Cedar Grove School District

Cedar Grove, NJ

2017 | Grade 9

Physical Science

Approved by the Cedar Grove Board of Education

Physical Science

Course Description

This course covers the physical sciences. One half of the year will be dedicated to the study of chemistry. The other half of the year will be the study of physics. The general topics of each discipline will be covered, but in a less in depth and slower pace than the individual chemistry and physics courses. The course is designed to promote the development of scientifically and technologically literate students through the assimilation of facts, concepts and the acquisition of process skills. The course maintains a traditional emphasis of physical science, while integrating earth science and space science. There is a lab component within the scheduled class time.

This curriculum was written in accordance with the
NEW JERSEY STUDENT LEARNING STANDARDS
for SCIENCE

The standards can be viewed at http://www.state.nj.us/education/aps/cccs/science/.

Physical Science

Unit 1: Nature of Science — Instructional Time: 3 Weeks

In this unit, students will learn about the field of science. Students will apply the scientific method and learn to question, predict answers to their question, and test to prove or disprove their predictions. Students will need to take linear measurements and organize the collected data into graphs. The use of equations and algebraic manipulation of those equations will be required for problem solving. Students will learn how to convert units of measure using dimensional analysis.

Student Learning Objectives

New Jersey Student Learning Standards for Science / NGSS

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.
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.
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.
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.
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.
HS-PS2-6	Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.

Enduring Understandings

- The same basic rules govern the motion of all bodies, from planets and stars to birds and billiard balls.
- Mathematics is a tool used to model objects, events, and relationships in the natural and designed world.
- Understanding the development of scientific ideas is essential for building scientific knowledge.
- Scientific inquiry involves asking scientifically-oriented questions, collecting evidence, forming explanations, connecting explanations to scientific knowledge and theory, and communicating and justifying explanations.

Essential Questions

- Why study Sherlock Holmes in physical science?
- Why do scientists study space?
- What is the difference between a scientific theory and a law?
- What is physical science?
- What steps do scientists use to solve problems?
- What are the three types of graphs and how are they used?
- How can you analyze data using various types of graphs?
- What is the difference between a direct and indirect relationship and what are their characteristic shapes on a graph?

Concepts

- Science is a method for studying the natural world
- Nature follows a set of rules
- Science falls into three different categories: life science, earth science, and physical science.
- Science changes
- The scientific method is a pattern of investigational procedures
- A hypothesis is a possible explanation for a problem
- An experiment tests the effect of one thing on another using a control
- A variable is a quantity that can have more than a single value
- A factor that does not change during an experiment is called a constant
- A model represents an idea, event, or object to help

Formative Assessment

Students who understand the concepts are able to:

- Analyze data
- Construct/interpret graphs and best fit line
- Employing the scientific method
- Make measurements
- Use dimensional analysis to convert metric units
- Manipulate basic algebraic equations
- Construct models
- Solve for density using $D = m/v$

people better understand • A scientific theory is an explanation of things or events based on knowledge gained from many observations and investigations • A scientific law is a statement about what happens in nature that seems to be true all the time • Density is a characteristic feature of matte	

Suggested Learning Activities	
• Sherlock Holmes video • Lab: Linear Measurement	• Lab: Volume Measurements • Lab: Density of Metals

Performance Expectations		
Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
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. (**HS-PS2-5**) **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. (**HS-PS2-1**) **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,		**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. (**HS-PS2-4**) **Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (**HS-PS2-1**),(**HS-PS2-5**) • Systems can be designed to cause a desired effect. (**HS-PS2-3**) **Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (**HS-PS2-2**)

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. (**HS-PS2-2**),(**HS-PS2-4**) **<u>Constructing Explanations and Designing Solutions</u>** • 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. (**HS-PS2-3**) **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). (**HS-PS2-6**)		

Cross-Curricular Connections	
English/Language Arts	**Mathematics**
• Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1) **RST.11-12.7** • Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-3) **RST.11-12.9** • Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3),(HS-ETS1-	• Reason abstractly and quantitatively. (HS-ETS1-1),(HS-ETS1-3),(HS-ETS1-4) **MP.2** • Model with mathematics. (HS-ETS1-1),(HS-ETS1-2),(HS-ETS1-3),(HS-ETS1-4) **MP.4** • Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),(HS-PS1-3) **HSN-Q.A.1**

1),(HS-ETS1-3) **WHST.9-12.9** • Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4) **SL.11-12.5**	

21st Century Career Ready Practices

- **CRP2.** - Apply appropriate academic and technical skills.
- **CRP4.** - Communicate clearly and effectively and with reason.
- **CRP6.** - Demonstrate creativity and innovation.
- **CRP8.** - Utilize critical thinking to make sense of problems and persevere in solving them.
- **CRP12**. - Work productively in teams while using cultural global competence.

Physical Science

Unit 2: Motion — Instructional Time: 3 weeks

This unit will introduce the students to motion. Students will explore mathematical models of velocity and acceleration. Students will apply the concepts of motion to examine projectiles and circular motion. Likewise, students will learn how to present measurements of motion. Position and time will be recorded and organized into data tables and graphs. This data will be used to calculate speed and acceleration. The concept of momentum will be introduced and students will be asked to consider the momentum of a speeding cyclist versus a slow moving automobile. The concepts of circular motion will be applied to analysis of rotating amusement rides.

Student Learning Objectives

New Jersey Student Learning Standards for Science / NGSS	
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.
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.
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.
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.
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.

New Jersey Student Learning Standards for Mathematics	
HSN-VM.A.3.	Solve problems involving velocity and other quantities that can be represented by vectors.
HSG-GPE.B.5.	Prove the slope criteria for parallel and perpendicular lines and use them to solve geometric problems (e.g., find the equation of a line parallel or perpendicular to a given line that passes through a given point).

Enduring Understandings

- The same basic rules govern the motion of all bodies, from planets and stars to birds and billiard balls.
- Mathematics is a tool used to model objects, events, and relationships in the natural and designed world.
- Understanding the development of scientific ideas is essential for building scientific knowledge.
- Scientific inquiry involves asking scientifically-oriented questions, collecting evidence, forming explanations, connecting explanations to scientific knowledge and theory, and communicating and justifying explanations.

Essential Questions

- How is an objects speed calculated?
- What information does a distance-time graph provide?
- How are distance and displacement different?
- What is the difference between speed and velocity?
- How is the motion of two objects relative to each other described?
- How can an objects momentum be calculated?
- How are acceleration, velocity and time related?
- What are three ways an object can accelerate?
- What are the similarities and differences between straight line motion, circular motion, and projectile motion?

Concepts

- Motion occurs when an object changes its position relative to a reference point.
- Displacement is the distance and direction of a change in position from a starting point.
- Speed is the rate at which an objects position changes.
- The slope on a distance vs time graph is the velocity
- Velocity of an object includes the object's speed and its direction of motion relative to a reference point
- The momentum of an object is the product of its mass and velocity
- Acceleration is the rate of change of velocity

Formative Assessment

Students who understand the concepts are able to:

- Calculate speed
- Calculate acceleration
- Construct and interpret speed graphs
- Construct and interpret acceleration graphs
- Calculate momentum
- Determine the slop of a graph

• The speed of an object increases if the acceleration is in the same direction as the velocity • Acceleration towards the center of a circular path is called centripetal acceleration	

Suggested Learning Activities

- Speed
- Velocity
- Acceleration
- Momentum
- Graph motion
- Graph velocity
- Graph acceleration
- Projectile motion
- Circular motion

Performance Expectations

Science and Engineering Practices	DCI	Crosscutting Concepts
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. (**HS-PS2-5**) **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. (**HS-PS2-1**) **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	**PS2.A: Forces and Motion** • Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (**HS-PS2-2**) • 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-PS2-2**),(**HS-PS2-3**)	**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. (**HS-PS2-4**) **Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (**HS-PS2-1**),(**HS-PS2-5**) • Systems can be designed to cause a desired effect. (**HS-PS2-3**) **Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (**HS-PS2-2**)

