides; and** **the history and technology of space exploration.**
Overview **Standard 6.8 is intended to provide students with a basic understanding of the solar system and the relationships among bodies within the solar system. This standard develops an understanding of Earth as part of the solar system and builds significantly on standards 3.8, 4.7, and 4.8. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and an understanding of the nature of science (6.1) in the context of the key concepts presented in this standard.**

6.8 The student will investigate and understand the organization of the solar system and the interactions among the various bodies that comprise it. Key concepts include the sun, moon, Earth, other planets and their moons, dwarf planets, meteors, asteroids, and comets; relative size of and distance between planets; the role of gravity; revolution and rotation; the mechanics of day and night and the phases of the moon; the unique properties of Earth as a planet; the relationship of Earth's tilt and the seasons; the cause of tides; and the history and technology of space exploration.	
Essential Understandings	**Essential Knowledge, Skills, and Processes**
The concepts developed in this standard include the following: The solar system consists of the sun, moon, Earth, other planets and their moons, meteors, asteroids, and comets. Each body has its own characteristics and features. The distance between planets and sizes of the planets vary greatly. The outer, "gas" planets are very large, and the four inner planets are comparatively small and rocky. Gravity is a force that keeps the planets in motion around the sun. Gravity acts everywhere in the universe. Planets revolve around the sun, and moons revolve around planets. A planet rotates upon an axis. A dwarf planet revolves around the sun, and can maintain a nearly round shape as planets do, but it cannot move other objects away from its orbital neighborhood.	In order to meet this standard, it is expected that students will describe the planets and their relative positions from the sun. compare the characteristics of Pluto to the planets and explain its designation as a dwarf planet. design and interpret a scale model of the solar system. (A scale model may be a physical representation of an object or concept. It can also be a mathematical representation that uses factors such as ratios, proportions, and percentages.) explain the role of gravity in the solar system. compare and contrast revolution and rotation and apply these terms to the relative movements of planets and their moons. model and describe how day and night and the phases of the moon occur. model and describe how Earth's axial tilt and its annual orbit around the sun cause the seasons.

6.8 The student will investigate and understand the organization of the solar system and the interactions among the various bodies that comprise it. Key concepts include
the sun, moon, Earth, other planets and their moons, dwarf planets, meteors, asteroids, and comets;
relative size of and distance between planets;
the role of gravity;
revolution and rotation;
the mechanics of day and night and the phases of the moon;
the unique properties of Earth as a planet;
the relationship of Earth's tilt and the seasons;
the cause of tides; and
the history and technology of space exploration.

Essential Understandings	Essential Knowledge, Skills, and Processes
As Earth rotates, different sides of Earth face toward or away from the sun, thus causing day and night, respectively. The phases of the moon are caused by its position relative to Earth and the sun. Earth is a rocky planet, extensively covered with large oceans of liquid water and having frozen ice caps in its polar regions. Earth has a protective atmosphere consisting predominantly of nitrogen and oxygen and has a magnetic field. The atmosphere and the magnetic field help shield Earth's surface from harmful solar radiation. Scientific evidence indicates that Earth is about 4.5 billion years old. Seasons are caused by a combination of the tilt of Earth on its axis, the curvature of Earth's surface and, thus, the angle at which sunlight strikes the surface of Earth during its annual revolution around the sun. Tides are the result of the gravitational pull of the moon and sun on the surface waters of Earth. The ideas of Ptolemy, Aristotle, Copernicus, and Galileo	describe the unique characteristics of planet Earth. discuss the relationship between the gravitational pull of the moon and the cycle of tides. compare and contrast the ideas of Ptolemy, Aristotle, Copernicus, and Galileo related to the solar system. create and interpret a timeline highlighting the advancements in solar system exploration over the past half century. This should include information on the first modern rockets, artificial satellites, orbital missions, missions to the moon, Mars robotic explorers, and exploration of the outer planets.

