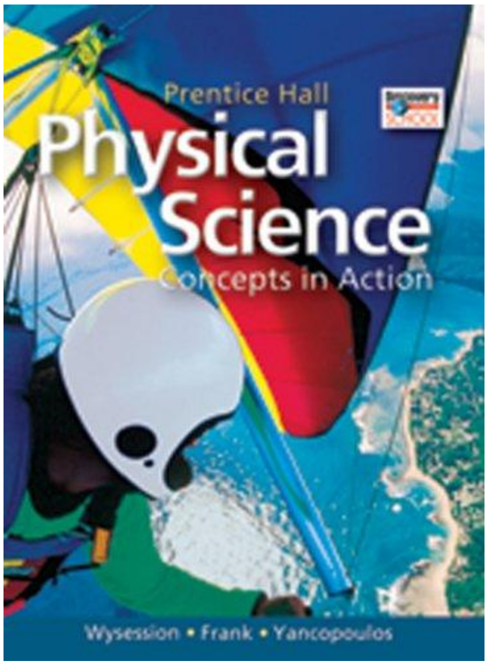
A Correlation of

Pearson
Physical Science
Concepts in Action
©2011



To the

Next Generation Science Standards

Physical Science Standards
Engineering Standards
May 2013

Grades 9-12

A Correlation of
Physical Science: Concepts in Action, ©2011
to the Next Generation Science Standards, May 2013
Grades 9-12

Dear Educator,

As we embark upon a new and exciting science journey, Pearson is committed to offering its complete support as classrooms transition to the new Next Generation Science Standards (NGSS). Ready-to-use solutions for today and a forward-thinking plan for tomorrow connect teacher education and development, curriculum content and instruction, assessment, and information and school design and improvement. We'll be here every step of the way to provide the easiest possible transition to the NGSS with a coherent, phased approach to implementation.

Pearson has long-standing relationships with contributors and authors who have been involved with the development and review of the Next Generation Science Frameworks and subsequent Next Generation Science Standards. As such, the spirit and pedagogical approach of the NGSS initiative is embedded in all of our programs, such as ***Physical Science: Concepts in Action.***

The planning and development of Pearson's ***Physical Science: Concepts in Action*** was informed by the same foundational research as the NGSS Framework. Specifically, our development teams used Project 2061, the National Science Education Standards (1996) developed by the National Research Council, as well as the Science Anchors Project 2009 developed by the National Science Teachers Association to inform the development of this program. As a result, students make connections throughout the program to concepts that cross disciplines, practice science and engineering skills, and build on their foundational knowledge of key science ideas.

Physical Science: Concepts in Action helps students make the important connection between the science they read and what they experience every day. Relevant content, lively explorations and a wealth of hands-on activities take students' understanding of science beyond the page and into the world around them.

21st Century Skills

Each chapter in ***Physical Science*** begins with an activity geared toward developing one or more 21st century skills. All of these activities task students to capture what they are learning in biology class and apply the knowledge to solving real-life problems in order to encourage productive, thoughtful members of the 21st century world.

Virtual Physical Science

A Pearson exclusive, this is the most robust interactive lab available. A proven formula for reading success before during, and after every lesson enables students to fully understand key concepts.

The Complete Interactive Textbook

Available online and on CD-ROM. Audio of the full text read-aloud supports English language learners and reluctant readers. PresentationEXPRESS helps you create dynamic presentations with slides, videos, and participatory activities.

The following document demonstrates how ***Physical Science: Concepts in Action, ©2011,*** supports the Next Generation Science Standards (NGSS). Correlation references are to the Student Editions, Teacher Editions, and Teacher Lab Resources.

A Correlation of
Physical Science: Concepts in Action, ©2011
to the Next Generation Science Standards, May 2013
Grades 9-12

Table of Contents

HS-PS1 Matter and Its Interactions

HS-PS1 Matter and Its Interactions

HS-PS1-1. Use the periodic table as a model to predict the relative properties of elements based on the patterns of electrons in the outermost energy level of atoms. [Clarification Statement: Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, and reactions with oxygen.] [Assessment Boundary: Assessment is limited to main group elements. Assessment does not include quantitative understanding of ionization energy beyond relative trends.]

PHYSICAL SCIENCE, Concepts in Action: Information on the periodic table is presented in Chapter 5, The Periodic Table on SE/TE pages 124-155. The organization of the table is described in Section 5.2, The Modern Periodic Table, on SE/TE pages 130-138. In Section 5.3, Representative Groups, the relationship of the outermost electrons to the periodic table is described in Valence Electrons on SE/TE page 139 and the effect of valence electrons on the properties of elements in groups 1A through 8A are described on SE/TE pages 140-145. Chemistry Refresher, Metalloids, on TE only page 124D, discusses the metalloid area of the periodic table and the properties of metalloids. Chemistry Refresher, Diagonals, on TE only page 124D, discusses the diagonal relationships between some elements in the periodic chart and the relationship to predictions of properties of those elements

In Section 5.3 Assessment question 1, on SE/TE page 145, students **explain** why elements in a group have similar properties; in question 5, students **identify** which group of elements is least reactive; in question 6, students **explain** why hydrogen is located in a group with reactive metals; in question 12, students **generalize** about the property of reactivity in metals. In Exploration Lab: Predicting the Density of an Element, SE/TE pages 150-151 and Lab pages 289-291, students **predict** the density of germanium based on the density of silicon, tin, and lead and the periodic table. In Teacher Demo, Variation Across a Period, on TE only page 138, students **observe** differences in electrical conductivity among three period 3 elements. In Valence Electrons: Integrate Space Science, on TE only page 139, students **research** and **explain** the conditions under which hydrogen has the properties of a metal. In Use Visuals: The Alkali Metals, on TE only page 140, students **predict** the reactivity of elements within one group. In Compare/Contrast Chart, on TE only page 140, students **record** similarities and differences between group 1A and 2A. In Build Science Skills, on TE only page 159, students **predict** the electron dot diagrams for various elements based on their position in the periodic chart. In Investigation 5A, Using Clues to Identify Elements, on Lab pages 47-52, students use their knowledge about valence electrons and the periodic table to **identify** 34 elements. In Investigation 5B, Comparing Chemical Properties Within a Group, on Lab pages 53-56, students **predict** reactivity of elements in the 2A group of the periodic table.

HS-PS1-2. Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
[Clarification Statement: Examples of chemical reactions could include the reaction of sodium and chlorine, of carbon and oxygen, or of carbon and hydrogen.] [Assessment Boundary: Assessment is limited to chemical reactions involving main group elements and combustion reactions.]

PHYSICAL SCIENCE, Concepts in Action: Chemical bonding is presented in Chapter 6, Chemical Bonds. Ionic bonding is introduced in Section 6.1, Ionic Bonding, on SE/TE pages 158-164. Covalent bonding content is located in Section 6.2, Covalent Bonding, on SE/TE pages 165-169. Metal bonding is introduced in Section 6.4, The Structure of Metals, SE/TE pages 176-181. Simple chemical reactions are introduced in Chapter 7, Chemical Reactions. Types of reactions are p in Section 7.2, Types of Reactions, on SE/TE pages 199-205. Patterns in the periodic table are introduced in Section 5.3, Representative Groups, on SE/TE pages 139-145. The role of electrons in chemical bonds are discussed in the Bond Strength in Ionic Compounds, Electronegativity and Bond Types, and Metallic Bonding sections of Chemistry Refresher on TE only pages 156C-156D.