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. (**HS-PS2-2**),(**HS-PS2-4**) **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. (**HS-PS2-3**) **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). (**HS-PS2-6**)		

Cross-Curricular Connections	
English/Language Arts	**Mathematics**
• Integrate multiple sources of information presented in diverse media or formats (e.g., visually, quantitatively, qualitatively, orally) in order to address a question or solve a problem. (HS-PS2-1) **SL.9-10.2** • Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4)	• Reason abstractly and quantitatively. (HS-ETS1-1),(HS-ETS1-3),(HS-ETS1-4) **MP.2** • Model with mathematics. (HS-ETS1-1),(HS-ETS1-2),(HS-ETS1-3),(HS-ETS1-4) **MP.4** • Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data

SL.9-10.5. • Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3),(HS-ETS1-1),(HS-ETS1-3) **WHST.9-12.9** • Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-3) **RST.11-12.9**	displays. (HS-PS1-2),(HS-PS1-3) **HSN-Q.A.1**

21st Century Career Ready Practices
• **CRP2.** - Apply appropriate academic and technical skills. • **CRP4**. - Communicate clearly and effectively and with reason. • **CRP6.** - Demonstrate creativity and innovation. • **CRP8.** - Utilize critical thinking to make sense of problems and persevere in solving them. • **CRP12**. - Work productively in teams while using cultural global competence.

Physical Science

Unit 3: Forces and Newton's Laws — Instructional Time: 4 Weeks

In this unit, students will examine Newton's laws of motion. Students will learn how objects interact through forces and the effects of these forces on the motion of objects. Students will learn how a force is required for circular motion and that an object is accelerating during circular motion. Momentum and how it is conserved in collision will also be explored.

The perception of falling due to the starting and stopping of a subway train will be contrasted with the interpretation of what happens due to Newton's Law of Inertia. The benefits of the use of lightweight components on racing cars, motorcycles, and bicycles will be explained via Newton's second law. A person's mass and weight on Earth versus the person's mass and weight on moon to explain that weight is a force and mass is a universal property of matter. The concept of momentum will be built upon to show that the application of a force will result in an impulse. The students will then be asked to examine various automobile safety devices, such as airbags and seatbelts, and explain how they function using the concepts of momentum, impulse, and force.

Student Learning Objectives

New Jersey Student Learning Standards for Science / NGSS

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.
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.
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
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.

New Jersey Student Learning Standards for Mathematics

HSN-VM.A.3.	Solve problems involving velocity and other quantities that can be represented by vectors.
HSG-GPE.B.5.	Prove the slope criteria for parallel and perpendicular lines and use them to solve geometric problems (e.g., find the equation of a line parallel or perpendicular to a given line that passes through a given point).

Enduring Understandings

- The same basic rules govern the motion of all bodies, from planets and stars to birds and billiard balls.
- Mathematics is a tool used to model objects, events, and relationships in the natural and designed world.
- Understanding the development of scientific ideas is essential for building scientific knowledge.
- Scientific inquiry involves asking scientifically-oriented questions, collecting evidence, forming explanations, connecting explanations to scientific knowledge and theory, and communicating and justifying explanations.

Essential Questions

- How is force and motion related
- How is the net force acting on an object determined?
- What variables determine the amount of sliding friction between two surfaces?
- What is the difference between mass and weight?
- If you jump out of an airplane, will you continue to accelerate until the parachute opens?
- What is inertia and how is it related to Newton's first law of motion?
- How can an object's acceleration be calculated using Newton's second law?
- How does Newton's first law explain what happens in a crash?

Concepts

- A force is a push or a pull
- The net force is the sum of all the forces acting on an object
- Unbalanced forces cause the motion of an object to change
- Friction is a force that always opposes motion
- Gravity is an attractive force between all objects with mass

Formative Assessment

Students who understand the concepts are able to:

- Use unbalanced forces to explain changes in motion
- Solve for:
  - Weight
  - Mass
  - Acceleration
  - momentum

• The motion of an object will remain constant unless acted upon by an unbalanced force • Inertia is a resistance to a change in motion • Acceleration is proportional to the force acting on an object • For every force, there is an equal and opposite force • Force is an interaction • A centripetal force is required for circular motion • In a collision, momentum is conserved.	

Suggested Learning Activities

1. Force
    - 1.1. Interaction between 2 objects
    - 1.2. A push or a pull
    - 1.3. Net force
        - 1.3.1. Friction
        - 1.3.2. Air resistance
2. Newton's Laws
    - 2.1. First law
        - 2.1.1. Inertia
        - 2.1.2. Constant velocity
    - 2.2. Second Law
        - 2.2.1. Acceleration
        - 2.2.2. Weight
        - 2.2.3. Gravity
        - 2.2.4. Free fall
        - 2.2.5. Lab: acceleration due to gravity
        - 2.2.6. Lab: Projectile motion
    - 2.3. Third Law
        - 2.3.1.Action - reaction
3. Circular motion
    - 3.1. Centripetal force
4. Momentum
    - 4.1. Conservation of momentum
    - 4.2. Lab: momentum
    - 4.3. Video: Bill Nye - momentum

Performance Expectations

Science and Engineering Practices	DCI	Crosscutting Concepts
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. (**HS-PS2-5**) **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	**PS2.A: Forces and Motion** • Newton's second law accurately predicts changes in the motion of macroscopic objects. (**HS-PS2-1**) • Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (**HS-PS2-2**) • 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-PS2-2**),(**HS-PS2-3**) **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**) • Forces at a distance are explained by fields (gravitational, electric, and	**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. (**HS-PS2-4**) **Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (**HS-PS2-1**),(**HS-PS2-5**) • Systems can be designed to cause a desired effect. (**HS-PS2-3**) **Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (**HS-PS2-2**)

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. (**HS-PS2-1**) **<u>Using Mathematics and Computational Thinking</u>** • 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. (**HS-PS2-2**),(**HS-PS2-4**) • 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. (**HS-PS2-3**) • 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	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-PS2-4**),(**HS-PS2-5**) • 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-PS2-6**),(secondary to **HS-PS1-1**),(secondary to **HS-PS1-3)**	

multiple formats (including orally, graphically, textually, and mathematically). (**HS-PS2-6**)		

Cross-Curricular Connections	
English/Language Arts Standards	**Mathematics Standards**
• Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1) **RST.11-12.7** • Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-3) **RST.11-12.9** • Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3),(HS-ETS1-1),(HS-ETS1-3) **WHST.9-12.9** • Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4) **SL.11-12.5**	• Reason abstractly and quantitatively. (HS-ETS1-1),(HS-ETS1-3),(HS-ETS1-4) **MP.2** • Model with mathematics. (HS-ETS1-1),(HS-ETS1-2),(HS-ETS1-3),(HS-ETS1-4) **MP.4** • Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),(HS-PS1-3) **HSN-Q.A.1**

21st Century Career Ready Practices
• **CRP2.** - Apply appropriate academic and technical skills. • **CRP4.** - Communicate clearly and effectively and with reason. • **CRP6**. - Demonstrate creativity and innovation. • **CRP8.** - Utilize critical thinking to make sense of problems and persevere in solving them. • **CRP12.** - Work productively in teams while using cultural global competence.

Physical Science

Unit 4: Work and Energy

Instructional Time: 3 Weeks

In this unit, students will learn about work and energy. Students will explore how energy is transferred between objects as work is done on or done by the object. Students will be asked to contrast the popular definition of work with the scientific definition and be asked to identify whether scientific work has been performed in several “work” scenarios. Students will measure the power they can generate by timing a sprint up a flight of stairs. The relationship between work and energy and conservation of energy will be reinforced through a lab in which a cart must be lifted to the top of a ramp, and rolled down the ramp. The mechanical advantage of machines will be demonstrated by arranging a system of pulleys to lift a mass.

Student Learning Objectives

New Jersey Student Learning Standards for Science / NGSS

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.
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
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
MS-PS2-5	Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.
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.
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.

