NEXT GENERATION SCIENCE STANDARDS

Inspire Physical Science with Earth Science is designed to meet 100% of the Next Generation Science Standards through both print and digital resources. The Student Edition, accessible in print and online, can be used as a research tool by students as they investigate concepts and collect evidence. Interactive Digital Content, labs, and projects that support the Science and Engineering Practices, Disciplinary Core Ideas, and Crosscutting Concepts, as well as CCSS Mathematics and ELA/Literacy, are available online.

Correlation of *Inspire Physical Science with Earth Science* to the NGSS

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,* Module 16 Lesson 3

SEP 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

DCI 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:** 398–403, 404–407, 412, 504–506, 518
• 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:** 408–416, 422–429, 430–434, 435–442
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:** 423, 455–457, 459–461, 504–506

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CCC 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.	**Online:** *Science and Engineering Handbook*
CCSS ELA/Literacy	
RST.9-10.7	**Online:** Applying Practices: *Electron Patterns in Atoms*

HS-PS1	Matter and Its Interactions	
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,* Module 19 Lesson 1 *Conservation of Mass*, Module 19, Lesson 1
SEP 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
DCI 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:** 408–416, 422–429, 430–434, 435–442
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:** 391–392, 422–429, 430–434, 435–442, 455–461, 474–481, 482–485
CCC 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.		**Online:** *Science and Engineering Handbook*

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CCSS Mathematics	
HSN-Q.A.1, HSN-Q.A.3	**Online:** Applying Practices: *Electron States and Simple Chemical Reactions* and *Conservation of Mass*
CCSS ELA/Literacy	
WHST.9-12.2, WHST.9-12.5	**Online:** Applying Practices: *Electron States and Simple Chemical Reactions* and *Conservation of Mass*

HS-PS1	**Matter and Its Interactions**	
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,* Module 18 Lesson 2
SEP 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
DCI 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:** 354–358, 360, 361, 455–461, 529, 538–539, 542–546, 611–612
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:** 423, 455–457, 459–461, 504–506

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CCC 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.	**Online:** *Science and Engineering Handbook*
CCSS Mathematics	
HSN-Q.A.1, HSN-Q.A.3	**Online:** Applying Practices: *Investigate Interparticle Forces*
CCSS ELA/Literacy	
RST.11-12.1, WHST.9-12.7, WHST.11-12.8, WHST.9-12.9	**Online:** Applying Practices: *Investigate Interparticle Forces*

HS-PS1	Matter and Its Interactions	
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,* Module 19 Lesson 3
SEP 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
DCI 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:** 452–454, 486–489
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:** 486–489, 490–496

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CCC 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.	**Online:** *Science and Engineering Handbook*
CCSS Mathematics	
MP.4, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3	**Online:** Applying Practices: *Investigate Interparticle Forces*
CCSS ELA/Literacy	
SL.11-12.5	**Online:** Applying Practices: *Investigate Interparticle Forces*

HS-PS1	Matter and Its Interactions	
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,* Module 19 Lesson 4
SEP 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
DCI 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:** 486–489, 490–493, 496, 537

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CCC 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.	**Online:** *Science and Engineering Handbook*
CCSS Mathematics	
MP.2, HSN-Q.A.1, HSN-Q.A.3	**Online:** Applying Practices: *Concentration and Reaction Rates*
CCSS ELA/Literacy	
RST.11-12.1, WHST.9-12.2	**Online:** Applying Practices: *Concentration and Reaction Rates*

HS-PS1	Matter and Its Interactions	
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 Châtelier'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,* Module 19 Lesson 4
SEP 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
DCI 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:** 493–496

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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, Practice 6
CCC Crosscutting Concepts	
Stability and Change • Much of science deals with constructing explanations of how things change and how they remain stable.	**Online:** *Science and Engineering Handbook*
CCSS ELA/Literacy	
WHST.9-12.7	**Online:** Applying Practices: *Food For Thought*

HS-PS1	**Matter and Its Interactions**	
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,* Module 15 Lesson 2, Module 19 Lesson 1
SEP 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
DCI 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:** 391–392, 422–429, 430–434, 435–442, 455–461, 474–481, 482–485

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CCC Crosscutting Concepts	
Energy and Matter • The total amount of energy and matter in closed systems is conserved.	**Online:** *Science and Engineering Handbook*
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.	**Online:** *Science and Engineering Handbook*
CCSS Mathematics	
MP.2, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3	**Online:** Applying Practices: *Conservation of Mass*

HS-PS1	Matter and Its Interactions	
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,* Module 20 Lesson 3
SEP 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
DCI 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:** 502–506, 507–513, 514-518
CCC Crosscutting Concepts		
Energy and Matter • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.		**Online:** *Science and Engineering Handbook*

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CCSS Mathematics	
MP.4, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3	**Online:** Applying Practices: *Modeling Fission, Fusion, and Radioactive Decay*

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,* Module 3 Lesson 2

SEP 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:** 11
• Laws are statements or descriptions of the relationships among observable phenomena.	**Science and Engineering Practices Handbook:** Practice 6 **Student Edition:** 11

DCI Disciplinary Core Ideas	
PS2.A: Forces and Motion • Newton's second law accurately predicts changes in the motion of macroscopic objects.	**Student Edition:** 60–61, 68–78, 80

CCC Crosscutting Concepts	
Cause and Effect • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	**Online:** *Science and Engineering Handbook*

CCSS Mathematics	
MP.2, MP.4, HSN.Q.A.1-3, HSA.SSE.A.1, HSA.SSE.B.3, HSA.CED.A.1, HSA.CED.A.2, HSA.CED.A.4, HSF-IF.C.7, HSS-IS.A.1	**Online:** Applying Practices: *Newton's Second Law*