In Section 6.1 Assessment question 6, on SE/TE page 164, students **explain** the outcome of reactions between elements from group 1A and group 7A in terms of valence electrons. In Connection Concepts, on SE/TE page 164, students **compare** the reactivity of potassium and calcium based on their position in the periodic chart which is based on valence electrons. In Quick Lab, Identifying a Type of Reaction, on SE/TE page 203, students **explain** a replacement reaction. In Section 7.2 Assessment question 6, on SE/TE page 205, students **explain** a redox reaction in terms of electron transfer. In Writing in Science, on SE/TE page 205, students **explain** the reaction types when water is formed from hydrogen and oxygen. Instruct, Integrate Social Studies, on TE only page 158, students **draw** valence diagrams for boron, carbon, nitrogen, oxygen, and fluorine. In Build Science Skills, on TE only page 159, students **predict** the electron dot diagrams for various elements based on their position in the periodic chart. Students **explain** the outcome of simple chemical reactions in Investigation 6B, Comparing Ionic and Molecular Compounds, on Lab pages 63-66. Students **predict** the products and **explain** the outcome of simple chemical reactions in Investigation 7A, Using Single-Replacement Reactions to Compare Reactivities, on Lab pages 67-72. Students **explain** the outcome of a synthesis reaction in Investigation 7B, Recognizing a Synthesis Reaction, on Lab pages 73-76.

HS-PS1-3. Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. [Clarification Statement: Emphasis is on understanding the strengths of forces between particles, not on naming specific intermolecular forces (such as dipole-dipole). Examples of particles could include ions, atoms, molecules, and networked materials (such as graphite). Examples of bulk properties of substances could include the melting point and boiling point, vapor pressure, and surface tension.] [Assessment Boundary: Assessment does not include Raoult's law calculations of vapor pressure.]

PHYSICAL SCIENCE, Concepts in Action: Electrical forces between particles are presented in Section 6.1, Ionic Bonding, on SE/TE pages 158-162 and 164, Section 6.2 Covalent Bonding, on SE/TE pages 165-169, and Section 7.4, The Structure of Metals, on SE/TE pages 176-181.

In Data Analysis, What Determines the Size of an Atom or Ion, on SE/TE page 160, students **analyze** data about atomic radii and **infer** the relationship between the number of valence electrons and atomic radius. In Connection Concepts, on SE/TE page 164, students **infer** the relative levels of the strength of electric forces in potassium and calcium atoms based on the bulk property reactivity. In Quick Lab, Analyzing Inks, on SE/TE 167 students **compare** the solubility of atoms in different inks to **compare** the strength of polar bonds. In Section 6.2 Assessment question 7, on SE/TE page 169, students **explain** the difference in boiling points for water and chlorine in terms of the strength of electrical forces. In Teacher Demo, Comparing Bond Types, on TE only page 177, students **compare** malleability of ionic and metal compounds.

HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy. [Clarification Statement: Emphasis is on the idea that a chemical reaction is a system that affects the energy change. Examples of models could include molecular-level drawings and diagrams of reactions, graphs showing the relative energies of reactants and products, and representations showing energy is conserved.] [Assessment Boundary: Assessment does not include calculating the total bond energy changes during a chemical reaction from the bond energies of reactants and products.]

PHYSICAL SCIENCE, Concepts in Action: Energy in chemical reactions is presented in Section 7.3, Energy Changes in Reactions, on SE/TE pages 206-209.

In figure 17, on SE/TE page 207, students **model** the release of energy from the combustion of propane. In figure 18, on SE/TE page 208, students **use** graphs to model the release of energy in exothermic reactions and the absorption of energy in endothermic reactions. In Teacher Lab, Exothermic Reaction, on TE only page 200, students **observe** the release of energy during a chemical reaction. In Build Science Skills, Chemical Bonds and Energy, on TE only page 206, students **model** the energy in a molecule of propane using ball-and-stick models.

HS-PS1-5. Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs. [Clarification Statement: Emphasis is on student reasoning that focuses on the number and energy of collisions between molecules.] [Assessment Boundary: Assessment is limited to simple reactions in which there are only two reactants; evidence from temperature, concentration, and rate data; and qualitative relationships between rate and temperature.]

PHYSICAL SCIENCE, Concepts in Action: Energy change in chemical reactions is presented in Section 7.3, Energy Changes in Reactions, on SE/TE pages 206-209. Factors affecting reaction rates are covered in Section 7.4, Reaction Rates, on SE/TE pages 212-215.

In figure 21, on SE/TE page 213, students **explain** how surface area affects reaction rates in a reaction between grain dust and oxygen. In Quick Lab, Observing the Action of Catalysts, on SE/TE page 214, students **describe** how a catalyst is able to promote a chemical reaction. In Writing in Science, on SE/TE page 215, students **write** a paragraph **explaining** how temperature, concentration, surface area, and catalysts affect reaction rates. In Section 7.4 Assessment question 3, on SE/TE page 215, students **explain** why reactions take place faster at higher temperatures.; in question 4, students **predict** the effect of dilution on a chemical reaction; in question 5, students **explain h**ow a catalyst makes a reaction go faster; in question 6, students **predict** the effect of a catalyst on a chemical reaction. In Teacher Demo, Temperature and Rate, on TE only page 213, students **observe** the effect of temperature on reaction rate.

HS-PS1-6. Refine the design of a chemical system by specifying a change in conditions that would produce increased amounts of products at equilibrium.* [Clarification Statement: Emphasis is on the application of Le Chatlier's Principle and on refining designs of chemical reaction systems, including descriptions of the connection between changes made at the macroscopic level and what happens at the molecular level. Examples of designs could include different ways to increase product formation including adding reactants or removing products.] [Assessment Boundary: Assessment is limited to specifying the change in only one variable at a time. Assessment does not include calculating equilibrium constants and concentrations.]

PHYSICAL SCIENCE, Concepts in Action: Equilibrium in chemical reactions is covered in Section 7.5, Equilibrium, on SE/TE pages 216-219.

In figure 25, on SE/TE page 217, students **model** equilibrium between aqueous and gaseous water. In Problem Solving Activity, Recreating High Altitudes, on SE/TE page 218, students change the density of oxygen in a closed space to **model** equilibrium between hemoglobin and oxygen at high altitudes. In Section 7.5 Assessment question 5, on SE/TE page 219, students **infer** how the increase in pressure on a reaction will alter the equilibrium for that reaction. In Design Your Own Lab, Manipulating Chemical Equilibrium, on SE/TE pages 220-221 and Lab pages 295-297, students **change** conditions in an experiment to alter the equilibrium of a chemical reaction. In Build Science Skills, Types of Equilibria, on TE only page 216, students **model** chemical equilibrium.