Enduring Understandings

- The same basic rules govern the motion of all bodies, from planets and stars to birds and billiard balls.
- Mathematics is a tool used to model objects, events, and relationships in the natural and designed world.
- Understanding the development of scientific ideas is essential for building scientific knowledge.
- Scientific inquiry involves asking scientifically-oriented questions, collecting evidence, forming explanations, connecting explanations to scientific knowledge and theory, and communicating and justifying explanations.

Essential Questions

- What is work?
- What is energy?
- How do machines make work easier?
- How is it possible to determine the mechanical advantage and efficiency of a machine?
- What is the difference between kinetic and potential energy?
- What are some forms of potential energy?
- What is mechanical energy?
- Is energy conserved?
- How are power and energy related?

Concepts

- Energy is transferred to an object when work is done on the object
- Machines, via mechanical advantage, are capable of increasing one factor at the expense of another factor
- No machine is 100% efficient
- Efficiency is the ratio of work input to work output
- Mechanical advantage is the ratio of force input to force output
- Potential energy is stored energy
- All moving objects have kinetic energy
- Energy cannot be created or destroyed, but can be

Formative Assessment

Students who understand the concepts are able to:

- determine efficiency
- calculate mechanical advantage
- solve problems involving:
  - work
  - conservation of energy
  - power

transformed • Power is the rate at which work is done • Mechanical energy can be kinetic or potential	

Suggested Learning Activities

1. Work
2. Power
   - 2.1. Lab: power (measure power generated by climbing a staircase)
3. Mechanical Energy
   - 3.1. Potential energy
     - 3.1.1. Elastic
     - 3.1.2. Gravitational
   - 3.2. Kinetic
   - 3.3. Conservation of energy
     - 3.3.1. Lab: conservation of energy (carts rolling down a ramp.)
4. Machines
   - 4.1. Efficiency
   - 4.2. Mechanical advantage
     - 4.2.1. Lab: Pulleys (compare force applied vs. weight lifted via a system of pulleys)

Performance Expectations

Science and Engineering Practices	DCI	Crosscutting Concepts
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. (**HS-PS2-5**) **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. (**HS-PS2-1**) **Using Mathematics and Computational Thinking** • Mathematical and computational	**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. (**HS-PS3-1**),(**HS-PS3-2)** • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (**HS-PS3-2**) (**HS-PS3-3**) **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. (**HS-PS3-1**) • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (**HS-PS3-1**),(**HS-PS3-4**) • Mathematical expressions, which quantify how the stored	**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. (HS-PS2-4) **Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (**HS-PS2-1**),(**HS-PS2-5**) • Systems can be designed to cause a desired effect. (**HS-PS2-3)** **Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (**HS-PS2-2**)

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. (**HS-PS2-2),(HS-PS2-4**) **<u>Constructing Explanations and Designing Solutions</u>** • 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. (**HS-PS2-3**) **<u>Obtaining, Evaluating, and Communicating Information</u>** • 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). (**HS-PS2-6**)	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. (**HS-PS3-1**) • The availability of energy limits what can occur in any system. (**HS-PS3-1**) • 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-PS3-4**)	

Cross-Curricular Connections	
English/Language Arts Standards	**Mathematics Standards**
• Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1) **RST.11-12.7**	• Reason abstractly and quantitatively. (HS-ETS1-1),(HS-ETS1-3),(HS-ETS1-4) **MP.2** • Model with mathematics. (HS-ETS1-1),(HS-ETS1-2),(HS-ETS1-3),(HS-ETS1-4) **MP.4**

• Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-3) **RST.11-12.9** • Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3),(HS-ETS1-1),(HS-ETS1-3) WHST.9-12.9 • Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4) **SL.11-12.5**	• Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),(HS-PS1-3) **HSN-Q.A.1**

21st Century Career Ready Practices
• **CRP2**. - Apply appropriate academic and technical skills. • **CRP4.** - Communicate clearly and effectively and with reason. • **CRP6.** - Demonstrate creativity and innovation. • **CRP8.** - Utilize critical thinking to make sense of problems and persevere in solving them. • **CRP12.** - Work productively in teams while using cultural global competence.

Physical Science

Unit 5: Thermal Energy	Instructional Time: 3 Weeks

In this unit students will learn about heat and the transfer of heat. Students will explore how the movement of heat can be used to produce mechanical energy, how mechanical energy can be used to move heat, and applications of heat transfer.

Student Learning Objectives

New Jersey Student Learning Standards for Science / NGSS	
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.
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
MS-PS2-5	Conduct an investigation and evaluate the experimental design to provide evidence that fields exist between objects exerting forces on each other even though the objects are not in contact.
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.
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 position of particles (objects).
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.
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).

Enduring Understandings	Essential Questions
• The same basic rules govern the motion of all bodies, from planets and stars to birds and billiard balls. • Mathematics is a tool used to model objects, events, and relationships in the natural and designed world. • Understanding the development of scientific ideas is essential for building scientific knowledge. • Scientific inquiry involves asking scientifically-oriented questions, collecting evidence, forming explanations, connecting explanations to scientific knowledge and theory, and communicating and justifying explanations.	• What is the difference between temperature and thermal energy? • How can you calculate changes in thermal energy? • Name the three ways thermal energy can be transferred? • How can the energy found in food be quantified? • What is a calorie? • What is a food Calorie? • How much heat is released from a burning candle? • What is specific heat? • What is the difference between radiation from the sun and radiation from a radioactive element? • Why do temperatures drop so quickly on a clear night in autumn? • What type of heating system is used in homes? • How do refrigerators work? • What is a heat pump? • What are the 4 strokes in a four stroke engine?

Concepts	Formative Assessment
• Temperature is a measure of the kinetic energy of the particles in an object • Thermal energy is the sum of potential and kinetic energy of the particles in an object • Heat is the transfer of thermal energy due to a temperature difference • A calorie is the amount of heat require to raise the temperature of 1 g of water by 1° C	Students who understand the concepts are able to: • Calculate change in thermal energy • Calculate the energy contained in a substance

• Specific heat is the heat required to raise the temperature of 1 gram of a substance by 1° C • Water has an unusually high specific heat • Metals have low specific heat • Conduction, convection and radiation are modes of heat transfer • Convection is the transfer of heat in a fluid by the movement of warm and cool particles. • Radiation is the transfer of energy by radioactive waves. • Conduction is the transfer of energy by collisions between particles • A heat engine is a device that converts heat energy to mechanical energy • A heat pump uses mechanical energy to transport thermal energy • Heat engines are less than 100% efficient	

Suggested Learning Activities

1. Temperature
2. Thermal Energy
    2.1 Calories
    2.1Lab: calories in a potato chip
3. Heat
    3.1 Lab/Demo: Heat of fusion of wax
    3.2 Lab/Demo: Heat of combustion of wax
4. Specific Heat
5. Heat Transfer
    5.1 Demo: Immersion heater water and oil
    5.2 Convection
    5.3 Conduction
    5.4 Radiation
    5.5 Insulators
6. Converting energy
    6.1 Heat engine
        6.1.1 Steam engine
        6.1.2 Internal combustion engine
7. Transferring energy
    7.1 Heat pump
        7.1.1 Air conditioners
        7.1.2 Refrigerator

Performance Expectations

Science and Engineering Practices	DCI	Crosscutting Concepts
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. (**HS-PS2-5**) **Analyzing and Interpreting Data**	**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. (**HS-PS3-1),(HS-PS3-2**) • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (**HS-PS3-2) (HS-PS3-3**) • These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be	**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. (**HS-PS2-4**) **Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (**HS-PS2-1),(HS-PS2-5**) • Systems can be designed to cause a desired effect. (**HS-PS2-3**) **Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (**HS-PS2-2**)

• 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. (**HS-PS2-1**) **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. (**HS-PS2-2),(HS-PS2-4**) **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. (**HS-PS2-3**) **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,	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-PS3-2**) **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. (**HS-PS3-1**) • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (**HS-PS3-1),(HS-PS3-4**) • The availability of energy limits what can occur in any system. (**HS-PS3-1**) • 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-PS3-4**)	

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). (**HS-PS2-6**)		

Cross-Curricular Connections	
English/Language Arts Standards	**Mathematics Standards**
• Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1) **RST.11-12.7** • Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-3) **RST.11-12.9** • Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3),(HS-ETS1-1),(HS-ETS1-3) **WHST.9-12.9** • Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4) **SL.11-12.5**	• Reason abstractly and quantitatively. (HS-ETS1-1),(HS-ETS1-3),(HS-ETS1-4**) MP.2** • Model with mathematics. (HS-ETS1-1),(HS-ETS1-2),(HS-ETS1-3),(HS-ETS1-4) **MP.4** • Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),(HS-PS1-3) **HSN-Q.A.1**

21st Century Career Ready Practices
• **CRP2.** - Apply appropriate academic and technical skills. • **CRP4.** - Communicate clearly and effectively and with reason. • **CRP6**. - Demonstrate creativity and innovation. • **CRP8.** - Utilize critical thinking to make sense of problems and persevere in solving them. • **CRP12.** - Work productively in teams while using cultural global competence.

