Louisiana STUDENT STANDARDS SCIENCE

STANDARDS	REFERENCES
MATTER AND ITS INTERACTIONS	**HS-PS1-1**
Performance Expectation 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 and the composition of the nucleus of atoms. **Clarification Statement** **Physical Science:** Examples of properties that could be predicted from patterns could include metals, nonmetals, metalloids, number of valence electrons, types of bonds formed, or atomic mass. Emphasis is on main group elements. **Chemistry:** Examples of properties that could be predicted from patterns could include reactivity of metals, types of bonds formed, numbers of bonds formed, atomic radius, atomic mass, or reactions with oxygen. Emphasis is on main group elements and qualitative understanding of the relative trends of ionization energy and electronegativity.	**Activity:** Electron Patterns in Atoms, Chapter 16 Section 3

STANDARDS	REFERENCES
Science and Engineering Practices	
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Use a model to predict the relationships between systems or between components of a system.	**Science and Engineering Practices Handbook:** Practice 2
Disciplinary Core Ideas	
STRUCTURE AND PROPERTIES OF MATTER Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS.PS1A.a)	**Student Edition:** 488–493, 494–497, 503, 512, 513, 618–620, 633–639
The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. The repeating patterns of this table reflect patterns of outer electron states.(HS.PS1A.b)	**Student Edition:** 498–506, 507, 508–509, 512, 513, 518–525, 526–530, 531, 532–539, 544, 545
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.(HS.PS2B.c)	**Student Edition:** 519, 558–560, 562–564, 572–573, 577, 618–620, 638, 639
Crosscutting Concepts	
PATTERNS Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.	**Student Edition:** 441, 442, 448, 450, 452-453

STANDARDS	REFERENCES
MATTER AND ITS INTERACTIONS	**HS-PS1-2**
Performance Expectation 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** **Physical Science:** Examples of chemical reactions could include the reaction of sodium and chlorine, carbon and oxygen, or hydrogen and oxygen. Reaction classification includes synthesis, decomposition, single displacement, double displacement, and acid-base. **Chemistry:** Examples of chemical reactions could include the reaction of sodium and chlorine, carbon and oxygen, or carbon and hydrogen. Reaction classification aids in the prediction of products (e.g. synthesis, decomposition, single displacement, double displacement, and acid-base).	**Activity:** Electron States and Simple Chemical Reactions, Chapter 19 Section 1
Science and Engineering Practices	
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.	**Science and Engineering Practices Handbook**: Practice 6
Disciplinary Core Ideas	
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. (HS.PS1A.b)	**Student Edition:** 498–506, 507, 508–509, 512, 513, 518–525, 526–530, 531, 532–539, 544, 545

STANDARDS	REFERENCES
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. (HS.PS1B.c)	**Student Edition:** 475–476, 478–479, 483, 518–525, 526–530, 532–539, 544, 545, 558–564, 576, 577, 582–589, 590–593, 610, 611
Crosscutting Concepts	
PATTERNS Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.	**Student Edition:** 590-593, 594-597, 603-604
MATTER AND ITS INTERACTIONS	**HS-PS1-7**
Performance Expectation Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction. **Clarification Statement** **Physical Science:** Emphasis is on using mathematical ideas to communicate the relationship between masses of reactants and products as well as balancing chemical equations. **Chemistry:** Emphasis is on using mathematical ideas as they relate to stoichiometry 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.	**Activity:** Conservation of Mass, Chapter 15 Section 2, Chapter 19 Section 1

STANDARDS	REFERENCES
Science and Engineering Practices	
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical representations of phenomena to support claims.	**Science and Engineering Practices Handbook:** Practice 5
Disciplinary Core Ideas	
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. (HS.PS1B.c)	**Student Edition:** 475–476, 478–479, 483, 518–525, 526–530, 532–539, 544, 545, 558–564, 576, 577, 582–589, 590–593, 610, 611
Crosscutting Concepts	
ENERGY AND MATTER The total amount of energy and matter in closed systems is conserved.	**Student Edition:** 120, 127, 582
MATTER AND ITS INTERACTIONS	**HS-PS1-8**
Performance Expectation 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** **Physical Science:** Emphasis is only 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. Radioactive decay focus is on its relationship to half-life. **Chemistry:** 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. Emphasis is on alpha, beta, and gamma radioactive decays.	**Activity:** Modeling Fission, Fusion, and Radioactive Decay, Chapter 20 Section 3