HS-PS1-7. Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. [Clarification Statement: Emphasis is on using mathematical ideas to communicate the proportional relationships between masses of atoms in the reactants and the products, and the translation of these relationships to the macroscopic scale using the mole as the conversion from the atomic to the macroscopic scale. Emphasis is on assessing students' use of mathematical thinking and not on memorization and rote application of problem-solving techniques.] [Assessment Boundary: Assessment does not include complex chemical reactions.]

PHYSICAL SCIENCE, Concepts in Action: Mathematical representations of chemical reactions are presented in Section 7.1, Describing Reactions, on SE/TE pages 192-198. Conservation of mass is introduced on SE/TE page 193.

In Figure 2, Burning Carbon, on SE/TE page 193, students **explain** how models of chemical reactions show conservation of mass. In Figure 4, on SE/TE page 194, students **explain** how balanced chemical equations show conservation of mass. In Math Practice, on SE/TE page 195, students **use** mathematical expressions to show conservation of mass. In Use Visuals, Balancing Equations, on TE only page 194, students **use** models to **create** mathematical representations of balanced reactions. In Additional Problems, on TE only page 195, students **use** mathematical representations to **show** conservation of mass. In Investigation 7A, Using Single-Replacement Reactions to compare Reactivities, Analysis questions 6 and 8 on Lab pages 71-72 and the Go Further section on Lab page 72, students **use** mathematical representations to show the conservation of mass. In Investigation 7B, Recognizing a Synthesis Reaction on Lab, Analysis, question 7 on page 76, students **use** mathematical representations to show the conservation of mass in a reaction between copper and oxygen.

HS-PS1-8. Develop models to illustrate the changes in the composition of the nucleus of the atom and the energy released during the processes of fission, fusion, and radioactive decay. [Clarification Statement: Emphasis is on simple qualitative models, such as pictures or diagrams, and on the scale of energy released in nuclear processes relative to other kinds of transformations.] [Assessment Boundary: Assessment does not include quantitative calculation of energy released. Assessment is limited to alpha, beta, and gamma radioactive decays.]

PHYSICAL SCIENCE, Concepts in Action: Radioactive decay is introduced in Section 10.1, Radioactivity and 10.2, Rates of Nuclear Decay, on SE/TE pages 292-301. Changes in the nucleus through transmutation are introduced in Section 10.3, Artificial Transmutation, on SE/TE pages 303-305. Fission and fusion are introduced in Section 10.4, Fission and Fusion, on SE/TE pages 309-311 and 315.

In Math Practice on SE/TE page 295, students **use a mathematical model** of radioactive decay to balance equations for nuclear decay. In Section 10.1 Assessment question 8, on SE/TE page 297, students **use a model** of nuclear decay to **predict** the effect of beta decay on the composition of a nucleus. In Math Practice, on SE/TE page 297, students **use a mathematical model** of radioactive decay to balance equations for nuclear decay. In Quick Lab Modeling Transmutation, on SE/TE page 304, students **model** changes during transmutation in the nuclei of boron and of nitrogen. In Section 10.3 Assessment question 4, on SE/TE page 305, students **model** the transmutation of oxygen to fluorine; in question 7, students **model** the transmutation of plutonium to curium. In Figure 15, on SE/TE page 308, students **use models** of nuclear and electric forces in the nucleus. In Figure 16, on SE/TE page 30, students **use models** of electric forces in the nucleus. In figure 19, on SE/TE page 311, students **use** a model of nuclear fission to **explain** the isotope formation from uranium 235. In Exploration Lab, Modeling a Chain Reaction, on SE/TE pages 316-317 and Lab pages 305-308, students **model** a nuclear fission chain reaction. In Additional Problems, on TE only page 295, students **use a mathematical model** of radioactive decay to **balance** equations for nuclear decay. In Teacher Demo, Nuclear Process, on TE only page 311, students **observe** a model of nuclear fission and fusion. In Investigation 10A, Modeling Radioactive Decay, on Lab pages 101-106, students **model** radioactive decay.

A Correlation of
Physical Science: Concepts in Action, ©2011
to the Next Generation Science Standards, May 2013
Grades 9-12

Science and Engineering Practices

Developing and Using Models

Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.

- Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS1-4),(HS-PS1-8)

SE/TE:
206-209 Section 7.3, Energy Changes in Reactions
292-297 Section 10.1, Radioactivity
298-302 Section 10.2, Rates of Nuclear Decay
303-305 Section 10.3, Artificial Transmutation
309-311, 315 Section 10.4, Fission and Fusion
316-315 Exploration Lab, Modeling a Chain Reaction

- Use a model to predict the relationships between systems or between components of a system. (HS-PS1-1)

SE/TE:
130-138 Section 5.2, The Modern Periodic Table
139-140 Section 5.3, Representative Groups

Planning and Carrying Out Investigations

Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.

- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS1-3)

SE/TE:
158-162, 164 Section 6.1, Ionic Bonding
165-169 Section 6.2, Covalent Bonding
176-181 Section 7.4, The Structure of Metals

Using Mathematics and Computational Thinking

Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.

- Use mathematical representations of phenomena to support claims. (HS-PS1-7)

SE/TE:
216-219 Section 7.5, Equilibrium

Disciplinary Core Ideas

PS1.A: Structure and Properties of Matter

- Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS-PS1-1)

SE/TE:
130-138 Section 5.2, The Modern Periodic Table
139-140 Section 5.3, Representative Groups

- The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states. (HS-PS1-1),(HS-PS1-2)

SE/TE:
130-138 Section 5.2, The Modern Periodic Table
139-145 Section 5.3, Representative Groups
158-164 Section 6.1, Ionic Bonding
165-169 Section 6.2, Covalent Bonding
176-181 Section 6.4, The Structure of Metals
199-205 Section 7.2, Types of Reactions

- The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (HS-PS1-3),(secondary to HS-PS2-6)

SE/TE:
158-162, 164 Section 6.1, Ionic Bonding
165-169 Section 6.2, Covalent Bonding
176-181 Section 7.4, The Structure of Metals

- A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4)

SE/TE:
206-209 Section 7.3, Energy Changes in Reactions

PS1.B: Chemical Reactions

- Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4),(HS-PS1-5)

SE/TE:
206-209 Section 7.3, Energy Changes in Reactions
212-215 Section 7.4, Reaction Rates

- In many situations, a dynamic and condition-dependent balance between a reaction and the reverse reaction determines the numbers of all types of molecules present. (HS-PS1-6)

SE/TE:
216-219 Section 7.5, Equilibrium

Crosscutting Concepts

Patterns

- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS1-1),(HS-PS1-2),(HS-PS-3),(HS-PS1-5)

SE/TE:
130-138 Section 5.2, The Modern Periodic Table
139-140 Section 5.3, Representative Groups
139-145 Section 5.3, Representative Groups
158-164 Section 6.1, Ionic Bonding
165-169 Section 6.2, Covalent Bonding
176-181 Section 6.4, The Structure of Metals
199-205 Section 7.2, Types of Reactions
206-209 Section 7.3, Energy Changes in Reactions
212-215 Section 7.4, Reaction Rates

Energy and Matter

- In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-PS1-8)