Physical Science

Unit 6: Electricity	Instructional Time: 4 Weeks
In this unit students will learn about electric charge. The flow of electric charge through circuits will be explored and analyzed by application of Ohm's Law. Students will calculate electrical energy and its associated cost.	

Student Learning Objectives

New Jersey Student Learning Standards for Science / NGSS

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.
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.
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.
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.
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.
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 position of particles (objects).
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.
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

Enduring Understandings	Essential Questions
• The same basic rules govern the motion of all bodies, from planets and stars to birds and billiard balls. • Mathematics is a tool used to model objects, events, and relationships in the natural and designed world. • Understanding the development of scientific ideas is essential for building scientific knowledge. • Scientific inquiry involves asking scientifically-oriented questions, collecting evidence, forming explanations, connecting explanations to scientific knowledge and theory, and communicating and justifying explanations.	• Why does a balloon stick to the wall after rubbing it in your hair? • What is electricity? • How is electricity commercially produced? • How can objects become electrically charged? • Why are we more likely to experience static shocks in the winter? • What produces lightning and thunder? • How is electricity measured? • What is the relationship between amp, volts, and ohms? • What is the purpose of a fuse and a circuit breaker? • How did the invention of the light bulb change the world? • What was the battle of the currents? • How did Nikola Tesla change the world? • Why is alternating power used for power?

Concepts	Formative Assessment
• Like charges repel; opposite charged attract • Charge by contact is the transfer of charge by touching • Charge by induction is a temporary charge that is induced by separating charges caused by the proximity of a charge object. • Electric current is the flow of electrons • Chemical reactions in a battery are responsible for the potential difference between the terminals • Resistance is like "friction" for the flow of charge • There is one pathway for current in a series circuit	Students who understand the concepts are able to: • Calculate current, resistance, and voltage using Ohm's Law • Diagram parts of a battery • Diagram series and parallel circuits • Calculate electric power • Calculate electric energy usage • Calculate the cost of electric energy used

• There are multiple pathways for current in a parallel circuit • Fuses and circuit breakers are used to protect circuits from drawing too much current and overheating	

Suggested Learning Activities

1. Static Electricity
    - 1.1 Demo: stick balloons to a wall
    - 1.2 Electric charge
    - 1.3 Conductors / insulators
    - 1.4 Lab: construct an electroscope
    - 1.5 Video: Thomas Edison
2. Circuits
    - 2.1 Ohm's Law
        - 2.1.1 Voltage
            - 2.1.1.1 batteries
        - 2.1.2 Current
        - 2.1.3 Resistance
    - 2.2 Series and Parallel
        - 2.2.1 Lab: Build series and parallel circuits
    - 2.3 Open / closed
    - 2.4 Power / energy
        - 2.4.1 Cost on energy
    - 2.5 Circuit protection
        - 2.5.1 Fuse
        - 2.5.2 Circuit breaker
    - 2.6 Video: Bill Nye – electricity
3. Video: Tesla – Mad electricity

Performance Expectations

Science and Engineering Practices	DCI	Crosscutting Concepts
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. (**HS-PS2-5**) **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. (**HS-PS2-1**)	**PS3.A: Definitions of Energy** • 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-PS3-2)** **PS3.B: Conservation of Energy and Energy Transfer** • 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-PS3-4**) **PS3.D: Energy in Chemical Processes** • Although energy cannot be destroyed, it can be converted to less useful forms—for	**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. (**HS-PS2-4**) **Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (**HS-PS2-1),(HS-PS2-5**) • Systems can be designed to cause a desired effect. (**HS-PS2-3)** **Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (**HS-PS2-2)**

<u>Using Mathematics and Computational Thinking</u> • 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. (**HS-PS2-2),(HS-PS2-4**) • 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. (**HS-PS2-3**) **<u>Obtaining, Evaluating, and Communicating Information</u>** • 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). (**HS-PS2-6**)	example, to thermal energy in the surrounding environment. (**HS-PS3-3),(HS-PS3-4**)	

Cross-Curricular Connections	
English/Language Arts Standards	**Mathematics Standards**
• Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1) **RST.11-12.7** • Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent	• Reason abstractly and quantitatively. (HS-ETS1-1),(HS-ETS1-3),(HS-ETS1-4) **MP.2** • Model with mathematics. (HS-ETS1-1),(HS-ETS1-2),(HS-ETS1-3),(HS-ETS1-4) **MP.4** • Use units as a way to understand problems and to

understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-3) **RST.11-12.9** • Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3),(HS-ETS1-1),(HS-ETS1-3) **WHST.9-12.9** • Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4) **SL.11-12.5**	guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),(HS-PS1-3) **HSN-Q.A.1**

21st Century Career Ready Practices

- **CRP2.** - Apply appropriate academic and technical skills.
- **CRP4.** - Communicate clearly and effectively and with reason.
- **CRP6**. - Demonstrate creativity and innovation.
- **CRP8.** - Utilize critical thinking to make sense of problems and persevere in solving them.
- **CRP12.** - Work productively in teams while using cultural global competence.

Physical Science

Unit 7: Solid, Liquids, and Gases — Instructional Time: 4 Weeks

In this unit students will learn the states of matter and the change of states of matter. The relationship between energy and the state of matter will be examined via kinetic theory, heating/cooling curves, and calculations with special attention paid to the unique properties of water. Fluid mechanics and gas laws will be introduced and used to explain the behaviors or liquids and gases.

Student Learning Objectives

New Jersey Student Learning Standards for Science / NGSS

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.
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.
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.
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.
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.
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 position of particles (objects).
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.
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).
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

Enduring Understandings	**Essential Questions**
• The same basic rules govern the motion of all bodies, from planets and stars to birds and billiard balls. • Mathematics is a tool used to model objects, events, and relationships in the natural and designed world. • Understanding the development of scientific ideas is essential for building scientific knowledge. • Scientific inquiry involves asking scientifically-oriented questions, collecting evidence, forming explanations, connecting explanations to scientific knowledge and theory, and communicating and justifying explanations.	• Why does matter exists in solid, liquid and gaseous forms? • How and why do phase changes occur? • What is temperature? • What is the difference between temperature and heat? • Do substances gain or lose energy as phase change takes place? • When did mankind first take to the skies? • Why do airplanes fly? • Why does the temperature stay at 0˚C when ice melts? • Ships are made of metal and yet they float. Why? • What is the relationship between temperature, volume and pressure of a gas? • What is the centigrade scale based on? • What is the difference between 10w30 and 10w40 motor oil?

