McGraw Hill Education

Alignment Guide

GLENCOE

CHEMISTRY

MATTER & CHANGE

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 Chemistry

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 6 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:** 106–114, 115–121, 128, 129, 130, 131, 146–155, 156–162, 167, 168, 169
	• 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:** 174–181, 182–186, 187–194, 196, 198, 199, 200, 201
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:** 206–209, 210–217, 225–228, 232, 233, 234, 235, 240–241, 242, 246–247, 265–270, 271, 274, 275, 276, 411–414, 417–419, 422–424, 432, 434, 435, 436, 477, 489–491, 497
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 8 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:** 174–181, 182–186, 187–194, 196, 198, 199, 200, 201
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:** 77–79, 105, 128, 285–288, 289–298, 299–308, 310, 312, 313, 314, 315, 368–372, 373–378, 379–384, 385–388, 390, 392, 393, 394, 395, 396, 397
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.	

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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 Boundary: Assessment does not include Raoult's law calculations of vapor pressure.	**Activity:** *Investigate Interparticle Forces,* Chapter 12 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		
	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:** 191–194, 199, 200, 201, 212–217, 226, 227, 228, 242, 246–247, 269–270, 411–414, 417, 418–419, 434, 435, 436, 437
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:** 206–209, 210–217, 225–228, 232, 233, 234, 235, 240–241, 242, 246–247, 265–270, 271, 274, 275, 276, 411–414, 417–419, 422–424, 432, 434, 435, 436, 477, 489–491, 497
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.	

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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 15 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 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:** 159, 193, 216–217, 240–241, 246–247
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:** 516–522, 522–528, 529–533, 535–541, 550, 552, 553, 554, 555, 560–567, 568–573, 580–582, 584, 586, 587, 588
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, Temperature, and Reaction Rates,* Chapter 16, 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		
	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:** 516–522, 522–528, 529–533, 535–541, 550, 552, 553, 554, 555, 560–567, 568–573, 580–582, 584, 586, 587, 588
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-PS1-6	**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 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		
	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:** 594–605, 606–611, 612–622, 623, 624, 626, 627, 628, 629
ET S1.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, Practice 6
Crosscutting Concepts		
	Stability and Change	
	• Much of science deals with constructing explanations of how things change and how they remain stable.	

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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 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		
	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:** 77–79, 105, 128, 285–288, 289–298, 299–308, 310, 312, 313, 314, 315, 368–372, 373–378, 379–384, 385–388, 390, 392, 393, 394, 395, 396, 397
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 24 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:** 122–124, 129, 130, 860–864, 865–869, 875–884, 894, 895, 896, 897
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-PS2-6	**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 12 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:** 191–194, 199, 200, 201, 212–217, 226, 227, 228, 242, 246–247, 269–270, 411–414, 417, 418–419, 434, 435, 436, 437
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:** 206–209, 210–217, 225–228, 232, 233, 234, 235, 240–241, 242, 246–247, 265–270, 271, 274, 275, 276, 411–414, 417–419, 422–424, 432, 434, 435, 436, 477, 489–491, 497
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-PS3-4	**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 15 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 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:** 516–517, 525–528, 552, 554
	• 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:** 240–241, 542–548, 554, 865–866, 874, 894
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:** 516–517
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-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 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		
	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:** 137–138, 140, 145, 166, 168
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-PS4-3	**Evaluate the claims, evidence, and reasoning behind 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 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		
	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:** 16
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.)	
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:** 136–145, 146–155, 166, 167
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.	

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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 24 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		
	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:** 888–890, 892, 895, 896
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-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, Practice 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: Evaluate 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 2, Practice 5, 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.	