SE/TE:
292-297 Section 10.1, Radioactivity
298-302 Section 10.2, Rates of Nuclear Decay
303-305 Section 10.3, Artificial Transmutation
309-311, 315 Section 10.4, Fission and Fusion
316-315 Exploration Lab, Modeling a Chain Reaction

- The total amount of energy and matter in closed systems is conserved. (HS-PS1-7)

SE/TE:
216-219 Section 7.5, Equilibrium

- Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS1-4)

SE/TE:
206-209 Section 7.3, Energy Changes in Reactions

Stability and Change

- Much of science deals with constructing explanations of how things change and how they remain stable. (HS-PS1-6)

SE/TE:
216-219 Section 7.5, Equilibrium

Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. ▪ Apply scientific principles and evidence to provide an explanation of phenomena and solve design problems, taking into account possible unanticipated effects. (HS-PS1-5) **SE/TE:** 206-209 Section 7.3, Energy Changes in Reactions 212-215 Section 7.4, Reaction Rates ▪ Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-PS1-2) **SE/TE:** 139-145 Section 5.3, Representative Groups 158-164 Section 6.1, Ionic Bonding 165-169 Section 6.2, Covalent Bonding 176-181 Section 6.4, The Structure of Metals 199-205 Section 7.2, Types of Reactions ▪ Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS1-6) **SE/TE:** 216-219 Section 7.5, Equilibrium	▪The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (HS-PS1-2),(HS-PS1-7) **SE/TE:** 139-145 Section 5.3, Representative Groups 158-164 Section 6.1, Ionic Bonding 165-169 Section 6.2, Covalent Bonding 176-181 Section 6.4, The Structure of Metals 199-205 Section 7.2, Types of Reactions 216-219 Section 7.5, Equilibrium **PS1.C: Nuclear Processes** ▪ Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. (HS-PS1-8) **SE/TE:** 292-297 Section 10.1, Radioactivity 298-302 Section 10.2, Rates of Nuclear Decay 303-305 Section 10.3, Artificial Transmutation 309-311, 315 Section 10.4, Fission and Fusion 316-315 Exploration Lab, Modeling a Chain Reaction **ETS1.C: Optimizing the Design Solution** ▪ Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (secondary to HS-PS1-6) **SE/TE:** 216-219 Section 7.5, Equilibrium	--- **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** ▪ Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS1-7) **SE/TE:** 216-219 Section 7.5, Equilibrium

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS-PS2 Motion and Stability: Forces and Interactions

HS-PS2 Motion and Stability: Forces and Interactions

Students who demonstrate understanding can:

HS-PS2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. [Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.] [Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.]

PHYSICAL SCIENCE, Concepts in Action: Newton's Second Law is introduced in Newton's Second Law of Motion, on SE/TE pages 365 and 368. Applications of Newton's Second Law is discussed in Crash-Test Dummies, on SE/TE page 366 and in Facts and Figures, Bike Helmets, on TE only page 366. Mathematical representations of Newton's Second Law are introduced in Math Skills and Math Practice, on SE/TE page 367 and in Additional Problems, on TE only page 367.

In Quick Lab, Investigating Inertia, on SE/TE page 365, students **observe** the proportional relationship between force and inertia. Students **solve** mathematical problems that describe net force, mass, and acceleration in Math Practice, on SE/TE page 367, and in Additional Problems, on TE only page 367. In Math Practice, on SE/TE page 369, students **calculate** deceleration and net force using Newton's Second Law. In Exploration Lab, Investigating a Balloon Jet, on SE/TE page 383 and Lab pages 311-312, students **analyze data** from a balloon jet experiment using support from Newton's Second Law. In Teacher Demo, Force and Acceleration, on TE only page 365, students **observe** that acceleration is directly proportional to force applied. In Investigation 12A, Using a Pendulum to Measure the Acceleration Due to Force of Gravity, on Lab pages 123-128, students **use** Newton's Second Law to **determine** the value of acceleration due to gravity. In Investigation 12B, Testing Galileo's Hypothesis, on Lab pages 129-132, students use Newton's Second Law to **test** Galileo's Hypothesis that freely falling objects fall at a constant rate.

HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. [Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.] [Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension.]

PHYSICAL SCIENCE, Concepts in Action: Conservation of momentum is discussed in Conservation of Momentum, on SE/TE pages 376-377.

In figure 17, on SE/TE page 376, students **analyze** data from collisions to show that the total momentum of the system does not change. In Data Analysis, Momentum, on SE/TE page 377, students **analyze** data in a graph that shows that momentum is conserved. In Section 12.3 Assessment question 3, on SE/TE page 377, students **describe** the necessary conditions for conservation of momentum.

HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.* [Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.] [Assessment Boundary: Assessment is limited to qualitative evaluations and/or algebraic manipulations.]

PHYSICAL SCIENCE, Concepts in Action: Newton's Second Law is introduced on SE/TE pages 365 and 368. Applications of Newton's Second Law is discussed in Crash-Test Dummies, on SE/TE page 366, and in Facts and Figures, Bike Helmets, on TE only page 366. Mathematical representations of Newton's Second Law are introduced in Math Skills and Math Practice, on SE/TE page 367, and in Additional Problems, on TE only page 367. In Concepts in Action, on SE/TE pages 370-371, parachutes and terminal velocity are explained. Newton's Third Law is introduced on SE/TE pages 373. Conservation of momentum is discussed in Conservation of Momentum, on SE/TE pages 376-377.

In Figure 12, on SE/TE pages 364-365, students **analyze** the functioning of air bags in automobiles that are used to minimize the force on a body during an accident. In Build Science Skills, on TE only page 370, students **evaluate** a model of a parachute.

HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects. [Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational and electric fields.] [Assessment Boundary: Assessment is limited to systems with two objects.]

PHYSICAL SCIENCE, Concepts in Action: Universal forces are introduced in Section 12.4, Universal Forces, on SE/TE pages 378-382. Electromagnetic forces are discussed on SE/TE pages 378-379. Gravitational forces are discussed on SE/TE pages 380-382. Newton's law of universal gravitation is defined on SE/TE page 380. Electric force is further discussed in Section 20.1, Electric Charge and Static Electricity, on SE/TE pages 600-603. Coulomb's law is defined on SE/TE page 601. In Facts and Figures, Electrical Force an Gravitational Force, on TE only page 602, the strength of electric and gravitational forces in a nucleus of an atom are calculated and compared.

In Quick Lab, Investigating Force and Distance, on SE/TE page 380, students **describe** how the force of electrostatic attraction is affected by distance. In Figure 21, on SE/TE page 380, students **use models** of the mathematical relationships in Newton's law of universal gravitation. In Figure 3, on SE/TE page 601, students **use models** of the mathematical relationships in Coulomb's law. In Section 20.1 Assessment question 6, on SE/TE page 603, students **explain** how electric force depends on the amount of charge and the distance between charges. In Teacher Demo, Electric Attraction and Repulsion, on TE only page 601, students **observe** electric forces.

HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. [Assessment Boundary: Assessment is limited to designing and conducting investigations with provided materials and tools.]

