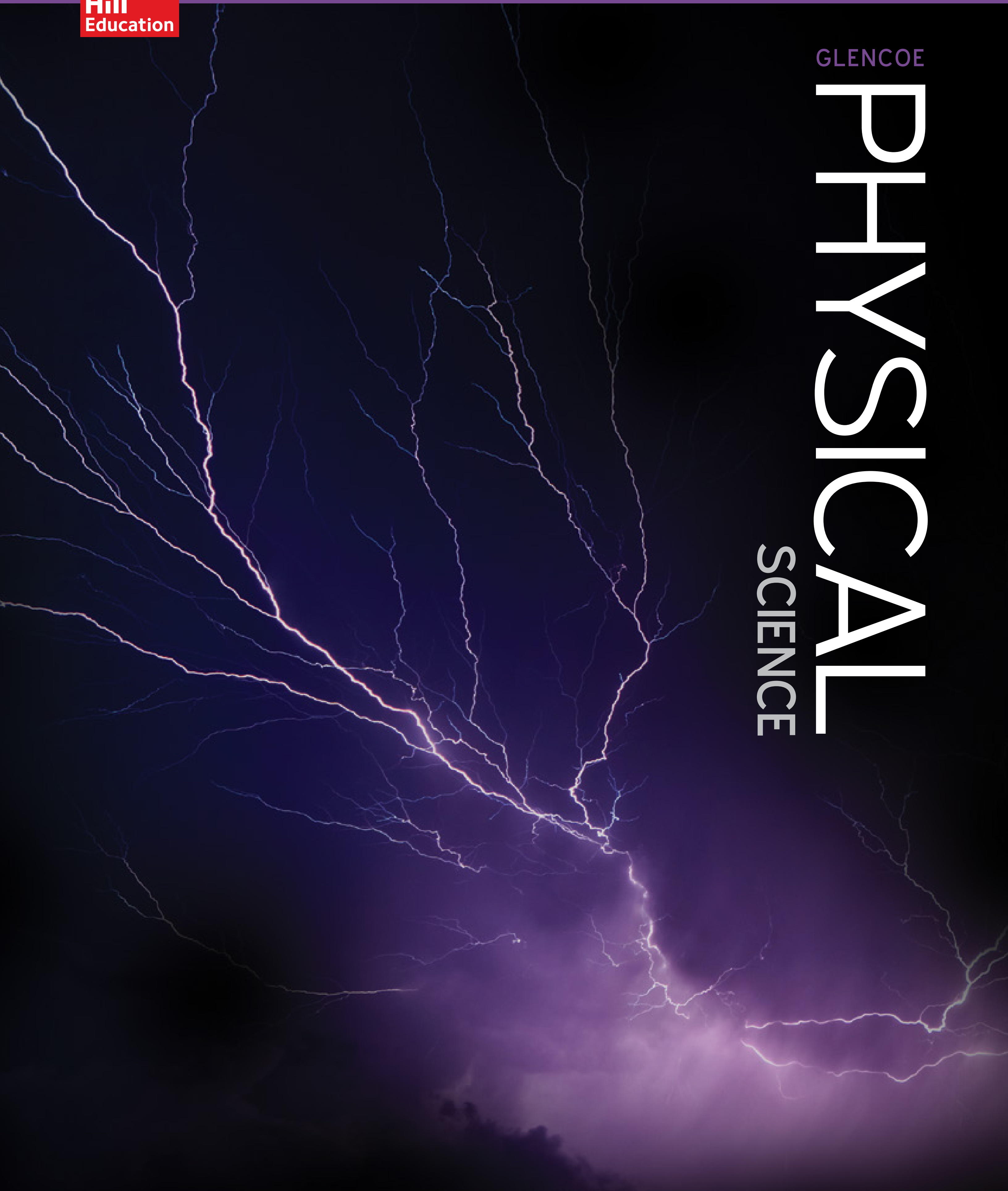
McGraw Hill Education

Alignment Guide

GLENCOE

PHYSICAL SCIENCE



Glencoe Science—Your Partner in Understanding and Implementing NGSS*

Ease the Transition to Next Generation Science Standards

Meeting NGSS

Glencoe Science helps ease the transition to Next Generation Science Standards (NGSS). Our high school science programs ensure you are fully aligned to:

- Performance Expectations
- Science and Engineering Practices
- Disciplinary Core Ideas
- Crosscutting Concepts

We are committed to ensuring that you have the tools and resources necessary to meet the expectations for the next generation of science standards.