Concepts	**Formative Assessment**
• Matter can exist as solid, liquid, gas, or plasma. • Kinetic theory explains how the particles that make up gases behave • Temperature is a measure of the kinetic energy of a substance • Thermal energy is the total energy of the particles of	Students who understand the concepts are able to: • Convert between Kelvin and Celsius • Describe the behavior of matter and phase changes with respect to KMT • Solve problems using gas law calculations • Create and interpret graphs of properties of gases

a substance including kinetic and potential energy
- Fluids flow and exert force on objects
- Buoyant force of a fluid acts in the opposite direction of gravity
- Pascal's principle states that the pressure applied to a fluid is transmitted throughout the fluid
- Bernoulli's principle states that there is an inverse relationship between velocity and pressure
- Viscosity is the resistance to flow
- Gases respond to changes in temperature, pressure, and volume in predictable ways

Suggested Learning Activities

1. Kinetic molecular theory of matter
    - 1.1 Temperature
    - 1.2 Thermal energy
    - 1.3 Movie: Modern Marvels - Gases
2. Changes of state
    - 2.1 Heating and cooling curves
        - 2.1.1 Lab: Heating curves
    - 2.2 Hot air and lighter than air balloons
    - 2.3 Water is weird
3. Fluids
    - 3.1 Archimedes' principle
        - 3.1.1 Lab: make a metal boat
    - 3.2 Pascal's principle
        - 3.2.1 Demo: Pascal's principle
    - 3.3 Bernoulli's principle
4. Gas laws
    - 4.1 Boyles
        - 4.1.1 Demo: Boyles law
    - 4.2 Charles
    - 4.3 Gay-Lussac
        - 4.3.1 Demo: Gay-Lussac's law
    - 4.4 Graphs
    - 4.5 Movie: Newton's Apple – gas pressure

Performance Expectations

Science and Engineering Practices	DCI	Crosscutting Concepts
<u>Planning and Carrying Out Investigations</u> • 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. (**HS-PS2-5**) ***<u>Analyzing and Interpreting Data</u>*** • Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for	**<u>PS3.A: Definitions of Energy</u>** • 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. (**HS-PS3-1),(HS-PS3-2)** • At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. **(HS-PS3-2)** **(HS-PS3-3**) • 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	**<u>Patterns</u>** • 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. (**HS-PS2-4**) **<u>Cause and Effect</u>** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (**HS-PS2-1),(HS-PS2-5**) • Systems can be designed to cause a desired effect. (**HS-PS2-3**) **<u>Systems and System Models</u>** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (**HS-PS2-2**)

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. (HS-PS2-1) **<u>Using Mathematics and Computational Thinking</u>** • 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. (**HS-PS2-2),(HS-PS2-4**) **<u>Constructing Explanations and Designing Solutions</u>** • 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. (**HS-PS2-3**) **<u>Obtaining, Evaluating, and Communicating Information</u>** • 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,	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-PS3-2**) **<u>PS3.B: Conservation of Energy and Energy Transfer</u>** • 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. (**HS-PS3-1**) • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (**HS-PS3-1),(HS-PS3-4**) • The availability of energy limits what can occur in any system. (**HS-PS3-1**) • 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-PS3-4)** **<u>ETS1.A: Defining and Delimiting Engineering Problems</u>** • 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 to **HS-PS3-3)**	

textually, and mathematically). (**HS-PS2-6**)		

Cross-Curricular Connections	
English/Language Arts Standards	**Mathematics Standards**
• Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1) **RST.11-12.7** • Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-3) **RST.11-12.9** • Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3),(HS-ETS1-1),(HS-ETS1-3) **WHST.9-12.9** • Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4) **SL.11-12.5**	• Reason abstractly and quantitatively. (HS-ETS1-1),(HS-ETS1-3),(HS-ETS1-4) **MP.2** • Model with mathematics. (HS-ETS1-1),(HS-ETS1-2),(HS-ETS1-3),(HS-ETS1-4) **MP.4** • Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),(HS-PS1-3) **HSN-Q.A.1**

21st Century Career Ready Practices
• **CRP2.** - Apply appropriate academic and technical skills. • **CRP4.** - Communicate clearly and effectively and with reason. • **CRP6.** - Demonstrate creativity and innovation. • **CRP8.** - Utilize critical thinking to make sense of problems and persevere in solving them. • **CRP12.** - Work productively in teams while using cultural global competence.

Physical Science

Unit 8: Classifications of Matter	Instructional Time: 4 weeks
Students will learn how to classify matter and explore the difference between chemical and physical properties.	

Student Learning Objectives	
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.
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.
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.
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.
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.
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.
HS-PS1-7	Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
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.

Enduring Understandings	Essential Questions
• The same basic rules govern the motion of all bodies, from planets and stars to birds and billiard balls. • Mathematics is a tool used to model objects, events, and relationships in the natural and designed world. • Understanding the development of scientific ideas is essential for building scientific knowledge. • Scientific inquiry involves asking scientifically-oriented questions, collecting evidence, forming explanations, connecting explanations to scientific knowledge and theory, and communicating and justifying explanations. • Safety first!	• How many elements are there? • How can we simplify the study of elements? • What is an element? • What is a compound? • What is a mixture? • How is it possible to identify unknown substance? • What is the difference between a physical property and a chemical property? • How can components of a mixture be separated?

Concepts	Formative Assessment
• An element is a substance composed of only one kind of atom • A compound is a substance composed of 2 or more elements • A mixture is a blend of different substances in which each retains its original identity • Mixtures can be heterogeneous or homogeneous • A suspension is a heterogeneous mixture composed of a liquid and solid particles that settle • A colloid is a heterogeneous mixture with particles that never settle • A homogeneous mixture is a mixture that is uniform throughout • A physical property is any characteristic of a material that you can observe without changing the identity of the substance • A chemical property is any characteristic of a material that you can observe that produces one or more new	Students who understand the concepts are able to: • Identify chemical vs. physical change • Classify matter as an element, compound, or type of mixture • Identify physical vs. chemical properties • Devise a process to separate a given mixture

substances • Mixtures can be separated based on physical properties • Distillation is process for separating materials based on different boiling points • Chemical changes produce new substances • Physical changes tend to be reversible • The law of conservation of matter states that matter is not created or destroyed in a chemical reaction	

Suggested Learning Activities

1. Classify matter
    1.1 Demo: examples of types of matter
    1.2 Elements
    1.3 Compounds
    1.4 Mixtures
        1.4.1 Lab: separate a mixture
        1.4.2 Homogeneous
        1.4.3 Heterogeneous
        Suspensions
        1.4.4 Colloids
        1.4.5 Intro to solutions
        1.6.7 Distillation
            1.4.7.1 Demo: distillation apparatus
2. Properties
    2.1 Physical
    2.2 Chemical
3. Change
    3.1 Physical
    3.2 Chemical
4. Law of conservation of mass

New Jersey Student Learning Standards for Science / NGSS and Foundations for the Unit

Science and Engineering Practices	DCI	Crosscutting Concepts
<u>Planning and Carrying Out Investigations</u> • 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. **(HS-PS2-5**) **<u>Analyzing and Interpreting Data</u>** • 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.	**<u>PS1.A: Structure and Properties of Matter</u>**	**<u>Patterns</u>** • 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. (**HS-PS2-4**) **<u>Cause and Effect</u>** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (**HS-PS2-1**),(**HS-PS2-5**) • Systems can be designed to cause a desired effect. (**HS-PS2-3**) **<u>Systems and System Models</u>** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (**HS-PS2-2**)

(**HS-PS2-1**) **<u>Using Mathematics and Computational Thinking</u>** • 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. (**HS-PS2-2**),(**HS-PS2-4**) **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. (**HS-PS2-3**) **<u>Obtaining, Evaluating, and Communicating Information</u>** • 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). (**HS-PS2-6**)		

Cross-Curricular Connections	
English/Language Arts Standards	**Mathematics Standards**
• Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1) **RST.11-12.7**	• Reason abstractly and quantitatively. (HS-ETS1-1),(HS-ETS1-3),(HS-ETS1-4) **MP.2** • Model with mathematics. (HS-ETS1-1),(HS-ETS1-2),(HS-ETS1-3),(HS-ETS1-4) **MP.4** • Use units as a way to understand problems and to guide

• Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-3) **RST.11-12.9** • Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3),(HS-ETS1-1),(HS-ETS1-3) **WHST.9-12.9** • Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4) **SL.11-12.5**	the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),(HS-PS1-3) **HSN-Q.A.1**
21st Century Career Ready Practices	
CRP2. - Apply appropriate academic and technical skills. **CRP4.** - Communicate clearly and effectively and with reason. **CRP6.** - Demonstrate creativity and innovation. **CRP8.** - Utilize critical thinking to make sense of problems and persevere in solving them. **CRP12.** - Work productively in teams while using cultural global competence.	