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CCSS ELA/Literacy	
RST.11-12.1, RST.11-12.7, WHST.11-12.9	**Online:** Applying Practices: *Newton's Second Law*

HS-PS2	Motion and Stability: Forces and Interactions	
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,* Module 3 Lesson 3
SEP 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
DCI 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:** 48–49
• 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:** 48–49, 79–80, 81
CCC Crosscutting Concepts		
Systems and System Models • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined.		**Online:** *Science and Engineering Handbook*
CCSS Mathematics		
MP.2, MP.4, HSN.Q.A.1-3, HSN.CED.A.1, HSN.CED.A.2, HSN.CED.A.4		**Online:** Applying Practices: *Conservation of Momentum*

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HS-PS2	Motion and Stability: Forces and Interactions	
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,* Module 3 Lesson 3
SEP 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
DCI 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:** 48–49, 79–80, 81
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, Practice 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, Practice 6
CCC Crosscutting Concepts		
Cause and Effect • Systems can be designed to cause a desired effect.		**Online:** *Science and Engineering Handbook*
CCSS ELA/Literacy		
WHST.11-12.7		**Online:** Applying Practices: *Egg Heads*

HS-PS2	Motion and Stability: Forces and Interactions	
HS-PS2-4	**Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.** **Clarification Statement:** Emphasis is on 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:** *Describe and Predict the Gravitational and Electrostatic Forces Between Objects*, Module 6, Lesson 1
SEP 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
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
• Laws are statements or descriptions of the relationships among observable phenomena.		**Science and Engineering Practices Handbook:** Practice 6
DCI 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.		**Student Edition:** 140–142, 147
• 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:** 64–67, 142, 167–169, 173–175, 202–204, 209–225, 228–229
CCC 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.		**Online:** *Science and Engineering Handbook*
CCSS Mathematics		
MP.2, MP.4, HSN-Q.A.1-3, HSA-SSE.A.1, HSA-SSE.B.3, HSA.CED.A.1, HAS-CED.A.2, HSA.CED.A.4, HSF-IF.C.7, HSS-ID.A.1		**Online:** Applying Practices: *Describe and Predict the Gravitational and Electrostatic Forces between Objects*

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CCSS ELA/Literacy	
RST.11-12.1, RST.11-12.7, WHST.9-12.2, WHST.9-12.7, WHST.9-12.8, WHST.11-12.9	**Online:** Applying Practices: *Describe and Predict the Gravitational and Electrostatic Forces between Objects*

HS-PS2	**Motion and Stability: Forces and Interactions**	
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,* Module 7 Lesson 3
SEP 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
DCI 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:** 140–142, 147
• 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:** 64–67, 142, 167–169, 173–175, 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:** 148–151, 157–160
CCC Crosscutting Concepts		
Cause and Effect • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.		**Online:** *Science and Engineering Handbook*

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CCSS Mathematics	
HSN.Q.A.1-3	**Online:** Applying Practices: *Investigate Electromagnetism*
CCSS ELA/Literacy	
WHST.11-12.7, WHST.11-12.8, WHST.11-12.9	**Online:** Applying Practices: *Investigate Electromagnetism*

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,* Module 17 Lesson 3
SEP 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
DCI 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:** 354–358, 360, 361, 455–461, 529, 538–539, 542–546
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:** 423, 455–457, 459–461, 504–506
CCC 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.		**Online:** *Science and Engineering Handbook*

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CCSS Mathematics	
HSN.Q.A.1-3	**Online:** Applying Practices: *Touching the Future*
CCSS ELA/Literacy	
RST.11-12.1, WHST.11-12.2	**Online:** Applying Practices: *Touching the Future*

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,* Module 4 Lesson 3, Module 5 Lesson 3
SEP 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
DCI 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:** 95–108, 114–134
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:** 101–108, 114–134, 489
• Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems.		**Student Edition:** 101–108, 114–134

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• 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:** 95–105
• The availability of energy limits what can occur in any system.	**Student Edition:** 95
CCC 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.	**Online:** *Science and Engineering Handbook*
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.	**Online:** *Science and Engineering Handbook*
CCSS Mathematics	
MP.2, MP.4, HSN.Q.A.1-3	**Online:** Applying Practices: *Modeling Changes in Energy*
CCSS ELA/Literacy	
SL.11-12.5	**Online:** Applying Practices: *Modeling Changes in Energy*

HS-PS3	**Energy**	
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,* Module 5 Lesson 3
SEP 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

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DCI 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:** 95–108, 114–134
• At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.	**Student Edition:** 95–100, 114–116, 157–160, 176–186, 206–210, 278–283, 354–361, 486–489
• 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:** 114–123, 354–361
CCC 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)	**Online:** *Science and Engineering Handbook*
• Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems.	**Online:** *Science and Engineering Handbook*
CCSS Mathematics	
MP.2, MP.4	**Online:** Applying Practices: *Modeling Energy on Different Scales*
CCSS ELA/Literacy	
SL.11-12.5	**Online:** Applying Practices: *Modeling Energy on Different Scales*

HS-PS3	Energy	
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,* Module 4 Lesson 3
SEP 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
DCI 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:** 95–100, 114–116, 157–160, 176–186, 206–211, 278–283, 354–361, 486–489
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:** 101–108, 127–134, 192
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, Practice 6
CCC 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.		**Online:** *Science and Engineering Handbook*
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.		**Online:** *Science and Engineering Handbook*

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CCSS Mathematics	
MP.2, MP.4, HSN.Q.A.1-3	**Online:** Applying Practices: *Earth Power*
CCSS ELA/Literacy	
WHST.9-12.7	**Online:** Applying Practices: *Earth Power*

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,* Module 5 Lesson 1

SEP 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

DCI 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:** 101–108, 114–134
• 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:** 130–131
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:** 101–108, 129–134, 192