PHYSICAL SCIENCE, Concepts in Action: Electric current is defined and described on SE/TE page 604. Magnetic field is defined and described on SE/TE page 631. Electromagnetism is introduced in Section 21.2, Electromagnetism, on SE/TE pages 635-639.

In Quick Lab, Making an Electromagnet, on SE/TE page 637, students **produce** a magnetic field using an electric current. In Application Lab, Investigating an Electric Generator, on SE/TE pages 648-649 and Lab pages 333-334, students **build** an electric generator using magnets. In Teacher Demo, Magnetic Field from Electric Current, on TE only page 636, students **observe** how an electric current produces a magnetic field. In Teacher Demo, Electromagnetic Force, on TE only page 638, students **observe** the magnetic force exerted on a wire carrying an electric current. In Investigation 21A, Studying Electromagnetic Induction, on Lab pages 221-225, students **investigate** inducing a current using a bar magnet.

HS-PS2-6. Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.* [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal, flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.] [Assessment Boundary: Assessment is limited to provided molecular structures of specific designed materials.]

PHYSICAL SCIENCE, Concepts in Action: Bulk properties of elements and the influence of those properties on their use are discussed in Section 5.3, Representative Groups, on SE/TE page 139-145. The relationship between the crystal structure of ionic compounds and their use is discussed in Properties of ionic Compounds, on SE/TE page 164. The relationship between the structure of lattices in metals and bulk properties such as malleability and ductility are discussed in Explaining the Properties of Metals, on SE/TE page 177. The properties of alloys and their use in designed products are discussed in Alloys, on SE/TE pages 178-181. The relationship between the atomic structure of silicon and their use in silicon chips is discussed in Concepts in Action, Chipping In, on SE/TE pages 182-183.

In Section 6.4 Assessment question 3, on SE/TE page 181, students **communicate** how scientists design alloys with specific properties; in question 5, students **explain** why metals are good conductors of electric current; in question 6 on SE/TE page 181, students **communicate** how adding carbon to steel makes the steel harder and stronger. In Writing in Science, on SE/TE page 181, students **write** a paragraph comparing the properties of ionic compounds and alloys. In Going Further, on SE/TE page 183, students **write** about the use of silicon in the development of transistors. In Consumer Lab, Improving the Dyeing of Nonpolar Fabrics, on SE/TE pages 184-185 and Lab pages 293-294, students observe the effect of polar bonds on the ability of a fabric to absorb dye. In Teacher Demo, on TE only page 177, students **observe** the difference in malleability of rock salt and copper wire and **explain** the difference in terms of the molecular structure of the materials.

A Correlation of
Physical Science: Concepts in Action, ©2011
to the Next Generation Science Standards, May 2013
Grades 9-12

Science and Engineering Practices

Planning and Carrying Out Investigations
Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical and empirical models.
- Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS2-5)

SE/TE:
604 Electric Current
631 Magnetic Fields
648-649 Application Lab, Investigating an Electric Generator

Analyzing and Interpreting Data
Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data.
- Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-PS2-1)

SE/TE:
365, 368 "Newton's Second Law of Motion"
366 "Crash-Test Dummies'
367 Math Skills and Math Practice

Using Mathematics and Computational Thinking
Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.
- Use mathematical representations of phenomena to describe explanations. (HS-PS2-2),(HS-PS2-4)

SE/TE:
376-377 "Conservation of Momentum"
378-382 Section 12.4, Universal Forces
600-603 Section 20.1, Electric Charge and Static Electricity

Constructing Explanations and Designing Solutions
Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.
- Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3)

SE/TE:
365, 368 "Newton's Second Law of Motion"
366 "Crash-Test Dummies'
367 Math Skills and Math Practice
373 "Newton's Third Law"

Disciplinary Core Ideas

PS2.A: Forces and Motion
- Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1)

SE/TE:
365, 368 "Newton's Second Law of Motion"
366 "Crash-Test Dummies"
367 Math Skills and Math Practice

- Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2)

SE/TE:
376-377 "Conservation of Momentum"
378-382 Section 12.4, Universal Forces
600-603 Section 20.1, Electric Charge and Static Electricity

- If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2),(HS-PS2-3)

SE/TE:
365, 368 "Newton's Second Law of Motion"
366 "Crash-Test Dummies"
367 Math Skills and Math Practice
373 "Newton's Third Law"
376-377 "Conservation of Momentum"
378-382 Section 12.4, Universal Forces
600-603 Section 20.1, Electric Charge and Static Electricity

PS2.B: Types of Interactions
- Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4)

TE Only: 380

- Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4),(HS-PS2-5)

SE/TE:
604 Electric Current
631 Magnetic Fields
648-649 Application Lab, Investigating an Electric Generator

- Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (HS-PS2-6),(secondary to HS-PS1-1),(secondary to HS-PS1-3)

SE/TE:
139-145 Section 5.3, Representative Groups
177 "Explaining the Properties of Metals"

Crosscutting Concepts

Patterns
- Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS2-4)

SE/TE:
378-382 Section 12.4, Universal Forces
600-603 Section 20.1, Electric Charge and Static Electricity

Cause and Effect
- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-1),(HS-PS2-5)

SE/TE:
365, 368 "Newton's Second Law of Motion"
366 "Crash-Test Dummies"
367 Math Skills and Math Practice
604 Electric Current
631 Magnetic Fields
648-649 Application Lab, Investigating an Electric Generator

- Systems can be designed to cause a desired effect. (HS-PS2-3)

SE/TE:
365, 368 "Newton's Second Law of Motion"
366 "Crash-Test Dummies'
367 Math Skills and Math Practice
373 "Newton's Third Law"
376-377 "Conservation of Momentum"

Systems and System Models
- When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2)

SE/TE:
376-377 "Conservation of Momentum"
378-382 Section 12.4, Universal Forces
600-603 Section 20.1, Electric Charge and Static Electricity

Structure and Function
- Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2-6)

SE/TE:
139-145 Section 5.3, Representative Groups
177 "Explaining the Properties of Metals"
178-181 "Alloys"
182-183 Concepts in Action, Chipping In

376-377 "Conservation of Momentum" **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs. · Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6) **SE/TE:** 139-145 Section 5.3, Representative Groups 177 "Explaining the Properties of Metals" 178-181 "Alloys" 182-183 Concepts in Action, Chipping In --- **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** · Theories and laws provide explanations in science. (HS-PS2-1),(HS-PS2-4) **SE/TE:** 365, 368 "Newton's Second Law of Motion" 366 "Crash-Test Dummies" 367 Math Skills and Math Practice 378-382 Section 12.4, Universal Forces 600-603 Section 20.1, Electric Charge and Static Electricity · Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1),(HS-PS2-4) **SE/TE:** 365, 368 "Newton's Second Law of Motion" 366 "Crash-Test Dummies" 367 Math Skills and Math Practice 378-382 Section 12.4, Universal Forces 600-603 Section 20.1, Electric Charge and Static Electricity	178-181 "Alloys" 182-183 Concepts in Action, Chipping In **PS3.A: Definitions of Energy** · ...and "electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (secondary to HS-PS2-5) **SE/TE:** 604 Electric Current 631 Magnetic Fields 648-649 Application Lab, Investigating an Electric Generator **ETS1.A: Defining and Delimiting Engineering Problems** · Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary to HS-PS2-3) **SE/TE:** 365, 368 "Newton's Second Law of Motion" 366 "Crash-Test Dummies' 367 Math Skills and Math Practice 373 "Newton's Third Law" 376-377 "Conservation of Momentum" **ETS1.C: Optimizing the Design Solution** · Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (secondary to HS-PS2-3) **SE/TE:** 365, 368 "Newton's Second Law of Motion" 366 "Crash-Test Dummies" 367 Math Skills and Math Practice 373 "Newton's Third Law" 376-377 "Conservation of Momentum"	

