

## MATTER AND ITS INTERACTIONS

<p><b>Performance Expectation</b></p>	<p>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.</p>
<p><b>Clarification Statement</b></p>	<p><b>Physical Science:</b> 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.</p> <p><b>Chemistry:</b> 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.</p>

<p><b>Science &amp; Engineering Practices</b></p>	<p><b>Disciplinary Core Ideas</b></p>	<p><b>Crosscutting Concepts</b></p>
<ol style="list-style-type: none"> <li>Asking questions and defining problems</li> <li><b>Developing and using models:</b> 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 worlds. <ul style="list-style-type: none"> <li>Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.</li> </ul> </li> <li>Planning and carrying out investigations</li> <li>Analyzing and interpreting data</li> <li>Using mathematical and computational thinking</li> <li>Constructing explanations and designing solutions</li> <li>Engaging in argument from evidence</li> <li>Obtaining, evaluating, and communicating information</li> </ol>	<p><b>STRUCTURE AND PROPERTIES OF MATTER</b></p> <p>Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (HS.PS1A.a)</p> <p>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)</p> <p><b>TYPES OF INTERACTIONS</b></p> <p>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)</p>	<p><b>PATTERNS</b></p> <p>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.</p>

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<b>Performance Expectation</b>	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.
<b>Clarification Statement</b>	<p><b>Physical Science:</b> 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.</p> <p><b>Chemistry:</b> 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).</p>

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> <li>Asking questions and defining problems</li> <li>Developing and using models</li> <li>Planning and carrying out investigations</li> <li>Analyzing and interpreting data</li> <li>Using mathematical and computational thinking</li> <li><b>Constructing explanations and designing solutions:</b> Constructing explanations (science) and designing solutions (engineering) 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. <ul style="list-style-type: none"> <li>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.</li> </ul> </li> <li>Engaging in argument from evidence</li> <li>Obtaining, evaluating, and communicating information</li> </ol>	<p><b>STRUCTURE AND PROPERTIES OF MATTER</b> 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)</p> <p><b>CHEMICAL REACTIONS</b> 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)</p>	<p><b>PATTERNS</b> 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.</p>

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<b>Performance Expectation</b>	Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
<b>Clarification Statement</b>	<p><b>Physical Science:</b> Emphasis is on using mathematical ideas to communicate the relationship between masses of reactants and products as well as balancing chemical equations.</p> <p><b>Chemistry:</b> 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.</p>

<b>Science &amp; Engineering Practices</b>	<b>Disciplinary Core Ideas</b>	<b>Crosscutting Concepts</b>
<ol style="list-style-type: none"> <li>Asking questions and defining problems</li> <li>Developing and using models</li> <li>Planning and carrying out investigations</li> <li>Analyzing and interpreting data</li> <li><b>Using mathematics and computational thinking:</b> 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, 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 <ul style="list-style-type: none"> <li>Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.</li> </ul> </li> <li>Constructing explanations and designing solutions</li> <li>Engaging in argument from evidence</li> <li>Obtaining, evaluating, and communicating information</li> </ol>	<p><b>CHEMICAL REACTIONS</b></p> <p>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)</p>	<p><b>ENERGY AND MATTER</b></p> <p>The total amount of energy and matter in closed systems is conserved.</p>

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<p><b>Performance Expectation</b></p>	<p>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.</p>
<p><b>Clarification Statement</b></p>	<p><b>Physical Science:</b> 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.</p> <p><b>Chemistry:</b> 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.</p>



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<ol style="list-style-type: none"> <li>1. Asking questions and defining problems</li> <li>2. <b>Developing and using models:</b> 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). <ul style="list-style-type: none"> <li>• Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.</li> </ul> </li> <li>3. Planning and carrying out investigations</li> <li>4. Analyzing and interpreting data</li> <li>5. Using mathematics and computational thinking</li> <li>6. Constructing explanations and designing solutions</li> <li>7. Engaging in argument from evidence</li> <li>8. Obtaining, evaluating, and communicating information</li> </ol>	<p><b>NUCLEAR PROCESSES</b></p> <p>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)</p>	<p><b>ENERGY AND MATTER</b></p> <p>In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved.</p>

## MOTION AND STABILITY: FORCES AND INTERACTIONS

<p><b>Performance Expectation</b></p>	<p>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.</p>
<p><b>Clarification Statement</b></p>	<p><b>Physical Science:</b> 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.</p> <p><b>Physics:</b> 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.</p>

<p><b>Science &amp; Engineering Practices</b></p>	<p><b>Disciplinary Core Ideas</b></p>	<p><b>Crosscutting Concepts</b></p>
<ol style="list-style-type: none"> <li>Asking questions and defining problems</li> <li>Developing and using models</li> <li>Planning and carrying out investigations</li> <li><b>Analyzing and interpreting data:</b> 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. <ul style="list-style-type: none"> <li>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.</li> </ul> </li> <li>Using mathematics and computational thinking</li> <li>Constructing explanations and designing solutions</li> <li>Engaging in argument from evidence</li> <li>Obtaining, evaluating, and communicating information</li> </ol>	<p><b>FORCES AND MOTION</b></p> <p>Newton’s second law accurately predicts changes in the motion of macroscopic objects. (HS.PS2.A.a)</p>	<p><b>CAUSE AND EFFECT</b></p> <p>Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.</p>

## MOTION AND STABILITY: FORCES AND INTERACTIONS

<b>Performance Expectation</b>	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.
<b>Clarification Statement</b>	<p><b>Physical Science:</b> Emphasis is on calculating momentum and the qualitative meaning of conservation of momentum.</p> <p><b>Physics:</b> 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.</p>