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CCC 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.	**Online:** *Science and Engineering Handbook*
CCSS Mathematics	
MP.2, MP.4	**Online:** Applying Practices: *Coffee Cup Calorimetry*
CCSS ELA/Literacy	
RST.11-12.1, WHST.9-12.7, WHST.11-12.8, WHST.9-12.9	**Online:** Applying Practices: *Coffee Cup Calorimetry*

HS-PS3	Energy	
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,* Module 7 Lesson 1
SEP 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
DCI 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:** 99–100, 142
CCC 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.		**Online:** *Science and Engineering Handbook*

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CCSS Mathematics	
MP.2, MP.4	**Online:** Applying Practices: *Modeling Magnetic Fields*
CCSS ELA/Literacy	
WHST.9-12.7, WHST.11-12.8, WHST.9-12.9, SL.11-12.5	**Online:** Applying Practices: *Modeling Magnetic Fields*

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*, Module 9 Lesson 2
SEP 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
DCI 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:** 232–234, 304–306, 253–254, 278–283
CCC Crosscutting Concepts		
Cause and Effect • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.		**Online:** *Science and Engineering Handbook*
CCSS Mathematics		
MP.2, MP.4, HSA-SSE.A.1, HSA-SSE.B.3, HSA.CED.A.4		**Online:** Applying Practices: *Wave Characteristics*

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CCSS ELA/Literacy	
RST.11-12.7	**Online:** Applying Practices: *Wave Characteristics*

HS-PS4	Waves and Their Applications in Technologies for Information Transfer	
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,* Module 11 Lesson 3
SEP 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
DCI 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:** 273, 293
CCC Crosscutting Concepts		
Stability and Change • Systems can be designed for greater or lesser stability.		**Online:** *Science and Engineering Handbook*
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.		**Online:** *Science and Engineering Handbook*
• Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks.		**Online:** *Science and Engineering Handbook*
CCSS ELA/Literacy		
RST.9-10.8, RST.11-12.1, RST.11-12.8		**Online:** Applying Practices: *Digital Transmission and Storage of Information*

NEXT GENERATION SCIENCE STANDARDS

HS-PS4	Waves and Their Applications in Technologies for Information Transfer	
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?*, Module 11 Lesson 1
SEP 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:** 11
DCI 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:** 243–246, 268
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:** 278–283
CCC 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.		**Online:** *Science and Engineering Handbook*

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CCSS Mathematics	
MP.2, HSA-SSE.A.1, HSA-SSE.B.3, HSA.CED.A.4	**Online:** Applying Practices: *Is light a wave or a particle?, Modeling Electromagnetic Radiation,* and *Canceling Noise*
CCSS ELA/Literacy	
RST.9-10.8, RST.11-12.1, RST.11-12.8	**Online:** Applying Practices: *Is light a Is light a wave or a particle?, Modeling Electromagnetic Radiation,* and *Canceling Noise*

HS-PS4	Waves and Their Applications in Technologies for Information Transfer	
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,* Module 11 Lesson 2
SEP 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
DCI 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:** 278–283, 284–290, 297
CCC 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.		**Online:** *Science and Engineering Handbook*

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CCSS ELA/Literacy	
RST.9-10.8, RST.11-12.1, RST.11-12.7, RST.11-12.8, WHST.11-12.8	**Online:** Applying Practices: *Human Health and Radiation Frequency*

HS-PS4	Waves and Their Applications in Technologies for Information Transfer	
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,* Module 11 Lesson 3

SEP 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

DCI 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:** 128
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:** 293
PS4.B: Electromagnetic Radiation • Photoelectric materials emit electrons when they absorb light of a high-enough frequency.	**Student Edition:** 282
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:** 257–262, 263–268, 269–272, 284–297, 312–317, 319–322, 323, 342–347

CCC Crosscutting Concepts	
Cause and Effect • Systems can be designed to cause a desired effect.	**Online:** *Science and Engineering Handbook*

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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).	**Online:** *Science and Engineering Handbook*
Influence of Engineering, Technology, and Science on Society and the Natural World • Modern civilization depends on major technological systems.	**Online:** *Science and Engineering Handbook*
CCSS ELA/Literacy	
WHST.9-12.2	**Online:** Applying Practices: *Catching Waves, Using Waves In Technology*

HS-ESS1	**Earth's Place in the Universe**	
HS-ESS1-1	**Develop a model based on evidence to illustrate the life span of the sun and the role of nuclear fusion in the sun's core to release energy that eventually reaches Earth in the form of radiation.** **Clarification Statement:** Emphasis is on the energy transfer mechanisms that allow energy from nuclear fusion in the sun's core to reach Earth. Examples of evidence for the model include observations of the masses and lifetimes of other stars, as well as the ways that the sun's radiation varies due to sudden solar flares ("space weather"), the 11-year sunspot cycle, and non-cyclic variations over centuries. **Assessment Boundary:** Assessment does not include details of the atomic and sub-atomic processes involved with the sun's nuclear fusion.	**Activity:** *The Sun's Energy Formation and Radiation,* Module 31 Lesson 2
SEP Science and Engineering Practices		
Developing and Using Models Modeling in 9–12 builds on K–8 experiences 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 world(s). • 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
DCI Disciplinary Core Ideas		
ESS1.A: The Universe and Its Stars • The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years.		**Student Edition:** 826–831
PS3.D: Energy in Chemical Processes and Everyday Life • Nuclear Fusion processes in the center of the sun release the energy that ultimately reaches Earth as radiation. *(secondary)*		**Student Edition:** 736, 825–829