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS-PS3 Energy

HS-PS3 Energy

Students who demonstrate understanding can:

HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]

PHYSICAL SCIENCE, Concepts in Action: Equations for calculating kinetic and gravitational potential energy are presented in Section 15.1, Energy and Its Forms, on SE/TE pages 447 and 449. Energy conversion and conservation are covered in Section 15.2, Energy Conversion and Conservation, on SE/TE pages 453-459. In Math Skills, on SE/TE page 458, the equations for conservation of mechanical energy are introduced.

In Math Practice, on SE/TE pages 448 and 452, students **calculate** kinetic and potential energies. In Math Practice, on SE/TE page 458 and 459, students **calculate** the change in energy when two of three of variables are known. In Investigation 15B, Determining the Kinetic Energy of a Pendulum, on Lab pages 163-166, students **calculate** the kinetic energy of a pendulum under various conditions.

HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects). [Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]

PHYSICAL SCIENCE, Concepts in Action: Energy as moving particles is presented in Thermal Energy and in Chemical Energy, on SE/TE page 451. Energy as fields is introduced in Electric Fields, on SE/TE page 602 and in Magnetic Fields, on SE/TE pages 631-632.

Students **use models** of particles accounting for energy in Figure 2, on SE/TE page 475. Students **use a model** of electric charges and fields to illustrate static electricity discharge in Figure 6, on SE/TE page 603. In Writing in Science, on SE/TE page 603, students **use a model** of electric fields to explain how a person might receive a shock from a metal door knob on a dry winter day.

HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.* [Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.] [Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.]

PHYSICAL SCIENCE, Concepts in Action: Information about devices that convert one form of energy to another is presented in How It Works, Wind Turbine, on SE/TE page 465; in Concepts in Action, Solar Home, on SE/TE page 484; in Heat Engines on SE/TE pages 486-487; in Electric Motor on SE/TE page 639; and Generators on SE/TE pages 643-644.

Students **build** an electric generator in Application Lab, Investigating an Electric Generator, on SE/TE pages 648-649 and Lab pages 333-334.

HS-PS3-4. Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics). [Clarification Statement: Emphasis is on analyzing data from student investigations and using mathematical thinking to describe the energy changes both quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.] [Assessment Boundary: Assessment is limited to investigations based on materials and tools provided to students.]

PHYSICAL SCIENCE, Concepts in Action: Thermal energy is presented in Section 16.1, Thermal Energy and Matter, on SE/TE pages 474-478.

In Teacher Demo, Calorimetry, on TE only page 478, students **observe** that a cold object placed in warmer water becomes warmer as the water becomes colder.

HS-PS3-5. Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. [Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other, including an explanation of how the change in energy of the objects is related to the change in energy of the field.] [Assessment Boundary: Assessment is limited to systems containing two objects.]

PHYSICAL SCIENCE, Concepts in Action: Energy as fields is introduced in Electric Fields, on SE/TE page 602 and in Magnetic Fields, on SE/TE pages 631-632.

Students **use a model** of electric charges and fields in Figure 4, on SE/TE page 602. Students **use a model** of the effect of charged particles being close together in Figure 5, on SE/TE page 602. Students **use a model** of electric charges and fields to illustrate static electricity discharge in Figure 6, on SE/TE page 603. In Writing in Science, on SE/TE page 603, students **use a model** of electric fields to explain how a person might receive a shock from a metal door knob on a dry winter day. Students **use a model** of magnetic fields to understand their forces in Figure 2 and Figure 3, on SE/TE page 631. Students **use a model** of magnetic and electric fields in How MRI Works, on SE/TE page 641.

Science and Engineering Practices

Developing and Using Models
Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds.
• Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-2),(HS-PS3-5)

SE/TE:
451 “Thermal Energy and in Chemical Energy”
602 “Electric Fields”
631-632 “Magnetic Fields”

Planning and Carrying Out Investigations
Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models.
• Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS3-4)

SE/TE:
474-475 Section 16.1, Thermal Energy and Matter

Using Mathematics and Computational Thinking
Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.
• Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-PS3-1)

SE/TE:
446-452 Section 15.1, Energy and Its Forms
453-459 Section 15.2, Energy Conversion and Conservation

Disciplinary Core Ideas

PS3.A: Definitions of Energy
• Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS-PS3-1),(HS-PS3-2)

SE/TE:
446-452 Section 15.1, Energy and Its Forms
453-459 Section 15.2, Energy Conversion and Conservation
451 “Thermal Energy and in Chemical Energy”
602 “Electric Fields”
631-632 “Magnetic Fields”

• At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS-PS3-2) (HS-PS3-3)

SE/TE:
451 “Thermal Energy and in Chemical Energy”
465 How It Works, Wind Turbine
484 Concepts in Action, Solar Home
486-487 “Heat Engines”
602 “Electric Fields”
631-632 “Magnetic Fields”
639 “Electric Motor”
634-635 “Generators”

• These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2)

SE/TE:
451 “Thermal Energy and in Chemical

Crosscutting Concepts

Cause and Effect
• Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS3-5)

SE/TE:
602 “Electric Fields”
631-632 “Magnetic Fields”

Systems and System Models
• When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-PS3-4)

SE/TE:
474-475 Section 16.1, Thermal Energy and Matter

• Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HS-PS3-1)

SE/TE:
446-452 Section 15.1, Energy and Its Forms
453-459 Section 15.2, Energy Conversion and Conservation

Energy and Matter
• Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS3-3)

SE/TE:
465 How It Works, Wind Turbine
484 Concepts in Action, Solar Home
486-487 “Heat Engines”
634-635 “Generators”
639 “Electric Motor”

Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. · Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS3-3) **SE/TE:** 465 How It Works, Wind Turbine 484 Concepts in Action, Solar Home 486-487 "Heat Engines" 634-635 "Generators" 639 "Electric Motor"	Energy" 602 "Electric Fields" 631-632 "Magnetic Fields" **PS3.B: Conservation of Energy and Energy Transfer** · Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1) **SE/TE:** 446-452 Section 15.1, Energy and Its Forms 453-459 Section 15.2, Energy Conversion and Conservation · Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4) **SE/TE:** 446-452 Section 15.1, Energy and Its Forms 453-459 Section 15.2, Energy Conversion and Conservation 474-475 Section 16.1, Thermal Energy and Matter · Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1) · The availability of energy limits what can occur in any system. (HS-PS3-1) **SE/TE:** 446-452 Section 15.1, Energy and Its Forms 453-459 Section 15.2, Energy Conversion and Conservation · Uncontrolled systems always evolve toward more stable states—that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4) **SE/TE:** 474-475 Section 16.1, Thermal Energy and Matter **PS3.C: Relationship Between Energy and Forces** · When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5) **SE/TE:** 602 "Electric Fields" 631-632 "Magnetic Fields"	· Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2) **SE/TE:** 451 "Thermal Energy and in Chemical Energy" 602 "Electric Fields" 631-632 "Magnetic Fields" --- **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** · Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS3-3) **SE/TE:** 465 How It Works, Wind Turbine 484 Concepts in Action, Solar Home 486-487 "Heat Engines" 634-635 "Generators" 639 "Electric Motor" --- **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** · Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS3-1) **SE/TE:** 446-452 Section 15.1, Energy and Its Forms 453-459 Section 15.2, Energy Conversion and Conservation