STANDARDS	REFERENCES
Science and Engineering Practices	
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop a model based on evidence to illustrate the relationships between systems or between components of a system.	**Science and Engineering Practices Handbook:** Practice 2
Disciplinary Core Ideas	
NUCLEAR PROCESSES Nuclear processes, including fusion, fission, and radioactive decays of unstable nuclei, involve release or absorption of energy. The total number of neutrons plus protons does not change in any nuclear process. (HS.PS1C.a)	**Student Edition:** 616–620, 621–627, 628, 634–635, 638, 639
Crosscutting Concepts	
ENERGY AND MATTER In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.	**Student Edition:** 623-625

STANDARDS	REFERENCES
MOTION AND STABILITY: FORCES AND INTERACTIONS	**HS-PS2-1**
Performance Expectation 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** **Physical Science:** 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. Emphasis is on one-dimensional motion and macroscopic objects moving at non-relativistic speeds. **Physics:** 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. Emphasis is on kinematics, one-dimensional motion, two-dimensional motion, and macroscopic objects moving at non-relativistic speeds.	**Activity:** Newton's Second Law, Chapter 3 Section 2
Science and Engineering Practices	
Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution.	**Science and Engineering Practices Handbook:** Practice 4
Connections to Nature of Science **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • Theories and laws provide explanations in science.	**Science and Engineering Practices Handbook:** Practice 6 **Student Edition:** 13
• Laws are statements or descriptions of the relationships among observable phenomena.	**Science and Engineering Practices Handbook:** Practice 6 **Student Edition:** 13

STANDARDS	REFERENCES
Disciplinary Core Ideas	
FORCES AND MOTION Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS.PS2.A.a)	**Student Edition:** 72–73, 80–90, 92–95, 98–101
Crosscutting Concepts	
CAUSE AND EFFECT Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	**Student Edition:** 73, 75, 84, 91, 94-95
MOTION AND STABILITY: FORCES AND INTERACTIONS HS-PS2-2	
Performance Expectation 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** **Physical Science:** Emphasis is on calculating momentum and the qualitative meaning of conservation of momentum. **Physics:** Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle as well as systems of two macroscopic bodies moving in one dimension.	**Activity:** Conservation of Momentum, Chapter 3 Section 3
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

STANDARDS	REFERENCES
Disciplinary Core Ideas	
FORCES AND MOTION Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. In any system, total momentum is always conserved. (HS.PS2A.b)	**Student Edition:** 54–55, 62–63, 66–67
If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS.PS2A.c)	**Student Edition:** 54–55, 62–63, 91–92, 96, 99–101
Crosscutting Concepts	
SYSTEMS AND 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.	**Student Edition:** 104, 113, 128-129
MOTION AND STABILITY: FORCES AND INTERACTIONS	**HS-PS2-3**
Performance Expectation 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** **Physical Science:** Examples of evaluation and refinement could include determining the success of a device at protecting an object from damage such as, but not limited to, impact resistant packaging and modifying the design to improve it. Emphasis is on qualitative evaluations. **Physics:** 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 by applying the impulse-momentum theorem. Examples of a device could include a football helmet or an airbag. Emphasis is on qualitative evaluations and/or algebraic manipulations.	**Activity:** Egg Heads, Chapter 3 Section 3

STANDARDS	REFERENCES
Science and Engineering Practices	
Constructing Explanations and Designing Solutions Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects.	**Science and Engineering Practices Handbook:** Practice 6
Disciplinary Core Ideas	
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. (HS.PS2A.c)	**Student Edition:** 54–55, 62–63, 91–92, 96, 99–101
DEFINING AND DELIMITING ENGINEERING PROBLEMS Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS.ETS1A.a)	**Science and Engineering Practices Handbook:** Practice 1, Practiced 6
OPTIMIZING THE DESIGN SOLUTION Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS.ETS1C.a)	**Science and Engineering Practices Handbook:** Practice 1, Practiced 6
Crosscutting Concepts	
CAUSE AND EFFECT Systems can be designed to cause a desired effect.	**Student Edition: 11, 104, 113, 128-129**