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CCC Crosscutting Concepts	
Scale, Proportion, and Quantity • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs.	**Online:** *Science and Engineering Handbook*
CCSS Mathematics	
MP.2, MP.4, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3, HSA-SSE.A.1, HSA-CED.A.2, HSA-CED.A.4	**Online:** Applying Practices: *The Sun's Energy Formation and Radiation*
CCSS ELA/Literacy	
RST.11-12.1	**Online:** Applying Practices: *The Sun's Energy Formation and Radiation*

HS-ESS1	Earth's Place in the Universe	
HS-ESS1-2	**Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.** **Clarification Statement:** Emphasis is on the astronomical evidence of the red shift of light from galaxies as an indication that the universe is currently expanding, the cosmic microwave background as the remnant radiation from the Big Bang, and the observed composition of ordinary matter of the universe, primarily found in stars and interstellar gases (from the spectra of electromagnetic radiation from stars), which matches that predicted by the Big Bang theory (3/4 hydrogen and 1/4 helium).	**Activity:** *The Big Bang Theory,* Module 31 Lesson 4
SEP 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 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
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

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DCI Disciplinary Core Ideas	
ESS1.A: The Universe and Its Stars • The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.	**Student Edition:** 824, 825–828
• The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe.	**Student Edition:** 837–840
• Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.	**Student Edition:** 826–827, 831
PS4.B: Electromagnetic Radiation • Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. *(secondary)*	**Student Edition:** 824
CCC Crosscutting Concepts	
Energy and Matter • Energy cannot be created or destroyed—only moved between one place and another place, between objects and/or fields, or between systems.	**Online:** Science and Engineering Handbook
Connection 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). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.	**Online:** Science and Engineering Handbook
Connection to Nature of Science **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.	**Online:** Science and Engineering Handbook
• Science assumes the universe is a vast single system in which basic laws are consistent.	**Online:** Science and Engineering Handbook
CCSS Mathematics	
MP.2, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3, HSA-SSE.A.1, HSA-CED.A.2, HSA-CED.A.4	**Online:** Applying Practices: *The Big Bang Theory*
CCSS ELA/Literacy	
RST.11-12.1, WHST.9-12.2	**Online:** Applying Practices: *The Big Bang Theory*

HS-ESS1	Earth's Place in the Universe	
HS-ESS1-3	**Communicate scientific ideas about the way stars, over their life cycle, produce elements.** **Clarification Statement:** Emphasis is on the way nucleosynthesis, and therefore the different elements created, varies as a function of the mass of a star and the stage of its lifetime. **Assessment Boundary:** Details of the many different nucleosynthesis pathways for stars of differing masses are not assessed.	**Activity:** *Element Production in Stars,* Module 31 Lesson 2
SEP 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 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
DCI Disciplinary Core Ideas		
ESS1.A: The Universe and Its Stars • The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth.		**Student Edition:** 824, 825–828
• Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode.		**Student Edition:** 826–827, 831
CCC Crosscutting Concepts		
Energy and Matter • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.		**Online:** *Science and Engineering Handbook*
CCSS Mathematics		
MP.2		**Online:** Applying Practices: *Element Production in Stars*
CCSS ELA/Literacy		
WHST.9-12.2, SL.11-12.4		**Online:** Applying Practices: *Element Production in Stars*

HS-ESS1	Earth's Place in the Universe	
HS-ESS1-4	**Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.** **Clarification Statement:** Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons. **Assessment Boundary:** Mathematical representations for the gravitational attraction of bodies and Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus.	**Activity:** *Planetary Orbits,* Module 30 Lesson 1
SEP Science and Engineering Practices		
Using Mathematical 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 or computational representations of phenomena to describe explanations.		**Science and Engineering Practices Handbook:** Practice 5
DCI Disciplinary Core Ideas		
ESS1.B: Earth and the Solar System • Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system.		**Student Edition:** 765–766, 782–783, 791, 794, 805, 808
CCC Crosscutting Concepts		
Scale, Proportion, and Quantity • Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth).		**Online:** *Science and Engineering Handbook*
Connection 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). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.		**Online:** *Science and Engineering Handbook*
CCSS Mathematics		
MP.2, MP.4, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3, HSA-SSE.A.1, HSA-CED.A.2, HSA-CED.A.4		**Online:** Applying Practices: *Planetary Orbits*

HS-ESS1	Earth's Place in the Universe	
HS-ESS1-5	**Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.** **Clarification Statement:** Emphasis is on the ability of plate tectonics to explain the ages of crustal rocks. Examples include evidence of the ages oceanic crust increasing with distance from mid-ocean ridges (a result of plate spreading) and the ages of North American continental crust increasing with distance away from a central ancient core (a result of past plate interactions).	**Activity:** *How old are crustal rocks?*, Module 25 Lesson 1
SEP 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 the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments.		**Science and Engineering Practices Handbook:** Practice 7
DCI Disciplinary Core Ideas		
ESS1.C: The History of Planet Earth • Continental rocks, which can be older than 4 billion years, are generally much older than the rocks of the ocean floor, which are less than 200 million years old.		**Student Edition:** 630
ESS2.B: Plate Tectonics and Large-Scale System Interactions • Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. *(ESS2.B Grade 8 GBE) (secondary)*		**Student Edition:** 628–635, 636–637, 645, 650–651, 656
PS1.C: Nuclear Processes • Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. *(secondary)*		**Student Edition:** 726–728
CCC Crosscutting Concepts		
Patterns • Empirical evidence is needed to identify patterns.		**Online:** *Science and Engineering Handbook*
CCSS Mathematics		
MP.2, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3		**Online:** Applying Practices: *How old are crustal rocks?*
CCSS ELA/Literacy		
RST.11-12.1, RST.11-12.8, WHST.9-12.2		**Online:** Applying Practices: *How old are crustal rocks?*