Physical Science

Unit 9: Atoms and the Periodic Table — Instructional Time: 4 Weeks

In this unit students will explore the parts of an atom. There will be an introduction to atomic models and a discussion of how the models have changed over time. The development and structure of the periodic table will be a major topic. Radioactivity and the practical applications of fusion and fission will be examined.

Student Learning Objectives

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.
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.
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.
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.
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.
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.
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
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.

Enduring Understandings

- The same basic rules govern the motion of all bodies, from planets and stars to birds and billiard balls.
- Mathematics is a tool used to model objects, events, and relationships in the natural and designed world.
- Understanding the development of scientific ideas is essential for building scientific knowledge.
- Scientific inquiry involves asking scientifically-oriented questions, collecting evidence, forming explanations, connecting explanations to scientific knowledge and theory, and communicating and justifying explanations.

Essential Questions

- What is the smallest unit of matter?
- What is the location of subatomic particles in an atom?
- How has the model of the atom changed over time?
- How does the current model of the atom resemble a bee hive?
- What is heavy water?
- What does radioactive mean?
- What is the fuel for a nuclear power plant?
- What fuels the sun?
- How can we determine the age of fossils and artifacts?
- How are element organized?

Concepts

- The atom is composed of protons, electrons, and neutrons
- Protons and neutrons are in the nucleus
- Electrons are in a cloud around the nucleus
- Neutrons and protons can be subdivided into quarks
- Protons are positive. Electrons are negative. Neutrons are neutral.
- Atom number is the number of protons in the nucleus
- Mass number is the number of protons and neutrons
- Isotopes are atoms of the same element with different number of neutrons
- Groups on the periodic table share similar physical and chemical properties
- Elements are classified as metal, nonmetal, and metalloids
- Radioactive atoms are unstable

Formative Assessment

Students who understand the concepts are able to:

- Diagram atoms
- Locate common elements in common groups
- Calculate number of protons, neutrons, and electrons in an atom
- Calculate average atomic mass

• Nuclear fusion powers the sun • Nuclear fission is used in nuclear power plants • Carbon dating is used to determine the age of artifacts	

Suggested Learning Activities

1. Parts of the atom
    1.1 Electrons
    1.2 Nucleus
        1.2.1 Protons
        1.2.2 Neutrons
    1.3 Atomic mass
    1.4 Atomic number
    1.5 Isotopes
2. Model of the atom
    2.1 Plum pudding
    2.2 Bohr
3. Periodic Table
    3.1 Periods
    3.2 Groups
4. Radioactivity
    4.1 Decay
    4.2 Fission
    4.2Fusion

New Jersey Student Learning Standards for Science / NGSS and Foundations for the Unit

Science and Engineering Practices	DCI	Crosscutting Concepts
<u>Planning and Carrying Out Investigations</u> • 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. (**HS-PS2-5**) **<u>Analyzing and Interpreting Data</u>** • 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. (**HS-PS2-1**) **<u>Using Mathematics and Computational Thinking</u>** • Mathematical and computational	**<u>PS1.A: Structure and Properties of Matter</u>** • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. **(HS-PS1-1)** • 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-PS1-1),(HS-PS1-2**) **<u>PS1.C: Nuclear Processes</u>** • 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-PS1-8**)	**<u>Patterns</u>** • 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. (**HS-PS2-4**) **<u>Cause and Effect</u>** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (**HS-PS2-1),(HS-PS2-5**) • Systems can be designed to cause a desired effect. (**HS-PS2-3**) **<u>Systems and System Models</u>** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (**HS-PS2-2**)

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. (**HS-PS2-2),(HS-PS2-4**) **<u>Constructing Explanations and Designing Solutions</u>** • 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. (**HS-PS2-3**) **<u>Obtaining, Evaluating, and Communicating Information</u>** • 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). (**HS-PS2-6**)		

Cross-Curricular Connections	
English/Language Arts Standards	**Mathematics Standards**
• Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1) **RST.11-12.7** • Synthesize information from a range of sources (e.g.,	• Reason abstractly and quantitatively. (HS-ETS1-1),(HS-ETS1-3),(HS-ETS1-4) **MP.2** • Model with mathematics. (HS-ETS1-1),(HS-ETS1-2),(HS-ETS1-3),(HS-ETS1-4) **MP.4** • Use units as a way to understand problems and to

texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-3) **RST.11-12.9** • Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3),(HS-ETS1-1),(HS-ETS1-3) **WHST.9-12.9** • Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4) **SL.11-12.5**	guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),(HS-PS1-3) **HSN-Q.A.1**

21st Century Career Ready Practices

- **CRP2.** - Apply appropriate academic and technical skills.
- **CRP4.** - Communicate clearly and effectively and with reason.
- **CRP6.** - Demonstrate creativity and innovation.
- **CRP8.** - Utilize critical thinking to make sense of problems and persevere in solving them.
- **CRP12**. - Work productively in teams while using cultural global competence.

Physical Science

Unit 10: Elements and Properties	Instructional Time: 4 Weeks
This unit will examine the properties of elements and the organization of those elements on the periodic table. Student will know what properties define a metal versus what properties define a nonmetal. Students will explore how to predict the properties of elements based upon the location in the periodic table.	

Student Learning Objectives

New Jersey Student Learning Standards for Science / NGSS

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
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.
HS-PS2-3	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.
HS-PS2-4	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.
HS-PS2-5	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.
HS-ESS1-3	Communicate scientific ideas about the way stars, over their life cycle, produce elements.
HS-LS1-6	Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules

Enduring Understandings	Essential Questions
• The same basic rules govern the motion of all bodies, from planets and stars to birds and billiard balls. • Mathematics is a tool used to model objects, events, and relationships in the natural and designed world. • Understanding the development of scientific ideas is essential for building scientific knowledge. • Scientific inquiry involves asking scientifically-oriented questions, collecting evidence, forming explanations, connecting explanations to scientific knowledge and theory, and communicating and justifying explanations.	• Is it possible to make a new element? • Why is our water chlorinated? • Are neon lights limited to neon gas only? • Name three metals that would be attracted by a magnet? • What makes a metal a metal? • Why do noble gases have low reactivity?

Concepts	Formative Assessment
• Metals possess loosely held electrons that are easily lost in reactions • Nonmetals possess tightly held electrons and gain electrons in reactions • Metals' loosely held electrons explain their conductivity and malleability properties. • Nonmetals tightly held electrons explains why they are brittle and insulators. • Most elements are too reactive to be found in their elemental state • Metals are found on the left side of the periodic table and are generally shiny, malleable, ductile, and good insulators. • Alkali and alkaline earth metals are reactive • Nonmetals are located on the right side of the periodic table and are generally dull, poor conductors, and brittle • Some groups on the periodic table contain metalloids:	Students who understand the concepts are able to: • Position an element in the correct family on the periodic table given the elements properties • Predict the properties of an element based upon its position on the periodic table • Know noteworthy properties on common elements

elements that have some properties of metals and nonmetals.	