What is NGSS?

The purpose of the NGSS Framework is to act as the foundation for science education standards while describing a vision of what it means to be proficient in science. It emphasizes the importance of the practices of science where the content becomes a vehicle for teaching the processes of science.

Why NGSS?

The NGSS were developed in an effort to create unified standards in science education that consider content, practices, pedagogy, curriculum, and professional development. The standards provide all students with an internationally benchmarked education in science.

Correlation of NGSS Performance Expectations to Physical Science

The Correlation Table lists a Performance Expectation that integrates a combination of Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts.

Performance Expectations

are tasks to evaluate student's knowledge. Each Performance Expectation is correlated to an Applying Practices activity written specifically for the purpose. These activities can be found in the resources for the section listed.

Science and Engineering Practices

are skills that scientists and engineers use in their work. Each Practice is correlated to a part of the Science and Engineering Practices Handbook, which can be found in the program resources.

Disciplinary Core Ideas

are the content knowledge students will need to learn. These are correlated to the main student text.

Crosscutting Concepts

are themes that appear throughout all branches of science and engineering. These are not directly correlated but are found implicitly in the other correlations listed on the page.

Find it here!

Code	Title/Text	Location
HS-LS4	Biological Evolution: Unity and Diversity	
HS-LS4-1	**Communicate scientific information that common ancestry and biological evolution are supported by multiple lines of empirical evidence.** Clarification Statement: Emphasis is on a conceptual understanding of the role each line of evidence has relating to common ancestry and biological evolution. Examples of evidence could include similarities in DNA sequences, anatomical structures, and order of appearance of structures in embryological development.	**Activity:** *Evidence for Evolution,* Chapter 15 Section 2, Chapter 17 Section 2
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs.	
	• Communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	**Science and Engineering Practices Handbook:** Practice 8
	Connections to Nature of Science Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena	
	• A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.	**Science and Engineering Practices Handbook:** Practice 6 **Student Edition:** 11, 13
Disciplinary Core Ideas		
LS4.A	Evidence of Common Ancestry and Diversity	
	• Genetic information, like the fossil record, provides evidence of evolution. DNA sequences vary among species, but there are many overlaps; in fact, the ongoing branching that produces multiple lines of descent can be inferred by comparing the DNA sequences of different organisms. Such information is also derivable from the similarities and differences in amino acid sequences and from anatomical and embryological evidence.	**Student Edition:** 423–427, 491, 493–495
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.	
	Scientific Knowledge Assumes an Order and Consistency in Natural Systems	
	• Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future.	

Code	Title/Text	Location
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.	**Activity:** *Electron Patterns in Atoms,* Chapter 16 Section 3
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
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.	
	• Use a model to predict the relationships between systems or between components of a system.	**Science and Engineering Practices Handbook:** Practice 2
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.	**Student Edition:** 488–493, 494–497, 503, 512, 513, 618–620, 633–639
	• 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.	**Student Edition:** 498–506, 507, 508–509, 512, 513, 518–525, 526–530, 531, 532–539, 544, 545
PS2.B	**Types of Interactions**	
	• 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. *(secondary)*	**Student Edition:** 519, 558–560, 562–564, 572–573, 577, 618–620, 638, 639
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.	

Code	Title/Text	Location
HS-PS1	**Matter and Its Interactions** *continued*	
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.	**Activity:** *Electron States and Simple Chemical Reactions,* Chapter 19 Section 1
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	
	• 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.	**Science and Engineering Practices Handbook:** Practice 6
Disciplinary Core Ideas		
PS1.A	**Structure and Properties of Matter**	
	• 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.	**Student Edition:** 498–506, 507, 508–509, 512, 513, 518–525, 526–530, 531, 532–539, 544, 545
PS1.B	**Chemical Reactions**	
	• 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.	**Student Edition:** 475–476, 478–479, 483, 518–525, 526–530, 532–539, 544, 545, 558–564, 576, 577, 582–589, 590–593, 610, 611
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.	

Code	Title/Text	Location
HS-PS1	**Matter and Its Interactions** *continued*	
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.	**Activity:** *Investigate Interparticle Forces,* Chapter 18 Section 2
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	**Science and Engineering Practices Handbook:** Practice 3
Disciplinary Core Ideas		
PS1.A	**Structure and Properties of Matter**	
	• The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms.	**Student Edition:** 432–436, 438, 439, 440, 456, 558–564, 572–573, 649, 658–659, 663–667
PS2.B	**Types of Interactions**	
	• 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. *(secondary)*	**Student Edition:** 519, 558–560, 562–564, 572–573, 577, 618–620, 638, 639
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.	