HS-ESS1	Earth's Place in the Universe	
HS-ESS1-6	**Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.** **Clarification Statement:** Emphasis is on using available evidence within the solar system to reconstruct the early history of Earth, which formed along with the rest of the solar system 4.6 billion years ago. Examples of evidence include the absolute ages of ancient materials (obtained by radiometric dating of meteorites, moon rocks, and Earth's oldest minerals), the sizes and compositions of solar system objects, and the impact cratering record of planetary surfaces.	**Activity:** *Earth's Formation and Early History,* Module 29 Lesson 3
SEP 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 reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion.		**Science and Engineering Practices Handbook:** Practice 6
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
• Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory.		**Science and Engineering Practices Handbook:** Practice 6
DCI Disciplinary Core Ideas		
ESS1.C: The History of Planet Earth • Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history.		**Student Edition:** 783, 784, 799–801
PS1.C: Nuclear Processes • Spontaneous radioactive decays follow a characteristic exponential decay law. Nuclear lifetimes allow radiometric dating to be used to determine the ages of rocks and other materials. *(secondary)*		**Student Edition:** 726–728
CCC Crosscutting Concepts		
Stability and Change • Much of science deals with constructing explanations of how things change and how they remain stable.		**Online:** Science and Engineering Handbook

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CCSS Mathematics	
MP.2, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3, HSF-IF.B.5, HSS-ID.B.6	**Online:** Applying Practices: *Earth's Formation and Early History*
CCSS ELA/Literacy	
RST.11-12.1, RST.11-12.8, WHST.9-12.1	**Online:** Applying Practices: *Earth's Formation and Early History*

HS-ESS2	Earth's Systems	
HS-ESS2-1	**Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.** **Clarification Statement:** Emphasis is on how the appearance of land features (such as mountains, valleys, and plateaus) and sea-floor features (such as trenches, ridges, and seamounts) are a result of both constructive forces (such as volcanism, tectonic uplift, and orogeny) and destructive mechanisms (such as weathering, mass wasting, and coastal erosion). **Assessment Boundary:** Assessment does not include memorization of the details of the formation of specific geographic features of Earth's surface.	**Activity:** *Modeling Earth's Internal and Surface Processes,* Module 25 Lesson 4 *How can feedbacks cause changes to Earth's systems?,* Module 27 Lesson 3

SEP Science and Engineering Practices	
Developing and Using Models Modeling in 9–12 builds on K–8 experiences 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 world(s). • 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

DCI Disciplinary Core Ideas	
ESS2.A: Earth Materials and Systems • Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.	**Student Edition:** 734, 744–745, 751-754
ESS2.B: Plate Tectonics and Large-Scale System Interactions • Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. *(ESS2.B Grade 8 GBE)*	**Student Edition:** 628–635, 636–637, 645, 650–652, 656

CCC Crosscutting Concepts	
Stability and Change • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.	**Online:** *Science and Engineering Handbook*

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CCSS Mathematics	
MP.2, MP.4, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3	**Online:** Applying Practices: *Modeling Earth's Internal and Surface Processes*
CCSS ELA/Literacy	
SL.11-12.5	**Online:** Applying Practices: *Modeling Earth's Internal and Surface Processes*

HS-ESS2	Earth's Systems	
HS-ESS2-2	**Analyze geoscience data to make the claim that one change to Earth's surface can create feedbacks that cause changes to other Earth systems.** **Clarification Statement:** Examples should include climate feedbacks, such as how an increase in greenhouse gases causes a rise in global temperatures that melts glacial ice, which reduces the amount of sunlight reflected from Earth's surface, increasing surface temperatures and further reducing the amount of ice. Examples could also be taken from other system interactions, such as how the loss of ground vegetation causes an increase in water runoff and soil erosion; how dammed rivers increase groundwater recharge, decrease sediment transport, and increase coastal erosion; or how the loss of wetlands causes a decrease in local humidity that further reduces the wetland extent.	**Activity:** *How can feedbacks cause changes to Earth's systems?,* Module 27 Lesson 3 *Mammoths in...Ohio?,* Module 28 Lesson 4
SEP Science and Engineering Practices		
Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 experiences 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
DCI Disciplinary Core Ideas		
ESS2.A: Earth Materials and Systems • Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes.		**Student Edition:** 734, 744–745, 751–754
ESS2.D: Weather and Climate • The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space.		**Student Edition:** 736–738, 744–749, 750–754

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CCC Crosscutting Concepts	
Stability and Change • Feedback (negative or positive) can stabilize or destabilize a system.	**Online:** *Science and Engineering Handbook*
Connections to Engineering, Technology, and Applications of Science *Influence of Engineering, Technology, and Science 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.	**Online:** *Science and Engineering Handbook*
CCSS Mathematics	
MP.2, HSN-Q.A.1, HSN-Q.A.3, HSF-IF.B.5, HSS-ID.B.6	**Online:** Applying Practices: *How can feedbacks cause changes to Earth's systems?*
CCSS ELA/Literacy	
RST.11-12.1, RST.11-12.2	**Online:** Applying Practices: *How can feedbacks cause changes to Earth's systems?*

HS-ESS2	Earth's Systems	
HS-ESS2-3	**Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection. Clarification Statement:** Emphasis is on both a one-dimensional model of Earth, with radial layers determined by density, and a three-dimensional model, which is controlled by mantle convection and the resulting plate tectonics. Examples of evidence include maps of Earth's three-dimensional structure obtained from seismic waves, records of the rate of change of Earth's magnetic field (as constraints on convection in the outer core), and identification of the composition of Earth's layers from high-pressure laboratory experiments.	**Activity:** *The Cycling of Matter Through Thermal Convection,* Module 25 Lesson 1 *Modeling Earth,* Module 25 Lesson 3