	PS3.D: Energy in Chemical Processes • Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3),(HS-PS3-4) **SE/TE:** 465 How It Works, Wind Turbine 474-475 Section 16.1, Thermal Energy and Matter 484 Concepts in Action, Solar Home 486-487 "Heat Engines" 639 "Electric Motor" 634-635 "Generators" **ETS1.A: Defining and Delimiting Engineering Problems** • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary to HS-PS3-3) **SE/TE:** 465 How It Works, Wind Turbine 484 Concepts in Action, Solar Home 486-487 "Heat Engines" 639 "Electric Motor" 634-635 "Generators"	

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

HS-PS4 Waves and Their Applications in Technologies for Information Transfer

HS-PS4 Waves and Their Applications in Technologies for Information Transfer

Students who demonstrate understanding can:

HS-PS4-1. Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. [Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.] [Assessment Boundary: Assessment is limited to algebraic relationships and describing those relationships qualitatively.]

PHYSICAL SCIENCE, Concepts in Action: Waves are presented in Section 17.1, Mechanical Waves, on SE/TE pages 500-507. Frequency, wavelength, and speed of waves are discussed in Section 17.2, Properties of Mechanical Waves, on SE/TE pages 504-507. Calculation of wave speed is introduced in Math Skills, on SE/TE page 506. Sound waves are described on SE/TE pages 514-515, and electromagnetic waves in Section 18.1, Electromagnetic Waves, on SE/TE pages 532-538.

Students **calculate** speed, wavelength, and frequency in Math Practice, on SE/TE page 506. In Section 17.2 Assessment question 6, on SE/TE page 507, students **relate** a change in frequency the period of the wave. In question 8, students **predict** how the wavelength will change when the frequency of a wave is doubled.

HS-PS4-2. Evaluate questions about the advantages of using a digital transmission and storage of information. [Clarification Statement: Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.]

PHYSICAL SCIENCE, Concepts in Action: Personal computers are discussed in Concepts in Action, Getting Personal with Computers, on SE/TE pages 614-617. Analog and digital signals are contrasted in Electronic Signals, on SE/TE pages 618-619. Digital cameras are discussed in How It Works, Digital Camera, on SE/TE page 620. Digital phones are discussed in Communications Technology, on SE/TE page 622.

In Section 20.4 Assessment question 5, on SE/TE page 622, students **explain** how microchips are beneficial for communication devices. In Build Science Skills, Comparing and Contrasting, on TE only page 619, students **compare** analog and digital signals. In For Enrichment, on TE only page 620, students **research** questions about digital cameras and image technology.

HS-PS4-3. Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. [Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.] [Assessment Boundary: Assessment does not include using quantum theory.]

PHYSICAL SCIENCE, Concepts in Action: The particle and wave theories of light are covered in Wave or Particle? on SE/TE pages 536-537.

Students **predict** what would happen in Young's slit interference experiment if light behaved like a stream of particles on TE only page 536. In Reading Checkpoint, on SE/TE page 536, students are prompted to **describe** the evidence that light travels like a wave. In Reading Checkpoint, on SE/TE page 537, students are prompted to **describe** the photoelectric effect, which is evidence for the particle theory of light. In Teacher Demo, The Photoelectric Effect, on TE only page 537, students indirectly **observe** the photoelectric effect.

HS-PS4-4. Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. [Clarification Statement: Emphasis is on the idea that different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.] [Assessment Boundary: Assessment is limited to qualitative descriptions.]

PHYSICAL SCIENCE, Concepts in Action: This expectation falls outside of the program scope and sequence. See ***Miller & Levine Biology***, ISBN: 978-013-361465-7, Chapter 32.

HS-PS4-5. Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.* [Clarification Statement: Examples could include solar cells capturing light and converting it to electricity; medical imaging; and communications technology.] [Assessment Boundary: Assessments are limited to qualitative information. Assessments do not include band theory.]

PHYSICAL SCIENCE, Concepts in Action: Solar panels are discussed in Concepts in Action, Solar Home, on SE/TE page 485. Radio, television, and radar are covered in Radio Waves, on SE/TE pages 541-543. Telescopes, cameras, and microscopes are discussed in Section 19.3, Optical Instruments, on SE/TE pages 580-584. Fiber optics are presented in Concepts in Action, Fiber Optics, on SE/TE pages 586-587. Magnetic Resonance Imaging is discussed in Concepts in Action, Peeking Inside the Human Body, on SE/TE pages 640-641

In Data Analysis, How Long Does an Antenna Need to Be? on SE/TE page 542, students **determine** the relationship between the length of an antenna and the wavelength of a radio transmission. In Writing in Science, "Compare-Contrast Paragraph," on SE/TE page 583, students **write** a comparison of analog and digital cameras. In Quick Lab, Building a Pinhole Viewer, on SE/TE page 585, students **build** a pinhole viewer and **describe** the formation of an inverted image by a pinhole camera. In Going Further on SE/TE page 587, students **research** how fiber optic strands are manufactured and **communicate** their findings to the class. In Build Science, Observe, on TE only page 540, students **observe** and **explain** the variability of radio reception in different locations. In Teacher Demo, Radio Reception, on TE only page 541, students **observe** factors that affect radio signal reception. In Build Science Skills, on TE only page 587, students **observe** the properties of optical fibers.

Disciplinary Core Ideas

PS3.D: Energy in Chemical Processes

- Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. (secondary to HS-PS4-5)

PS4.A: Wave Properties

- The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (HS-PS4-1)

SE/TE:
500-503 Section 17.1, Mechanical Waves
504-507 Section 17.2, Properties of Mechanical Waves
514-515 "Properties of Sound Waves"
532-538 Section 18.1, Electromagnetic Waves

- Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. (HS-PS4-2),(HS-PS4-5)

SE/TE:
485 Concepts in Action, Solar Home
541-543 "Radio Waves"
580-584 Section 19.3, Optical Instruments
586-587 Concepts in Action, Fiber Optics
614-615 Concepts in Action, Getting Personal with Computers
618-619 "Electronic Signals"
620 How It Works, Digital Camera
622 "Communications Technology"
640-641 Concepts in Action, Peeking Inside the Human Body

Crosscutting Concepts

Cause and Effect

- Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS4-1)

SE/TE:
500-503 Section 17.1, Mechanical Waves
504-507 Section 17.2, Properties of Mechanical Waves
514-515 "Properties of Sound Waves"
532-538 Section 18.1, Electromagnetic Waves

- Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS4-4)

SE/TE:
500-503 Section 17.1, Mechanical Waves
504-507 Section 17.2, Properties of Mechanical Waves
514-515 "Properties of Sound Waves"
532-538 Section 18.1, Electromagnetic Waves

- Systems can be designed to cause a desired effect. (HS-PS4-5)

Systems and System Models

- Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-PS4-3)

SE/TE:
536-537 "Wave or Particle?"