*Next Generation Science Standards is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards was involved in the production of, and does not endorse, this product.

Code	Title/Text	Location
HS-PS1	**Matter and Its Interactions** *continued*	
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.	**Activity:** *Modeling Energy in Chemical Reactions,* Chapter 19 Section 3
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
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.	**Science and Engineering Practices Handbook:** Practice 2
Disciplinary Core Ideas		
PS1.A	**Structure and Properties of Matter**	
	• 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.	**Student Edition:** 554–556, 557, 577, 594–597
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.	**Student Edition:** 594–597, 598–601, 604, 605, 606–607, 611
Crosscutting Concepts		
	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.	

Code	Title/Text	Location
HS-PS1	**Matter and Its Interactions** *continued*	
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.	**Activity:** *Concentration and Reaction Rates,* Chapter 19 Section 4
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	**Science and Engineering Practices Handbook:** Practice 6
Disciplinary Core Ideas		
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.	**Student Edition:** 594–597, 598–601, 604, 605, 606–607, 611
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.	

*Next Generation Science Standards is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards was involved in the production of, and does not endorse, this product.

Code	Title/Text	Location
HS-PS1	**Matter and Its Interactions** *continued*	
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 Chatelier'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.	**Activity:** *Food For Thought,* Chapter 19 Section 4
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	
	• Refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**Science and Engineering Practices Handbook:** Practice 6
Disciplinary Core Ideas		
PS1.B	**Chemical Reactions**	
	• 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.	**Student Edition:** 601–604, 611
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)*	**Science and Engineering Practices Handbook:** Practice 1, Practiced 6
Crosscutting Concepts		
	Stability and Change	
	• Much of science deals with constructing explanations of how things change and how they remain stable.	

*Next Generation Science Standards is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards was involved in the production of, and does not endorse, this product.

Code	Title/Text	Location
HS-PS1	**Matter and Its Interactions** *continued*	
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.	**Activity:** *Conservation of Mass,* Chapter 15 Section 2, Chapter 19 Section 1
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	**Science and Engineering Practices Handbook:** Practice 5
Disciplinary Core Ideas		
PS1.B	**Chemical Reactions**	
	• 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.	**Student Edition:** 475–476, 478–479, 483, 518–525, 526–530, 532–539, 544, 545, 558–564, 576, 577, 582–589, 590–593, 610, 611
Crosscutting Concepts		
	Energy and Matter	
	• The total amount of energy and matter in closed systems is conserved.	
	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.	

Code	Title/Text	Location
HS-PS1	**Matter and Its Interactions** *continued*	
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.	**Activity:** *Modeling Fission, Fusion, and Radioactive Decay,* Chapter 20 Section 3
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
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.	**Science and Engineering Practices Handbook:** Practice 2
Disciplinary Core Ideas		
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.	**Student Edition:** 616–620, 621–627, 628, 634–635, 638, 639
Crosscutting Concepts		
	Energy and Matter	
	• In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.	

Code	Title/Text	Location
HS-PS2	**Motion and Stability: Forces and Interactions**	
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.	**Activity:** *Newton's Second Law,* Chapter 3 Section 2
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	**Science and Engineering Practices Handbook:** Practice 4
	Connections to Nature of Science **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**	
	• Theories and laws provide explanations in science.	**Science and Engineering Practices Handbook:** Practice 6 **Student Edition:** 13
	• Laws are statements or descriptions of the relationships among observable phenomena.	**Science and Engineering Practices Handbook:** Practice 6 **Student Edition:** 13
Disciplinary Core Ideas		
PS2.A	**Forces and Motion**	
	• Newton's second law accurately predicts changes in the motion of macroscopic objects.	**Student Edition:** 72–73, 80–90, 92–95, 98–101
Crosscutting Concepts		
	Cause and Effect	
	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	

*Next Generation Science Standards is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards was involved in the production of, and does not endorse, this product.

Code	Title/Text	Location
HS-PS2	**Motion and Stability: Forces and Interactions** *continued*	
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.	**Activity:** *Conservation of Momentum,* Chapter 3 Section 3
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	**Science and Engineering Practices Handbook:** Practice 5
Disciplinary Core Ideas		
PS2.A	**Forces and Motion**	
	• Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object.	**Student Edition:** 54–55, 62–63, 66–67
	• 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.	**Student Edition:** 54–55, 62–63, 91–92, 96, 99–101
Crosscutting Concepts		
	Systems and System Models	
	• When investigating or describing a system, the boundaries and initial conditions of the system need to be defined.	