Suggested Learning Activities

1. Periodic table
   1.1 Families
   1.2 Properties
   1.3 Lab: Flame test
   1.4 Video: elements
2. Metals
   2.1 properties
3. Nonmetals
   3.1 Properties
   3.2 Video: modern marvels - carbon
   3.3 Noble gases
   3.4 Halogens
      3.4.1 Video: halogens
4. Transition elements
   4.1 Video: transition metals

Performance Expectations

Science and Engineering Practices	DCI	Crosscutting Concepts
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. (**HS-PS2-5**) **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. (**HS-PS2-1**) **Using Mathematics and Computational Thinking** • Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic	**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. (**HS-PS1-1**),(**HS-PS1-2**)	**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. (**HS-PS2-4**) **Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (**HS-PS2-1**),(**HS-PS2-5**) • Systems can be designed to cause a desired effect. (**HS-PS2-3**) **Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (**HS-PS2-2**)

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. (**HS-PS2-2),(HS-PS2-4)** **<u>Constructing Explanations and Designing Solutions</u>** • 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. (**HS-PS2-3**) **<u>Obtaining, Evaluating, and Communicating Information</u>** • 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). (**HS-PS2-6**)		

Cross-Curricular Connections	
English/Language Arts Standards	**Mathematics Standards**
• Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1) **RST.11-12.7** • Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-3) **RST.11-12.9**	• Reason abstractly and quantitatively. (HS-ETS1-1),(HS-ETS1-3),(HS-ETS1-4) **MP.2** • Model with mathematics. (HS-ETS1-1),(HS-ETS1-2),(HS-ETS1-3),(HS-ETS1-4) **MP.4** • Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),(HS-PS1-3) **HSN-Q.A.1**

• Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3),(HS-ETS1-1),(HS-ETS1-3) **WHST.9-12.9** • Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4) **SL.11-12.5**	
21st Century Career Ready Practices	
• **CRP2**. - Apply appropriate academic and technical skills. • **CRP4**. - Communicate clearly and effectively and with reason. • **CRP6.** - Demonstrate creativity and innovation. • **CRP8. -** Utilize critical thinking to make sense of problems and persevere in solving them. • **CRP12.** - Work productively in teams while using cultural global competence.	

Physical Science

Unit 11: Chemical Bonding — Instructional Time: 4 Weeks

In this unit the various mechanisms of chemical bonding will be investigated. Students will learn the role of valance shell electrons in chemical bonding. Students will learn when and why the types of bonds occur and will learn how to represent these bonds with Lewis Dot structure and chemical formulas.

Student Learning Objectives

New Jersey Student Learning Standards for Science / NGSS	
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
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.
HS-PS2-3	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.
HS-PS2-4	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.
HS-PS2-5	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.
HS-ESS1-3	Communicate scientific ideas about the way stars, over their life cycle, produce elements.
HS-LS1-6	Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules

Enduring Understandings

- The same basic rules govern the motion of all bodies, from planets and stars to birds and billiard balls.
- Mathematics is a tool used to model objects, events, and relationships in the natural and designed world.
- Understanding the development of scientific ideas is essential for building scientific knowledge.
- Scientific inquiry involves asking scientifically-oriented questions, collecting evidence, forming explanations, connecting explanations to scientific knowledge and theory, and communicating and justifying explanations.

Essential Questions

- Why are noble gases nonreactive?
- Why do chemical bonds form?
- What does “8 is great” mean?
- What is relationship between group number and valance electrons?
- How can you predict charges in ionic bonds?
- What does a chemical formula supply?
- What is Lewis Dot structure?
- What is the relationship between group number and the number of bonds formed?
- What are structural formulas?
- What is a polar bond?

Concepts

- Noble gasses have complete valance shells and are nonreactive
- Group number = number of valance electrons
- Elements gain stability by losing or gaining electrons to complete outer shell
- Ions are positively or negatively charged due to loss or gain of electrons
- Ionic compounds are composed of ions
- In an ionic compounds, electrons are transferred from metals to nonmetals; metal ions are always positive, nonmetal ions are always negative
- The magnitude of the charge reflects the number of electrons lost or gained
- An electron is shared between two nonmetals in a covalent bond

Formative Assessment

Students who understand the concepts are able to:

- Create Lewis Dot diagrams
- Write and interpret chemical formulas
- Name compounds

• A polar bond is a covalent bond where the electrons are shared unequally • Molecules are composed of covalently bonded atoms • The carbon family forms 4 bonds; nitrogen family 3 bonds, oxygen family 2 bonds, halogens 1 bond • A polyatomic ion is a positively or negatively charged covalently bonded group of atoms	

Suggested Learning Activities

1. Chemical formulas
   - 1.1 Lewis Dot
   - 1.2 Structural
2. Chemical bonds
   - 2.1 Lab: Molecular models
   - 2.2 Video: bonding
   - 2.3 Valance electrons
     - 2.3.1 Oxidation numbers
   - 2.4 Ionic
     - 2.4.1 Ions
     - 2.4.2 Polyatomic ions
   - 2.5 covalent
   - 2.6 Double and triple bonds
   - 2.7 Polar bonds

Performance Expectations

Science and Engineering Practices	DCI	Crosscutting Concepts
<u>Planning and Carrying Out Investigations</u> • 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. (**HS-PS2-5**) **<u>Analyzing and Interpreting Data</u>** • 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. (**HS-PS2-1**) **<u>Using Mathematics and Computational Thinking</u>**	**<u>PS1.A: Structure and Properties of Matter</u>** • 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-PS1-1),(HS-PS1-2**)	**<u>Patterns</u>** • 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. (**HS-PS2-4**) **<u>Cause and Effect</u>** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (**HS-PS2-1),(HS-PS2-5**) • Systems can be designed to cause a desired effect. (**HS-PS2-3**) **<u>Systems and System Models</u>** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (**HS-PS2-2**)

• 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. (**HS-PS2-2),(HS-PS2-4)** **<u>Constructing Explanations and Designing Solutions</u>** • 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. (**HS-PS2-3**) **<u>Obtaining, Evaluating, and Communicating Information</u>** • 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). (**HS-PS2-6**)		

Cross-Curricular Connections	
English/Language Arts Standards	**Mathematics Standards**
• Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1) **RST.11-12.7** • Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent	• Reason abstractly and quantitatively. (HS-ETS1-1),(HS-ETS1-3),(HS-ETS1-4) **MP.2** • Model with mathematics. (HS-ETS1-1),(HS-ETS1-2),(HS-ETS1-3),(HS-ETS1-4) **MP.4** • Use units as a way to understand problems and to guide the solution of multi-step problems; choose and

understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-3) **RST.11-12.9** • Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3),(HS-ETS1-1),(HS-ETS1-3) **WHST.9-12.9** • Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4) **SL.11-12.5**	interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),(HS-PS1-3) **HSN-Q.A.1**

21st Century Career Ready Practices

- **CRP2**. - Apply appropriate academic and technical skills.
- **CRP4**. - Communicate clearly and effectively and with reason.
- **CRP6.** - Demonstrate creativity and innovation.
- **CRP8. -** Utilize critical thinking to make sense of problems and persevere in solving them.
- **CRP12.** - Work productively in teams while using cultural global competence.

Physical Science

Unit 12: Chemical Reactions	Instructional Time: 5 Weeks

In this unit students will learn how chemical compounds change through reactions. Students will learn the different types of reactions and why these reactions occur. The reaction rate and factors that influence it will be examined.

Student Learning Objectives

New Jersey Student Learning Standards for Science / NGSS

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
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.
HS-PS2-3	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.
HS-PS2-4	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.
HS-PS2-5	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.
HS-ESS1-3	Communicate scientific ideas about the way stars, over their life cycle, produce elements.
HS-LS1-6	Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules

Enduring Understandings

- The same basic rules govern the motion of all bodies, from planets and stars to birds and billiard balls.
- Mathematics is a tool used to model objects, events, and relationships in the natural and designed world.
- Understanding the development of scientific ideas is essential for building scientific knowledge.
- Scientific inquiry involves asking scientifically-oriented questions, collecting evidence, forming explanations, connecting explanations to scientific knowledge and theory, and communicating and justifying explanations.

Essential Questions

- What information does a chemical equation offer?
- What roles do coefficients play in balancing equations?
- How are chemical reactions classified?
- What factors affect reaction rates?
- Why is there a strip of sandpaper located on the back of a matchbook?
- What is catalyst?