6.8 The student will investigate and understand the organization of the solar system and the interactions among the various bodies that comprise it. Key concepts include the sun, moon, Earth, other planets and their moons, dwarf planets, meteors, asteroids, and comets; relative size of and distance between planets; the role of gravity; revolution and rotation; the mechanics of day and night and the phases of the moon; the unique properties of Earth as a planet; the relationship of Earth's tilt and the seasons; the cause of tides; and the history and technology of space exploration.	
Essential Understandings	**Essential Knowledge, Skills, and Processes**
contributed to the development of our understanding of the solar system. With the development of new technology over the last half-century, our knowledge of the solar system has increased substantially.	

Grade Six
Science Strand

Earth Resources

The strand focuses on student understanding of the role of resources in the natural world and how people can utilize those resources in a sustainable way. An important idea represented in this strand is the importance of managing resources. This begins with basic ideas of conservation and proceeds to more abstract consideration of costs and benefits. The topics developed include conservation of materials, soil and plants as resources, energy use, water, Virginia's resources, and how public policy impacts the environment. This strand includes science standards K.11, 1.8, 2.8, 3.10, 3.11, 4.9, and 6.9.

6.9 The student will investigate and understand public policy decisions relating to the environment. Key concepts include **management of renewable resources;** **management of nonrenewable resources;** **the mitigation of land-use and environmental hazards through preventive measures; and** **cost/benefit tradeoffs in conservation policies.**
Overview **Standard 6.9 is intended to develop student understanding of the importance of Earth's natural resources, the need to manage them, how they are managed, and the analysis of costs and benefits in making decisions about those resources. It applies and builds on the concepts described in several lower grades, especially science standard 4.9. Knowledge gained from this standard will be important to understanding numerous concepts in Life Science and Earth Science. It is intended that students will actively develop scientific investigation, reasoning, and logic skills, and an understanding of the nature of science (6.1) in the context of the key concepts presented in this standard.**

6.9 The student will investigate and understand public policy decisions relating to the environment. Key concepts include management of renewable resources; management of nonrenewable resources; the mitigation of land-use and environmental hazards through preventive measures; and cost/benefit tradeoffs in conservation policies.	
Essential Understandings	**Essential Knowledge, Skills, and Processes**
The concepts developed in this standard include the following: People, as well as other living organisms, are dependent upon the availability of clean water and air and a healthy environment. Local, state, and federal governments have significant roles in managing and protecting air, water, plant, and wildlife resources. Modern industrial society is dependent upon energy. Fossil fuels are the major sources of energy in developed and industrialized nations and should be managed to minimize adverse impacts. Many renewable and nonrenewable resources are managed by the private sector (private individuals and corporations). Renewable resources should be managed so that they produce continuously. Sustainable development makes decisions about long-term use of the land and natural resources for maximum community benefit for the longest time and with the least environmental damage. Regulations, incentives, and voluntary efforts help conserve resources and protect environmental quality. Conservation of resources and environmental protection begin with individual acts of stewardship.	In order to meet this standard, it is expected that students will differentiate between renewable and nonrenewable resources. describe the role of local and state conservation professionals in managing natural resources. These include wildlife protection; forestry and waste management; and air, water, and soil conservation. analyze resource-use options in everyday activities and determine how personal choices have costs and benefits related to the generation of waste. analyze how renewable and nonrenewable resources are used and managed within the home, school, and community. analyze reports, media articles, and other narrative materials related to waste management and resource use to determine various perspectives concerning the costs/benefits in real-life situations. evaluate the impact of resource use, waste management, and pollution prevention in the school and home environment.

6.9 The student will investigate and understand public policy decisions relating to the environment. Key concepts include management of renewable resources; management of nonrenewable resources; the mitigation of land-use and environmental hazards through preventive measures; and cost/benefit tradeoffs in conservation policies.	
Essential Understandings	**Essential Knowledge, Skills, and Processes**
Use of renewable (water, air, soil, plant life, animal life) and nonrenewable resources (coal, oil, natural gas, nuclear power, and mineral resources) must be considered in terms of their cost/benefit tradeoffs. Preventive measures, such as pollution prevention or thoughtfully planned and enforced land-use restrictions, can reduce the impact of potential problems in the future. Pollution prevention and waste management are less costly than cleanup.	