SEP Science and Engineering Practices	
Developing and Using Models Modeling in 9–12 builds on K–8 experiences 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 world(s). • 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
Connections to Nature of Science **Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based on empirical evidence.	**Science and Engineering Practices Handbook:** Practice 1, Practice 8

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• Science disciplines share common rules of evidence used to evaluate explanations about natural systems.	**Science and Engineering Practices Handbook:** Practice 6, Practice 7, Practice 8
• Science includes the process of coordinating patterns of evidence with current theory.	**Science and Engineering Practices Handbook:** Practice 6, Practice 7
DCI Disciplinary Core Ideas	
ESS2.A: Earth Materials and Systems • Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior.	**Student Edition:** 631, 634–635, 646–649, 764
ESS2.B: Plate Tectonics and Large-Scale System Interactions • The radioactive decay of unstable isotopes continually generates new energy within Earth's crust and mantle, providing the primary source of the heat that drives mantle convection. Plate tectonics can be viewed as the surface expression of mantle convection.	**Student Edition:** 634–635
CCC Crosscutting Concepts	
Energy and Matter • Energy drives the cycling of matter within and between systems.	**Online:** *Science and Engineering Handbook*
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). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.	**Online:** *Science and Engineering Handbook*
CCSS Mathematics	
MP.2, MP.4, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3	**Online:** Applying Practices: *The Cycling of Matter Through Thermal Convection*
CCSS ELA/Literacy	
RST.11-12.1, SL.11-12.5	**Online:** Applying Practices: *The Cycling of Matter Through Thermal Convection*

NEXT GENERATION SCIENCE STANDARDS

HS-ESS2	Earth's Systems	
HS-ESS2-4	**Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.** **Clarification Statement:** Examples of the causes of climate change differ by timescale, over 1-10 years: large volcanic eruption, ocean circulation; 10-100s of years: changes in human activity, ocean circulation, solar output; 10-100s of thousands of years: changes to Earth's orbit and the orientation of its axis; and 10-100s of millions of years: long-term changes in atmospheric composition. **Assessment Boundary:** Assessment of the results of changes in climate is limited to changes in surface temperatures, precipitation patterns, glacial ice volumes, sea levels, and biosphere distribution.	**Activity:** *Variations in Albedo,* Module 28 Lesson 3
SEP Science and Engineering Practices		
Developing and Using Models Modeling in 9–12 builds on K–8 experiences 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 world(s). • Use a model to provide mechanistic accounts of phenomena.		**Science and Engineering Practices Handbook:** Practice 2
Connections to Nature of Science **Scientific Knowledge is Based on Empirical Evidence** • Science arguments are strengthened by multiple lines of evidence supporting a single explanation.		**Science and Engineering Practices Handbook:** Practice 3, Practice 4
DCI Disciplinary Core Ideas		
ESS1.B: Earth and the Solar System • Cyclical changes in the shape of Earth's orbit around the sun, together with changes in the tilt of the planet's axis of rotation, both occurring over hundreds of thousands of years, have altered the intensity and distribution of sunlight falling on the earth. These phenomena cause a cycle of ice ages and other gradual climate changes. *(secondary)*		**Student Edition:** 751, 754
ESS2.A: Earth Materials and Systems • The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles.		**Student Edition:** 654, 750–754
ESS2.D: Weather and Climate • The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space.		**Student Edition:** 736
• Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.		**Student Edition:** 751–754

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CCC Crosscutting Concepts	
Cause and Effect • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	**Online:** *Science and Engineering Handbook*
CCSS Mathematics	
MP.2, MP.4, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3	**Online:** Applying Practices: *Variations in Albedo*
CCSS ELA/Literacy	
SL.11-12.5	**Online:** Applying Practices: *Variations in Albedo*

HS-ESS2	Earth's Systems	
HS-ESS2-5	**Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.** **Clarification Statement:** Emphasis is on mechanical and chemical investigations with water and a variety of solid materials to provide the evidence for connections between the hydrologic cycle and system interactions commonly known as the rock cycle. Examples of mechanical investigations include stream transportation and deposition using a stream table, erosion using variations in soil moisture content, or frost wedging by the expansion of water as it freezes. Examples of chemical investigations include chemical weathering and recrystallization (by testing the solubility of different materials) or melt generation (by examining how water lowers the melting temperature of most solids).	**Activity:** *Investigate the Effects of Water on Earth Materials and Surface Processes,* Module 27, Lesson 2 *Investigate Stream Erosion,* Module 27, Lesson 2
SEP 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
DCI Disciplinary Core Ideas		
ESS2.C: The Roles of Water in Earth's Surface Processes • The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks.		**Applying Practices:** *Water's Unique Properties,* Module 28 Lesson 1 **Student Edition:** 653–654, 685, 688, 695–699, 704–714, 715–720, 737–738, 747–748, 754

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CCC Crosscutting Concepts	
Structure and Function • The functions and properties of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials.	**Online:** *Science and Engineering Handbook*
CCSS Mathematics	
HSN-Q.A.3	**Online:** Applying Practices: *Investigate the Effects of Water on Earth Materials and Surface Processes*
CCSS ELA/Literacy	
WHST.9-12.7	**Online:** Applying Practices: *Investigate the Effects of Water on Earth Materials and Surface Processes*

HS-ESS2	Earth's Systems	
HS-ESS2-6	Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere. [Clarification Statement: ****The carbon cycle is a property of the Earth system that arises from interactions among the hydrosphere, atmosphere, geosphere, and biosphere.** Emphasis is on modeling biogeochemical cycles that include the cycling of carbon through the ocean, atmosphere, soil, and biosphere (including humans), providing the foundation for living organisms.]	**Activity:** *Carbon Cycling Through Earth's Spheres,* Module 28 Lesson 4