*Next Generation Science Standards is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards was involved in the production of, and does not endorse, this product.

Code	Title/Text	Location
HS-PS2	**Motion and Stability: Forces and Interactions** *continued*	
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.	**Activity:** *Egg Heads,* Chapter 3 Section 3
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	**Science and Engineering Practices Handbook:** Practice 6
Disciplinary Core Ideas		
PS2.A	**Forces and Motion**	
	• 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.	**Student Edition:** 54–55, 62–63, 91–92, 96, 99–101
ETS1.A	**Defining and Delimiting an Engineering Problem**	
	• 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)*	**Science and Engineering Practices Handbook:** Practice 1, Practiced 6
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)*	**Science and Engineering Practices Handbook:** Practice 1, Practiced 6
Crosscutting Concepts		
	Cause and Effect	
	• Systems can be designed to cause a desired effect.	

*Next Generation Science Standards is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards was involved in the production of, and does not endorse, this product.

Code	Title/Text	Location
HS-PS2	**Motion and Stability: Forces and Interactions** *continued*	
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.	**Activity:** *Investigate Electromagnetism,* Chapter 7 Section 3
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
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.	**Science and Engineering Practices Handbook:** Practice 3
Disciplinary Core Ideas		
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)	**Student Edition:** 76–79, 98–101, 170–172, 177, 196–197
	• 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.	**Student Edition:** 77–79, 172, 202–204, 209–225, 228–229
PS3.A	**Definitions of Energy**	
	• "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. *(secondary)*	**Student Edition:** 178–181, 188–191, 196–199
Crosscutting Concepts		
	Cause and Effect	
	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	

*Next Generation Science Standards is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards was involved in the production of, and does not endorse, this product.

Code	Title/Text	Location
HS-PS2	**Motion and Stability: Forces and Interactions** *continued*	
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.	**Activity:** *Touching the Future,* Chapter 17 Section 3
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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).	**Science and Engineering Practices Handbook:** Practice 8
Disciplinary Core Ideas		
PS1.A	**Structure and Properties of Matter**	
	• The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. *(secondary)*	**Student Edition:** 432–436, 438, 439, 440, 456, 558–564, 572–573, 649, 658–659, 663–667
PS2.B	**Types of Interactions**	
	• 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.	**Student Edition:** 519, 558–560, 562–564, 572–573, 577, 618–620, 638, 639
Crosscutting Concepts		
	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.	

Code	Title/Text	Location
HS-PS3	**Energy**	
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.	**Activity:** *Modeling Changes in Energy,* Chapter 4 Section 3, Chapter 5 Section 3
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	**Science and Engineering Practices Handbook:** Practice 5
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.	**Student Edition:** 114–129, 132–135, 138–161, 164–167
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.	**Student Edition:** 120–129, 132–135, 138–161, 164–167, 597
	• Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.	**Student Edition:** 120–129, 132–135, 138–161, 164–167
	• 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.	**Student Edition:** 114–124
	• The availability of energy limits what can occur in any system.	**Student Edition:** 114
Crosscutting Concepts		
	Systems and System Models	
	• 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.	
	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.	

Code	Title/Text	Location
HS-PS3	**Energy** *continued*	
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 positions 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.	**Activity:** *Modeling Energy on Different Scales,* Chapter 5 Section 3
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
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.	**Science and Engineering Practices Handbook:** Practice 2
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.	**Student Edition:** 114–129, 132–135, 138–161, 164–167
	• At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.	**Student Edition:** 114–119, 132–135, 138–140, 187–191, 196–199, 212–222, 228–229, 248–252, 254, 338–343, 432–439, 594–597
	• 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.	**Student Edition:** 138–147, 432–439, 660–661
Crosscutting Concepts		
	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)	
	• Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.	

Code	Title/Text	Location
HS-PS3	**Energy** *continued*	
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.	**Activity:** *Earth Power,* Chapter 4 Section 3
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	**Science and Engineering Practices Handbook:** Practice 6
Disciplinary Core Ideas		
PS3.A	**Definitions of Energy**	
	• At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.	**Student Edition:** 114–119, 132–135, 138–140, 187–191, 196–199, 212–222, 228–229, 248–252, 254, 338–343, 432–439, 594–597
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.	**Student Edition:** 120–129, 154–157
ETS1.A	**Defining and Delimiting an Engineering Problem**	
	• 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)*	**Science and Engineering Practices Handbook:** Practice 1, Practiced 6
Crosscutting Concepts		
	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.	
	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.	