STANDARDS	REFERENCES
MOTION AND STABILITY: FORCES AND INTERACTIONS	**HS-PS2-5**
Performance Expectation 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. **Clarification Statement** **Physical Science:** Emphasis is on designing and conducting investigations including evaluating simple series and parallel circuits. Qualitative evidence is used to explain the relationship between a current-carrying wire and a magnetic compass. **Physics:** Evidence of changes within a circuit can be represented numerically, graphically, or algebraically using Ohm's law. Emphasis is on designing and conducting investigations using qualitative evidence to determine the relationship between electric current and magnetic fields. Examples of evidence can include movement of a magnetic compass needle when placed in the vicinity of a current-carrying wire, and a magnet passing through a coil that turns on the light of a Faraday flashlight.	**Activity:** Investigate Electromagnetism, Chapter 7 Section 3
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

STANDARDS	REFERENCES
Disciplinary Core Ideas	
TYPES OF INTERACTIONS Forces that act over a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS.PS2B.b)	**Student Edition:** 77–79, 172, 202–204, 209–225, 228–229
DEFINITIONS OF ENERGY "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (HS.PS3A.d)	**Student Edition:** 178–181, 188–191, 196–199
Crosscutting Concepts	
CAUSE AND EFFECT Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	**Student Edition:** 73, 75, 84, 91, 94-95
ENERGY	**HS-PS3-2**
Performance Expectation 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** **Physical Science:** Examples of phenomena at the macroscopic scale could include the conversion of potential energy to kinetic and thermal energy. Examples of models could include diagrams, drawings, descriptions, and computer simulations. **Physics:** Examples of phenomena at the macroscopic scale could include the conversion of potential energy to kinetic and thermal energy, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.	**Activity:** Modeling Energy on Different Scales, Chapter 5 Section 3

STANDARDS	REFERENCES
Science and Engineering Practices	
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	**Science and Engineering Practices Handbook:** Practice 2
Disciplinary Core Ideas	
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. There is a single quantity called energy. A system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HS.PS3A.a)	**Student Edition:** 114–129, 132–135, 138–161, 164–167
At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS.PS3A.b)	**Student Edition:** 114–119, 132–135, 138–140, 187–191, 196–199, 212–222, 228–229, 248–252, 254, 338–343, 432–439, 594–597
These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS.PS3A.c)	**Student Edition:** 138–147, 432–439, 660–661
Crosscutting Concepts	
ENERGY AND MATTER Energy cannot be created or destroyed—it only moves between one place and another place, between objects and/or fields, or between systems.	**Student Edition:** 114-118, 120-122, 124-127

STANDARDS	REFERENCES
ENERGY	**HS-PS3-3**
Performance Expectation Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy. **Clarification Statement** **Physical Science:** Emphasis is on qualitative evaluations of devices. Constraints could include use of renewable energy forms and efficiency. Emphasis is on devices constructed with teacher approved materials. Examples of devices can be drawn from chemistry or physics clarification statements below. **Chemistry:** Emphasis is on both qualitative and quantitative evaluations of devices. Constraints could include use of renewable energy forms and efficiency. Focus of quantitative evaluations is limited to total output for a given input. Emphasis is on devices constructed with teacher approved materials. Examples of devices in chemistry could include hot/cold packs and batteries. **Physics:** Emphasis is on both qualitative and quantitative evaluations of devices. Constraints could include use of renewable energy forms and efficiency. Focus of quantitative evaluations is limited to total output for a given input. Emphasis is on devices constructed with teacher approved materials. Examples of devices in physics could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and electric motors.	**Activity:** Earth Power, Chapter 4 Section 3
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