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
<ol style="list-style-type: none"> <li>1. Asking questions and defining problems</li> <li>2. Developing and using models</li> <li>3. Planning and carrying out investigations</li> <li>4. Analyzing and interpreting data</li> <li>5. <b>Using mathematics and computational thinking:</b> 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, 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. <ul style="list-style-type: none"> <li>• Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.</li> </ul> </li> <li>6. Constructing explanations and designing solutions</li> <li>7. Engaging in argument from evidence</li> <li>8. Obtaining, evaluating, and communicating information</li> </ol>	<p><b>FORCES AND MOTION</b></p> <p>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)</p> <p>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)</p>	<p><b>SYSTEMS AND SYSTEM MODELS</b></p> <p>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.</p>

## MOTION AND STABILITY: FORCES AND INTERACTIONS

<p><b>Performance Expectation</b></p>	<p>Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.</p>
<p><b>Clarification Statement</b></p>	<p><b>Physical Science:</b> 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.</p> <p><b>Physics:</b> 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.</p>

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## MOTION AND STABILITY: FORCES AND INTERACTIONS

<b>Performance Expectation</b>	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.
<b>Clarification Statement</b>	<p><b>Physical Science:</b> 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.</p> <p><b>Physics:</b> 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.</p>



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<ol style="list-style-type: none"> <li>1. Asking questions and defining problems</li> <li>2. Developing and using models</li> <li>3. <b>Planning and carrying out Investigations:</b> 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. <ul style="list-style-type: none"> <li>• 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.</li> </ul> </li> <li>4. Analyzing and interpreting data</li> <li>5. Using mathematics and computational thinking</li> <li>6. Constructing explanations and designing solutions</li> <li>7. Engaging in argument from evidence</li> <li>8. Obtaining, evaluating, and communicating information</li> </ol>	<p><b>TYPES OF INTERACTIONS</b> 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)</p> <p><b>DEFINITIONS OF ENERGY</b> “Electrical energy” may mean energy stored in a battery or energy transmitted by electric currents. (HS.PS3A.d)</p>	<p><b>CAUSE AND EFFECT</b> Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.</p>



## ENERGY

<b>Performance Expectation</b>	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.
<b>Clarification Statement</b>	<p><b>Physical Science:</b> 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.</p> <p><b>Physics:</b> 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.</p>

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## ENERGY

<b>Performance Expectation</b>	Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
<b>Clarification Statement</b>	<p><b>Physical Science:</b> 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.</p> <p><b>Chemistry:</b> 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.</p> <p><b>Physics:</b> 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.</p>

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## ENERGY

<b>Performance Expectation</b>	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).
<b>Clarification Statement</b>	<b>Physical Science, Physics and Chemistry:</b> 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.

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## ENERGY

<p><b>Performance Expectation</b></p>	<p>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.</p>
<p><b>Clarification Statement</b></p>	<p><b>Physical Science:</b> 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.</p> <p><b>Physics:</b> 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.</p>

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## WAVES AND THEIR APPLICATIONS

<p><b>Performance Expectation</b></p>	<p>Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.</p>
<p><b>Clarification Statement</b></p>	<p><b>Physical Science:</b> Emphasis is on describing waves both qualitatively and quantitatively. Qualitative focus includes standard repeating waves and transmission/absorption of electromagnetic waves/radiation.</p> <p><b>Physics:</b> 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.</p>



<p><b>Science &amp; Engineering Practices</b></p>	<p><b>Disciplinary Core Ideas</b></p>	<p><b>Crosscutting Concepts</b></p>
<ol style="list-style-type: none"> <li>1. Asking questions and defining problems</li> <li>2. <b>Developing and using models:</b> 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). <ul style="list-style-type: none"> <li>• Develop, revise, and/or use a model based on evidence to illustrate and/or predict the relationships between systems or between components of a system.</li> </ul> </li> <li>3. Planning and carrying out investigations</li> <li>4. Analyzing and interpreting data</li> <li>5. Using mathematics and computational thinking</li> <li>6. Constructing explanations and designing solutions</li> <li>7. Engaging in argument from evidence</li> <li>8. Obtaining, evaluating, and communicating information</li> </ol>	<p><b>WAVE PROPERTIES</b></p> <p>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)</p>	<p><b>CAUSE AND EFFECT</b></p> <p>Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects.</p>

## WAVES AND THEIR APPLICATIONS

<p><b>Performance Expectation</b></p>	<p>Evaluate the validity and reliability of claims in published materials regarding the effects that different frequencies of electromagnetic radiation have when absorbed by matter.</p>
<p><b>Clarification Statement</b></p>	<p>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.</p>

<p><b>Science &amp; Engineering Practices</b></p>	<p><b>Disciplinary Core Ideas</b></p>	<p><b>Crosscutting Concepts</b></p>
<ol style="list-style-type: none"> <li>1. Asking questions and defining problems</li> <li>2. Developing and using models</li> <li>3. Planning and carrying out investigations</li> <li>4. Analyzing and interpreting data</li> <li>5. Using mathematics and computational thinking</li> <li>6. Constructing explanations and designing solutions</li> <li>7. Engaging in argument from evidence</li> <li>8. 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.</li> </ol> <ul style="list-style-type: none"> <li>• Evaluate the validity and reliability of and/or synthesize multiple claims, methods, and/or designs that appear in scientific and technical texts or media reports, verifying the data when possible.</li> </ul>	<p><b>ELECTROMAGNETIC RADIATION</b> 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)</p>	<p><b>CAUSE AND EFFECT</b> 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.</p>