Code	Title/Text	Location
HS-PS3	**Energy** *continued*	
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.	**Activity:** *Coffee Cup Calorimetry,* Chapter 5 Section 1
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
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.	**Science and Engineering Practices Handbook:** Practice 3
Disciplinary Core Ideas		
PS3.B	**Conservation of Energy and Energy Transfer**	
	• Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.	**Student Edition:** 120–129, 132–135, 138–161, 164–167
	• 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).	**Student Edition:** 155
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.	**Student Edition:** 120–129, 154–157
Crosscutting Concepts		
	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.	

Code	Title/Text	Location
HS-PS3	**Energy** *continued*	
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. **Assessment Boundary:** Assessment is limited to systems containing two objects.	**Activity:** *Modeling Magnetic Fields,* Chapter 7 Section 1
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
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.	**Science and Engineering Practices Handbook:** Practice 2
Disciplinary Core Ideas		
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.	*For related information, see* **Student Edition:** 118–119, 172
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.	

Code	Title/Text	Location
HS-PS4	**Waves and Their Applications in Technologies for Information Transfer**	
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.	**Activity:** *Wave Characteristics,* Chapter 9 Section 2
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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 or design solutions to describe and/or support claims and/or explanations.	**Science and Engineering Practices Handbook:** Practice 5
Disciplinary Core Ideas		
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.	**Student Edition:** 280–282, 296, 300–303, 307–308, 338–342, 344
Crosscutting Concepts		
	Cause and Effect	
	• Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	

Code	Title/Text	Location
HS-PS4	**Waves and Their Applications in Technologies for Information Transfer** *continued*	
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.	**Activity:** *Digital Transmission and Storage of Information,* Chapter 11 Section 3
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	Asking Questions and Defining Problems Asking questions and defining problems in grades 9–12 builds from grades K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations.	
	• Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design.	**Science and Engineering Practices Handbook:** Practice 1
Disciplinary Core Ideas		
PS4.A	**Wave Properties**	
	• 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.	**Student Edition:** 354
Crosscutting Concepts		
	Stability and Change	
	• Systems can be designed for greater or lesser stability.	
	Connections to Engineering, Technology, and Applications of Science **Influence of Engineering, Technology, and Science 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.	

Code	Title/Text	Location
HS-PS4	**Waves and Their Applications in Technologies for Information Transfer** *continued*	
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.	**Activity:** *Is Light a Wave or a Particle?,* Chapter 11 Section 1
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	Engaging in Argument from Evidence Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed worlds. Arguments may also come from current scientific or historical episodes in science.	
	• Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments.	**Science and Engineering Practices Handbook:** Practice 7
	Connections to Nature of Science **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**	
	• A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence.	**Science and Engineering Practices Handbook:** Practice 6 **Student Edition:** 13
Disciplinary Core Ideas		
PS4.A	**Wave Properties**	
	• [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.)	**Student Edition:** 292–295, 322
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.	**Student Edition:** 338–343
Crosscutting Concepts		
	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.	

Code	Title/Text	Location
HS-PS4	**Waves and Their Applications in Technologies for Information Transfer** *continued*	
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 photons associated with 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.	**Activity:** *Human Health and Radiation Frequency,* Chapter 11 Section 2
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	
	• Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible.	**Science and Engineering Practices Handbook:** Practice 8
Disciplinary Core Ideas		
PS4.B	**Electromagnetic Radiation**	
	• 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.	**Student Edition:** 338–343, 345–351, 360, 362–365
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.	

*Next Generation Science Standards is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards was involved in the production of, and does not endorse, this product.

Code	Title/Text	Location
HS-PS4	**Waves and Their Applications in Technologies for Information Transfer** *continued*	
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.	**Activity:** *Catching Waves,* Chapter 11 Section 3
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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 technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically).	**Science and Engineering Practices Handbook:** Practice 8
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)*	**Student Edition:** 153
PS4.A	**Wave Properties**	
	• 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.	**Student Edition:** 354
PS4.B	**Electromagnetic Radiation**	
	• Photoelectric materials emit electrons when they absorb light of a high-enough frequency.	**Student Edition:** 342
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.	**Student Edition:** 316, 319–320, 324–329, 332–335, 344–360, 360–365, 378–388, 392, 394–397, 415–422, 424–427
Crosscutting Concepts		
	Cause and Effect	
	• Systems can be designed to cause a desired effect.	
	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).	
	Influence of Engineering, Technology, and Science on Society and the Natural World	
	• Modern civilization depends on major technological systems.	
*Next Generation Science Standards is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards was involved in the production of, and does not endorse, this product.		