SEP Science and Engineering Practices	
Developing and Using Models Modeling in 9–12 builds on K–8 experiences 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 world(s). • 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
DCI Disciplinary Core Ideas	
ESS2.D: Weather and Climate • Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.	**Student Edition:** 734–735, 738
• Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate.	**Student Edition:** 751–754
CCC Crosscutting Concepts	
Energy and Matter • The total amount of energy and matter in closed systems is conserved.	**Online:** *Science and Engineering Handbook*

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CCSS Mathematics	
MP.2, MP.4, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3	**Online:** Applying Practices: *Carbon Cycling Through Earth's Spheres*

HS-ESS2	Earth's Systems	
HS-ESS2-7	**Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth. Clarification Statement:** Emphasis is on the dynamic causes, effects, and feedbacks between the biosphere and Earth's other systems, whereby geoscience factors control the evolution of life, which in turn continuously alters Earth's surface. Examples of include how photosynthetic life altered the atmosphere through the production of oxygen, which in turn increased weathering rates and allowed for the evolution of animal life; how microbial life on land increased the formation of soil, which in turn allowed for the evolution of land plants; or how the evolution of corals created reefs that altered patterns of erosion and deposition along coastlines and provided habitats for the evolution of new life forms. **Assessment Boundary:** Assessment does not include a comprehensive understanding of the mechanisms of how the biosphere interacts with all of Earth's other systems.	**Activity:** *The Coevolution of Living Things and the Atmosphere,* Module 28, Lesson 1
SEP 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 the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Construct an oral and written argument or counter-arguments based on data and evidence.		**Science and Engineering Practices Handbook:** Practice 7
DCI Disciplinary Core Ideas		
ESS2.D: Weather and Climate • Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen.		**Student Edition:** 734–735, 738
ESS2.E: Biogeology • The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it.		**Student Edition:** 734–735, 738
CCC Crosscutting Concepts		
Stability and Change • Much of science deals with constructing explanations of how things change and how they remain stable.		**Online:** *Science and Engineering Handbook*

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CCSS Literacy	
WHST.9-12.1	**Online:** Applying Practices: *The Coevolution of Living Things and the Atmosphere*

HS-ESS3	**Earth and Human Activity**	
HS-ESS3-1	**Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.** **Clarification Statement:** Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soils such as river deltas, and high concentrations of minerals and fossil fuels. Examples of natural hazards can be from interior processes (such as volcanic eruptions and earthquakes), surface processes (such as tsunamis, mass wasting and soil erosion), and severe weather (such as hurricanes, floods, and droughts). Examples of the results of changes in climate that can affect populations or drive mass migrations include changes to sea level, regional patterns of temperature and precipitation, and the types of crops and livestock that can be raised.	**Activity:** *Natural Hazards and Human History,* Module 25 Lesson 3, Module 28 Lesson 2 *Resource Availability and the Development of Human Society,* Module 26, Lesson 1 *Human Activity, Natural Resources, Hazards, and Climate Change,* Module 28 Lesson 4
SEP 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. • Construct 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
DCI Disciplinary Core Ideas		
ESS3.A: Natural Resources • Resource availability has guided the development of human society.		**Student Edition:** 670, 719
ESS3.B: Natural Hazards • Natural hazards and other geologic events have shaped the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations.		**Student Edition:** 642–645, 713–714, 742–743
CCC Crosscutting Concepts		
Cause and Effect • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.		**Online:** *Science and Engineering Handbook*

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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.	**Online:** *Science and Engineering Handbook*
CCSS Mathematics	
MP.2, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3	**Online:** Applying Practices: *Human Activity, Natural Resources, Hazards, and Climate Change*
CCSS Literacy	
RST.11-12.1, WHST.9-12.2	**Online:** Applying Practices: *Human Activity, Natural Resources, Hazards, and Climate Change*

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,* Module 8 Lesson 4 *Costs and Benefits of Energy Production and Resource Extraction,* Module 26, Lesson 1 *Environmental Consulting: Finding Solutions,* Module 27, Lesson 3
SEP 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
DCI 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:** 192–221, 569, 670

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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:** 24–30, 55, 135, 187, 297, 393, 469, 610
CCC 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.	**Online:** *Science and Engineering Handbook*
• Analysis of costs and benefits is a critical aspect of decisions about technology.	**Online:** *Science and Engineering Handbook*
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.	**Online:** *Science and Engineering Handbook*
• 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.	**Online:** *Science and Engineering Handbook*
• Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues.	**Online:** *Science and Engineering Handbook*
CCSS Mathematics	
MP.2	**Online:** Applying Practices: *Environmental Consulting: Finding Solutions* Applying Practices: *Costs and Benefits of Energy Production and Resource Extraction*
CCSS ELA/Literacy	
RST.11-12.1, RST.11-12.8	**Online:** Applying Practices: *Environmental Consulting: Finding Solutions* Applying Practices: *Costs and Benefits of Energy Production and Resource Extraction*

HS-ESS3	Earth and Human Activity	
HS-ESS3-3	**Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity. Clarification Statement:** Examples of factors that affect the management of natural resources include costs of resource extraction and waste management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include agricultural efficiency, levels of conservation, and urban planning. **Assessment Boundary:** Assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.	**Activity:** *Responsible Management of Natural Resources,* Module 27, Lesson 1
SEP 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. • Create a computational model or simulation of a phenomenon, designed device, process, or system.		**Science and Engineering Practices Handbook:** Practice 5
DCI Disciplinary Core Ideas		
ESS3.C: Human Impacts on Earth Systems • The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources.		**Activity:** *Responsible Management of Natural Resources,* Module 27, Lesson 1
CCC Crosscutting Concepts		
Stability and Change • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.		**Online:** *Science and Engineering Handbook*
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.		**Online:** *Science and Engineering Handbook*
• New technologies can have deep impacts on society and the environment, including some that were not anticipated.		**Online:** *Science and Engineering Handbook*
Connections to Nature of Science **Science is a Human Endeavor** • Science is a result of human endeavors, imagination, and creativity.		**Online:** *Science and Engineering Handbook*
CCSS Mathematics		
MP.2, MP.4		**Online:** Applying Practices: *Responsible Management of Natural Resources*