Concepts

- A balanced chemical equation describes the rearrangement of atoms in a chemical reaction
- A chemical reaction is a process that involves one or more reactants changing into one or more products
- A balanced chemical equation indicates relative amounts of reactants and products
- Reactions can be classified based on how atoms are rearranged
- There are 5 basic classes of chemical reactions: combustion, synthesis, decomposition, single replacement, double replacement
- Some reactions products are called a precipitate when two aqueous ionic substances are combined
- Exothermic reactions release energy, endothermic reactions absorb energy
- Five factors that affect reaction rate include: temperature, concentration, surface area, nature of reactants, catalyst

Formative Assessment

Students who understand the concepts are able to:

- Balance equations
- Classify reactions
- Interpret reaction coordinate diagrams

• Activation energy is the energy required to start a reaction	

Suggested Learning Activities

1. Balancing equations
2. Classify reactions
   - 2.1 Combustion
     - 2.1.1 Demo: Observation of combustion reactions
   - 2.2 Synthesis
   - 2.3 Decomposition
     - 2.3.1 Lab: decomposition of hydrogen peroxide using MnO_2 catalyst
   - 2.4 Single replacement
   - 2.5 Double replacement
3. Reaction Rate
   - 3.1 Temperature
     - 3.1.1 Lab: steel wool and copper sulfate (room temperature vs. hot solution)
   - 3.2 Concentration
   - 3.3 Surface area
   - 3.4 Nature of reactants
   - 3.5 Catalyst
   - 3.6 Lab: vinegar and baking soda
4. Energy
   - 4.1 Activation energy
   - 4.2 Endothermic
   - 4.3 Exothermic

Performance Expectations

Science and Engineering Practices	DCI	Crosscutting Concepts
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. (**HS-PS2-5**) **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. (**HS-PS2-1**) **Using Mathematics and Computational Thinking**	**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. (**HS-PS1-4**) **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. (**HS-PS1-4),(HS-PS1-5**) • 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. (**HS-PS1-6**) • 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-PS1-2),(HS-PS1-7)**	**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. (**HS-PS2-4**) **Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (**HS-PS2-1),(HS-PS2-5**) • Systems can be designed to cause a desired effect. (**HS-PS2-3**) **Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (**HS-PS2-2**)

• 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. (**HS-PS2-2),(HS-PS2-4)** **<u>Constructing Explanations and Designing Solutions</u>** • 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. (**HS-PS2-3**) **<u>Obtaining, Evaluating, and Communicating Information</u>** • 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). (**HS-PS2-6**)		

Cross-Curricular Connections	
English/Language Arts Standards	**Mathematics Standards**
• Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1) **RST.11-12.7** • Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent	• Reason abstractly and quantitatively. (HS-ETS1-1),(HS-ETS1-3),(HS-ETS1-4) **MP.2** • Model with mathematics. (HS-ETS1-1),(HS-ETS1-2),(HS-ETS1-3),(HS-ETS1-4) **MP.4** • Use units as a way to understand problems and to guide the solution of multi-step problems; choose and

understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-3) **RST.11-12.9** • Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3),(HS-ETS1-1),(HS-ETS1-3) **WHST.9-12.9** • Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4) **SL.11-12.5**	interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),(HS-PS1-3) **HSN-Q.A.1**

21st Century Career Ready Practices
• **CRP2**. - Apply appropriate academic and technical skills. • **CRP4**. - Communicate clearly and effectively and with reason. • **CRP6.** - Demonstrate creativity and innovation. • **CRP8. -** Utilize critical thinking to make sense of problems and persevere in solving them. • **CRP12.** - Work productively in teams while using cultural global competence.

Physical Science

Unit 13: Radioactivity and Nuclear	Instructional Time: 4 Weeks
Students will explore reactions that involve the nucleus of the atom. The Alpha, Beta, and gamma decay will be examined. The process of fission and fusion will be discussed as well as the applications of both of these processes.	

Student Learning Objectives

New Jersey Student Learning Standards for Science / NGSS

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
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.
HS-PS2-3	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.
HS-PS2-4	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.
HS-PS2-5	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.
HS-ESS1-3	Communicate scientific ideas about the way stars, over their life cycle, produce elements.
HS-LS1-6	Construct and revise an explanation based on evidence for how carbon, hydrogen, and oxygen from sugar molecules may combine with other elements to form amino acids and/or other large carbon-based molecules

Enduring Understandings	Essential Questions
• The same basic rules govern the motion of all bodies, from planets and stars to birds and billiard balls. • Mathematics is a tool used to model objects, events, and relationships in the natural and designed world. • Understanding the development of scientific ideas is essential for building scientific knowledge. • Scientific inquiry involves asking scientifically-oriented questions, collecting evidence, forming explanations, connecting explanations to scientific knowledge and theory, and communicating and justifying explanations.	• What is radioactivity? • What is the fuel in a nuclear power plant? • How does a nuclear power plant work? • How are nuclear power plants controlled? • If noble gases are nonreactive, why is radon gas a health hazard? • What is a half-life? • How is it possible to determine the age of artifacts and fossils? • Why do nuclear power plants produce more energy than traditional fossil fuel plants?

Concepts	Formative Assessment
• The world around us is radioactive • Controlled nuclear reactions generate 20% of the worlds electricity • Isotopes are atoms of the same elements with a different number of neutrons • Unstable isotopes are radioactive • Radioactivity is the process of nuclei decaying and emitting matter and/or energy • When elements decay they form new elements • Transmutation is the process of changing from one element to a new element • The alpha particle is equivalent to a helium nucleus • A fission chain reaction is caused by the release of neutrons in every fission • Nuclear fission is the process of splitting heavy nuclei in to lighter nuclei • Nuclear fusion is the process in which light nuclei	Students who understand the concepts are able to: • Balance transmutation reactions • Diagram fission reactions • Diagram fusion reactions • Illustrate a chain reaction • Recognize common radioisotopes

combine • $E=mc^2$ deals with the equivalence of matter and energy • Radon is a hazardous gas that may be present in your home	

Suggested Learning Activities

The prevalence of radon gas in homes in the local area will be used as teaching tool to introduce the concept of radioactivity, the decay process, and health hazards of radioactivity. Half-life will be discussed in terms of carbon dating ancient relics. Nuclear disasters will be studied and used to learn the process of fission.

1. Radioactivity
   - 1.1 Isotopes
   - 1.2 Decay
     - 1.2.1 Alpha
     - 1.2.2 Beta
     - 1.2.3 Gamma
   - 1.3 Transmutation
   - 1.4 Half-life
   - 1.5 Radiometric dating
   - 1.6 Video: irradiation
2. Fission
   - 2.1 Power plants
   - 2.2 Video: Modern marvels – nuclear power
   - 2.3 Video: Chernobyl
3. Fusion
   - 3.1 Hydrogen bomb
   - 3.2 Stars

Performance Expectations

Science and Engineering Practices	DCI	Crosscutting Concepts
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. (**HS-PS2-5**) **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,	**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. (**HS-PS1-8**)	**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. (**HS-PS2-4**) **Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (**HS-PS2-1**),(**HS-PS2-5**) • Systems can be designed to cause a desired effect. (**HS-PS2-3**) **Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (**HS-PS2-2**)

and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (**HS-PS2-1**) **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. (**HS-PS2-2),(HS-PS2-4)** **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. (**HS-PS2-3**) **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). (**HS-PS2-6**)		

Cross-Curricular Connections	
English/Language Arts Standards	**Mathematics Standards**
• Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g.,	• Reason abstractly and quantitatively. (HS-ETS1-1),(HS-ETS1-3),(HS-ETS1-4) **MP.2**

quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1) **RST.11-12.7** • Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible. (HS-ETS1-3) **RST.11-12.9** • Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS1-3),(HS-ETS1-1),(HS-ETS1-3) **WHST.9-12.9** • Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS1-4) **SL.11-12.5**	• Model with mathematics. (HS-ETS1-1),(HS-ETS1-2),(HS-ETS1-3),(HS-ETS1-4) **MP.4** • Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS1-2),(HS-PS1-3) **HSN-Q.A.1**

21st Century Career Ready Practices

- **CRP2**. - Apply appropriate academic and technical skills.
- **CRP4**. - Communicate clearly and effectively and with reason.
- **CRP6.** - Demonstrate creativity and innovation.
- **CRP8. -** Utilize critical thinking to make sense of problems and persevere in solving them.
- **CRP12.** - Work productively in teams while using cultural global competence.