STANDARDS	REFERENCES
Disciplinary Core Ideas	
DEFINITIONS OF ENERGY At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HS.PS3A.b)	**Student Edition:** 114–119, 132–135, 138–140, 187–191, 196–199, 212–222, 228–229, 248–252, 254, 338–343, 432–439, 594–597
ENERGY IN CHEMICAL PROCESSES Although energy cannot be destroyed, it can be converted to other forms—for example, to thermal energy in the surrounding environment. (HS.PS3D.a)	**Student Edition:** 120–129, 154–157
DEFINING AND DELIMITING ENGINEERING PROBLEMS Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS.ETS1A.a)	**Science and Engineering Practices Handbook:** Practice 1, Practiced 6
Crosscutting Concepts	
ENERGY AND MATTER Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.	**Student Edition:** 121-122, 124-125, 128-129
ENERGY	**HS-PS3-4**
Performance Expectation 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** **Physical Science, Physics and Chemistry:** Emphasis is on analyzing data from student investigations and using mathematical thinking appropriate to the subject to describe the energy changes quantitatively and conceptually. Examples of investigations could include mixing liquids at different initial temperatures or adding objects at different temperatures to water.	**Activity:** Coffee Cup Calorimetry, Chapter 5 Section 1

STANDARDS	REFERENCES
Science and Engineering Practices	
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly.	**Science and Engineering Practices Handbook:** Practice 3
Disciplinary Core Ideas	
CONSERVATION OF ENERGY AND ENERGY TRANSFER Energy cannot be created or destroyed, but it can be transported from one place to another, transformed into other forms, and transferred between systems. (HS.PS3B.b)	**Student Edition:** 120–129, 132–135, 138–161, 164–167
Uncontrolled systems always evolve toward more stable states--that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS.PS3B.e)	**Student Edition:** 155
ENERGY IN CHEMICAL PROCESSES AND EVERYDAY LIFE Although energy cannot be destroyed, it can be converted to less useful other forms—for example, to thermal energy in the surrounding environment. (HS.PS3D.a)	**Student Edition:** 120–129, 154–157
Crosscutting Concepts	
SYSTEMS AND 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.	**Student Edition:** 104, 113, 128-129

STANDARDS	REFERENCES
ENERGY	**HS-PS3-5**
Performance Expectation 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** **Physical Science:** Examples of models could include drawings, diagrams, simulations and texts, such as what happens when two charged objects or two magnetic poles are near each other. **Physics:** 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.	**Activity:** Modeling Magnetic Fields, Chapter 7 Section 1
Science and Engineering Practices	
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system.	**Science and Engineering Practices Handbook:** Practice 2
Disciplinary Core Ideas	
RELATIONSHIP BETWEEN ENERGY AND FORCES When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS.PS3C.a)	For related information, see **Student Edition:** 118–119,172
Crosscutting Concepts	
CAUSE AND EFFECT Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system.	**Student Edition:** 174, 175, 181

STANDARDS	REFERENCES
WAVES AND THEIR APPLICATIONS	**HS-PS4-1**
Performance Expectation Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. **Clarification Statement** **Physical Science:** Emphasis is on describing waves both qualitatively and quantitatively. Qualitative focus includes standard repeating waves and transmission/absorption of electromagnetic waves/radiation. **Physics:** Examples of data could include electromagnetic radiation traveling through a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth. Emphasis is on algebraic relationships and describing those relationships qualitatively.	**Activity:** Wave Characteristics, Chapter 9 Section 2
Science and Engineering Practices	
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations.	**Science and Engineering Practices Handbook:** Practice 5
Disciplinary Core Ideas	
WAVE PROPERTIES The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (HS.PS4A.a)	**Student Edition:** 280–282, 296, 300–303,307–308, 338–342, 344

STANDARDS	REFERENCES
Crosscutting Concepts	
CAUSE AND EFFECT Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.	**Student Edition:** 369, 371, 373, 407
WAVES AND THEIR APPLICATIONS HS-PS4-4	
Performance Expectation Evaluate the validity and reliability of claims in published materials regarding 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. Emphasis is on qualitative descriptions.	**Activity:** Human Health and Radiation Frequency, Chapter 11 Section 2
Science and Engineering Practices	
Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible.	**Science and Engineering Practices Handbook:** Practice 8
Disciplinary Core Ideas	
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. (HS.PS4B.b)	**Student Edition:** 338–343, 345–351, 360,362–365

STANDARDS	REFERENCES
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.	**Student Edition:** 381, 384, 390-391