HS-ESS3	Earth and Human Activity	
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,* Module 8 Lesson 4; Module 28, Lesson 4 *Developing Technologies that Preclude Ecosystem Degradation,* Module 27, Lesson 3
SEP 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
DCI 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:** 201–205, 206-211, 212–218, 569
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:** 24–30, 55, 135, 187, 297, 393, 469
CCC Crosscutting Concepts		
Stability and Change • Feedback (negative or positive) can stabilize or destabilize a system.		**Online:** *Science and Engineering Handbook*
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.		**Online:** *Science and Engineering Handbook*
CCSS Mathematics		
MP.2, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3		**Online:** Applying Practices: *Locking Up Carbon*

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CCSS ELA/Literacy	
RST.11-12.1, RST.11-12.8, WHST.9-12.7	**Online:** Applying Practices: *Locking Up Carbon*

HS-ESS3	Earth and Human Activity	
HS-ESS3-5	**Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.** **Clarification Statement:** Examples of evidence, for both data and climate model outputs, are for climate changes (such as precipitation and temperature) and their associated impacts (such as on sea level, glacial ice volumes, or atmosphere and ocean composition). **Assessment Boundary:** Assessment is limited to one example of a climate change and its associated impacts.	**Activity:** *Forecasting Climate Change,* Module 28, Lesson 4

SEP Science and Engineering Practices	
Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 experiences 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 computational models in order to make valid and reliable scientific claims.	**Science and Engineering Practices Handbook:** Practice 4
Connections to Nature of Science **Scientific Investigations Use a Variety of Methods** • Science investigations use diverse methods and do not always use the same set of procedures to obtain data.	**Science and Engineering Practices Handbook:** Practice 1, Practice 3
• New technologies advance scientific knowledge.	**Science and Engineering Practices Handbook:** Introduction
Scientific Knowledge is Based on Empirical Evidence • Science knowledge is based on empirical evidence.	**Science and Engineering Practices Handbook:** Practice 1, Practice 8
• Science arguments are strengthened by multiple lines of evidence supporting a single explanation.	**Science and Engineering Practices Handbook:** Practice 7, Practice 8

DCI Disciplinary Core Ideas	
ESS3.D: Global Climate Change • Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts.	**Student Edition:** 750–754

NEXT GENERATION SCIENCE STANDARDS

Continued from previous page.

CCC Crosscutting Concepts	
Stability and Change • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible.	**Online:** *Science and Engineering Handbook*
CCSS Mathematics	
MP.2, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3	**Online:** Applying Practices: *Forecasting Climate Change*
CCSS ELA/Literacy	
RST.11-12.1, RST.11-12.2, RST.11-12.7	**Online:** Applying Practices: *Forecasting Climate Change*

HS-ESS3	Earth and Human Activity	
HS-ESS3-6	**Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.** **Clarification Statement:** Examples of Earth systems to be considered are the hydrosphere, atmosphere, cryosphere, geosphere, and/or biosphere. An example of the far-reaching impacts from a human activity is how an increase in atmospheric carbon dioxide results in an increase in photosynthetic biomass on land and an increase in ocean acidification, with resulting impacts on sea organism health and marine populations. **Assessment Boundary:** Assessment does not include running computational representations but is limited to using the published results of scientific computational models.	**Activity:** *Exploring Relationships: Climate Change and Human Activity,* Module 28 Lesson 4

SEP 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 a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations.	**Science and Engineering Practices Handbook:** Practice 5
DCI Disciplinary Core Ideas	
ESS2.D: Weather and Climate • Current models predict that, although future regional climate changes will be complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. *(secondary)*	**Student Edition:** 751–754

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ESS3.D: Global Climate Change • Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities.	**Student Edition:** 751–754
CCC 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.	**Online:** *Science and Engineering Handbook*
CCSS Mathematics	
MP.2, MP.4, HSN-Q.A.1, HSN-Q.A.2, HSN-Q.A.3	**Online:** Applying Practices: *Exploring Relationships: Climate Change and Human Activity*

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)
SEP 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
DCI 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
CCC 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.		**Online:** *Science and Engineering Handbook*

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CCSS Mathematics	
MP.2, MP.4	**Online:** Applying Practices: *Engineer a Better World: Analyze a Major Global Challenge*
CCSS ELA/Literacy	
RST.11-12.7, RST.11-12.8, RST.11-12.9	**Online:** Applying Practices: *Engineer a Better World: Analyze a Major Global Challenge*

HS-ETS1	**Engineering Design**	
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)
SEP 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
DCI 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
CCSS Mathematics		
MP.4		**Online:** Applying Practices: *Engineer a Better World: Design a Solution*

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)
SEP 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
DCI 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
CCC 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.		**Online:** *Science and Engineering Handbook*
CCSS Mathematics		
MP.2, MP.4		**Online:** Applying Practices: *Engineer a Better World: Evaluate a Solution*
CCSS ELA/Literacy		
RST.11-12.7, RST.11-12.8, RST.11.12-9		**Online:** Applying Practices: *Engineer a Better World: Evaluate a Solution*

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)

SEP 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

DCI 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

CCC 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.	**Online:** *Science and Engineering Handbook*

CCSS Mathematics

MP.2, MP.4	**Online:** Applying Practices: *Engineer a Better World: Use a Computer Simulation*