Code	Title/Text	Location
HS-ESS3	**Earth and Human Activity**	
HS-ESS3-2	**Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.*** Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practices for agricultural soil use, mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems—not what should happen.	**Activity:** *Environmental Consulting: Finding Solutions,* Chapter 8 Section 4
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	Engaging in Argument from Evidence Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed world(s). Arguments may also come from current scientific or historical episodes in science.	
	• Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations).	**Science and Engineering Practices Handbook:** Practice 7
Disciplinary Core Ideas		
ESS3.A	**Natural Resources**	
	• All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors.	**Student Edition:** 232–269, 698, 838, 876
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. *(secondary)*	**Student Edition:** 26–32, 33, 64, 162, 226, 360, 480, 574, 760
Crosscutting Concepts		
	Connections to Engineering, Technology, and Applications of Science **Influence of Science, Engineering, and Technology on Society and the Natural World**	
	• Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.	
	• Analysis of costs and benefits is a critical aspect of decisions about technology.	
	Connections to Nature of Science **Science Addresses Questions About the Natural and Material World**	
	• Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions.	
	• Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge.	
	• Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues.	

Code	Title/Text	Location
HS-ESS3	**Earth and Human Activity** *continued*	
HS-ESS3-4	**Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*** Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).	**Activity:** *Locking Up Carbon,* Chapter 8 Section 4
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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 knowledge, principles, and theories.	
	• Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**Science and Engineering Practices Handbook:** Practice 6
Disciplinary Core Ideas		
ESS3.C	**Human Impacts on Earth Systems**	
	• Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation.	**Student Edition:** 244–247, 248–253, 255–261, 698, 902–905
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. *(secondary)*	**Student Edition:** 26–32, 33, 64, 162, 226, 360, 480, 574, 760
Crosscutting Concepts		
	Stability and Change	
	• Feedback (negative or positive) can stabilize or destabilize a system.	
	Connections to Engineering, Technology, and Applications of Science **Influence of Science, Engineering, and Technology on Society and the Natural World**	
	• Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.	

Code	Title/Text	Location
HS-ETS1	**Engineering Design**	
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.**	**Activity:** *Engineer a Better World: Analyze a Major Global Challenge,* for use as long-term project (see Program Resources)
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	**Science and Engineering Practices Handbook:** Practice 1
Disciplinary Core Ideas		
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.	**Science and Engineering Practices Handbook:** Practice 1, Practiced 6
	• 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.	**Science and Engineering Practices Handbook:** Introduction, all Practices
Crosscutting Concepts		
	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.	

Code	Title/Text	Location
HS-ETS1	**Engineering Design** *continued*	
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.**	**Activity:** *Engineer a Better World: Design a Solution,* for use as long-term project (see Program Resources)
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	**Science and Engineering Practices Handbook:** Practice 6
Disciplinary Core Ideas		
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.	**Science and Engineering Practices Handbook:** Practice 1, Practice 6

Code	Title/Text	Location
HS-ETS1	**Engineering Design** *continued*	
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.**	**Activity:** *Engineer a Better World: Design a Solution,* for use as long-term project (see Program Resources
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	
	• Evaluate a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations.	**Science and Engineering Practices Handbook:** Practice 6
Disciplinary Core Ideas		
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.	**Science and Engineering Practices Handbook:** Practice 1, Practice 6
Crosscutting Concepts		
	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.	

Code	Title/Text	Location
HS-ETS1	**Engineering Design** *continued*	
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.**	**Activity:** *Engineer a Better World: Use a Computer Simulation,* for use as long-term project (see Program Resources)
The performance expectation above was developed using the following elements from the NRC document *A Framework for K–12 Science Education:*		
Science and Engineering Practices		
	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.	**Science and Engineering Practices Handbook:** Practice 5
Disciplinary Core Ideas		
ETS1.B	**Developing Possible Solutions**	
	• 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.	**Science and Engineering Practices Handbook:** Practice 1, Practice 6
Crosscutting Concepts		
	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.	

*Next Generation Science Standards is a registered trademark of Achieve. Neither Achieve nor the lead states and partners that developed the Next Generation Science Standards was involved in the production of, and does not endorse, this product.