	· [From the 3–5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) (HS-PS4-3) **SE/TE:** 536-537 "Wave or Particle?" **PS4.B: Electromagnetic Radiation** · Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (HS-PS4-3) **SE/TE:** 536-537 "Wave or Particle?" · When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. (HS-PS4-4) **SE/TE:** 570-573 Section 19.1, Mirrors · Photovoltaic materials emit electrons when they absorb light of a high-enough frequency. (HS-PS4-5) **SE/TE:** 485 Concepts in Action, Solar Home 541-543 "Radio Waves" 580-584 Section 19.3, Optical Instruments 586-587 Concepts in Action, Fiber Optics 640-641 Concepts in Action, Peeking Inside the Human Body **PS4.C: Information Technologies and Instrumentation** · Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. (HS-PS4-5) **SE/TE:** 485 Concepts in Action, Solar Home 541-543 "Radio Waves" 580-584 Section 19.3, Optical Instruments 586-587 Concepts in Action, Fiber Optics 640-641 Concepts in Action, Peeking Inside the Human Body	**Stability and Change** · Systems can be designed for greater or lesser stability. (HS-PS4-2) **SE/TE:** 614-615 Concepts in Action, Getting Personal with Computers 618-619 "Electronic Signals" 620 How It Works, Digital Camera 622 "Communications Technology" -- **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** · Science and engineering complement each other in the cycle known as research and development (R&D). (HS-PS4-5) **SE/TE:** 485 Concepts in Action, Solar Home 541-543 "Radio Waves" 580-584 Section 19.3, Optical Instruments 586-587 Concepts in Action, Fiber Optics 640-641 Concepts in Action, Peeking Inside the Human Body **Influence of Engineering, Technology, and Science on Society and the Natural World** · Modern civilization depends on major technological systems. (HS-PS4-2),(HS-PS4-5) **SE/TE:** 614-615 Concepts in Action, Getting Personal with Computers 618-619 "Electronic Signals" 620 How It Works, Digital Camera 622 "Communications Technology" · Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS4-2) **SE/TE:** 614-615 Concepts in Action, Getting Personal with Computers 618-619 "Electronic Signals" 620 How It Works, Digital Camera 622 "Communications Technology"

*The performance expectations marked with an asterisk integrate traditional science content with engineering through a Practice or Disciplinary Core Idea.

A Correlation of
Physical Science: Concepts in Action, ©2011
to the Next Generation Science Standards, May 2013
Grades 9-12

HS-ETS1 Engineering Design

HS-ETS1 Engineering Design

Students who demonstrate understanding can:

HS-ETS1-1. Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

PHYSICAL SCIENCE, Concepts in Action: In Issues in Science, Genetically Modified Organisms, on SE/TE page 281, students **analyze** problems associated with genetically modified food. In Issues in Science, Are Regulations Needed to Protect Whales from Noise Pollution? on SE/TE page 513, they **analyze** the challenge posed by noise pollution in the oceans.

HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

PHYSICAL SCIENCE, Concepts in Action: A solution to the complex real-world problem of water purification, in which the solution is broken down into numerous smaller parts, is discussed in Concepts in Action, Getting a Fresh Start, on SE/TE pages 52-53. A solution to the complex problem of air pollution, in which the solution is broken down into numerous smaller parts, is discussed in Concepts in Action, Breathing Easier, on SE/TE pages 270-271. A solution to the complex real-world problem of airplane flight controls is presented in Concepts in Action, Airplane Motion, on SE/TE pages 398-399.

In Problem-Solving Activity, Transmitting Electricity to a new School, on SE/TE page 646, students **design** a method of transmitting energy from a power plant to a school.

HS-ETS1-3. Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.

PHYSICAL SCIENCE, Concepts in Action: In Issues in Science, What Should Be Done With Arsenic-Treated Wood? on SE/TE page 59, students **evaluate** different plans for disposing arsenic contaminated wood. In Data Analysis, What Is the Real Cost of a Washing Machine? on SE/TE page 491, students **evaluate** the costs of running washing machines in homes.

HS-ETS1-4. Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

PHYSICAL SCIENCE, Concepts in Action: Computer simulations fall outside of the program scope and sequence. Students **evaluate** different plans for disposing arsenic contaminated wood in Issues in Science, What Should Be Done With Arsenic-Treated Wood? on SE/TE page 59. In Data Analysis, What Is the Real Cost of a Washing Machine? on SE/TE page 491, students **evaluate** the costs of running washing machines in homes.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1) **SE/TE:** 281 Issues in Science, Genetically Modified Organisms 513 Issues in Science, Are Regulations Needed to Protect Whales from Noise Pollution? 646 Problem-Solving Activity	**ETS1.A: Defining and Delimiting Engineering Problems** • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1) **SE/TE:** 281 Issues in Science, Genetically Modified Organisms 513 Issues in Science, Are Regulations Needed to Protect Whales from Noise Pollution?	**Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows— within and between systems at different scales. HS-ETS1-4) --- **Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** • New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1) (HS-ETS1-3)

Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. ▪Use mathematical models and/or computer simulations to predict the effects of a design solution on systems and/or the interactions between systems. (HS-ETS1-4) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles and theories. · Design a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-2) **SE/TE:** 52-53 Concepts in Action, Getting a Fresh Start 270-271 Concepts in Action, Breathing Easier 398-399 Concepts in Action, Airplane Motion 646 Problem-Solving Activity · Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ETS1-3) **SE/TE:** 59 Issues in Science, What Should Be Done With Arsenic-Treated Wood? 491 Data Analysis, What Is the Real Cost of a Washing Machine?	· Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1) **SE/TE:** 281 Issues in Science, Genetically Modified Organisms 513 Issues in Science, Are Regulations Needed to Protect Whales from Noise Pollution? 646 Problem-Solving Activity **ETS1.B: Developing Possible Solutions** · When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. (HS-ETS1-3) **SE/TE:** 59 Issues in Science, What Should Be Done With Arsenic-Treated Wood? 491 Data Analysis, What is the real Cost of a Washing Machine? · Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4) **ETS1.C: Optimizing the Design Solution** · Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS-ETS1-2) **SE/TE:** 52-53 Concepts in Action, Getting a Fresh Start 270-271 Concepts in Action, Breathing Easier 398-399 Concepts in Action, Airplane Motion	**SE/TE:** 59 Issues in Science, What Should Be Done With Arsenic-Treated Wood? 281 Issues in Science, Genetically Modified Organisms 491 Data Analysis, What is the real Cost of a Washing Machine? 513 Issues in Science, Are Regulations Needed to Protect Whales from Noise Pollution?