Burlington County Institute of Technology

Medford Campus

Westampton Campus

STEM

Department: Science
Credits: 5
Revised: August 2023
Board Approval Date: August, 2023

Course Description

STEM focuses on inquiry driven lab activities that interweave the four disciplines of science, technology, engineering, and mathematics. Topics covered in this course include formation of the universe, geologic timelines, volcanic eruptions, earthquakes, climate change, renewable energies, sustainability, and human's interactions with the world.

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Pacing Guide

Unit	Standards	Days
Unit 1: Space Systems	HS-ESS1-1, 2, 3, 4 HS-ETS1-4 HS-PS2-4	Weeks 1-3
Unit 2: History of the Earth	HS-ESS1-5, 6 HS-ESS2-1 HS-PS4-1	Weeks 4-6
Unit 3: Earth Systems	HS-ESS2-2, 3, 6, 7	Weeks 7-9
Unit 4: Weather and Climate	HS-ESS2-4, 5 HS-ESS3-5 HS-ETS1-1	Weeks 10-11
Unit 5: Energy	HS-PS2-5 HS-PS3-1, 2, 3	Weeks 12-13
Unit 6: Human Sustainability	HS-ESS3-1, 2, 3, 4, 6 HS-ETS1-2	Weeks 14-16
Unit 7: Forces and Interaction at Earth’s Surface	HS-PS2-1, 2, 3	Weeks 17-18

Curriculum Maps

Unit 1: Space Systems
Desired Outcomes

Established Goals: NJSLS

Earth and Space Science (ESS):

- HS-ESS1-2 Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe.
- 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
- HS-ESS1-3 Communicate scientific ideas about the way stars, over their life cycle, produce elements.
- HS-ESS1-4 Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.

Physical Sciences (PS):

- 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.

Engineering, Technology, and Applications of Science (ETS)

- HS-ETS1-4 Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Science and Engineering Practices	***Disciplinary Core Ideas***	***Crosscutting Concepts***

Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). • Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS1-1) **Using Mathematical and Computational Thinking** Mathematical and computational thinking in 9–12 builds on K–8 experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions.	**ESS1.A: The Universe and Its Stars** • The star called the sun is changing and will burn out over a lifespan of approximately 10 billion years. (HS-ESS1-1) • The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1- 2),(HS-ESS1-3) • The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (HS-ESS1-2) • Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are	**Scale, Proportion, and Quantity** • The significance of a phenomenon is dependent on the scale, proportion, and quantity at which it occurs. (HS-ESS1-1) • Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). (HS-ESS1-4) **Energy and Matter** • Energy cannot be created or destroyed– only moved between one place and another place, between objects and/or fields, or between systems. (HS-ESS1-2) • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HSESS1-3) **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

• Use mathematical or computational representations of phenomena to describe explanations. (HS-ESS1-4),(HS-PS2-4),(HS-ETS1-4) **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. • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS1-2)	produced when certain massive stars achieve a supernova stage and explode. (HS-ESS1- 2),(HS-ESS1-3) **ESS1.B: Earth and the Solar System** • Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1-4) **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 magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause	phenomena. (HS-PS2-4) **Systems and System Models** • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interaction – including energy, matter, and information flows – within and between systems at different scales. (HS-ETS1-4) **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** • Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (HS-ESS1-2),(HS-ESS1-4) **Connections to Nature of Science** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Scientific knowledge is based

Obtaining, Evaluating, and Communicating Information Obtaining, evaluating, and communicating information in 9–12 builds on K–8 experiences and progresses to evaluating the validity and reliability of the claims, methods, and designs. ● Communicate scientific ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-ESS1-3) **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the	magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4) **ETS1.B: Developing Possible Solutions** ● Both physical models and computers can be used in various ways to aid in the engineering design process. Computers are useful for a variety of purposes, such as running simulations to test different ways of solving a problem or to see which one is most efficient or economical; and in making a persuasive presentation to a client about how a given design will meet his or her needs. (HS-ETS1-4)	on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. (HS-ESS1-2) ● Science assumes the universe is a vast single system in which basic laws are consistent. (HS-ESS1-2)

theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-ESS1-2) • Theories and laws provide explanations in science. (HS-PS2-4) • Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-4)		

Enduring Understandings:

- The Big Bang theory provides an explanation for the origin of the universe and is supported by evidence such as light spectra, distant galaxy motion, and the composition of matter.
- The sun's life span is determined by nuclear fusion in its core, which releases energy that eventually reaches Earth as radiation.
- Stars go through a life cycle during which they produce elements, contributing to the abundance of elements in the universe.
- Mathematical and computational representations can be used to accurately predict the motion of orbiting objects in the solar system.
- Newton's Law of Gravitation and Coulomb's Law provide mathematical descriptions for

Essential Questions:

- How does the Big Bang theory explain the origin and evolution of the universe, and what evidence supports this theory?
- How does nuclear fusion in the sun's core produce energy, and how does that energy eventually reach Earth in the form of radiation?
- How do stars create and produce different elements throughout their life cycle?
- How can mathematical and computational representations be used to predict and understand the motion of objects in the solar system?
- What are the mathematical relationships described by Newton's Law of Gravitation and Coulomb's Law, and how do these laws explain the forces between objects?
- How can computer simulations be used to model

understanding and predicting the gravitational and electrostatic forces between objects. ○ Computer simulations can model the impact of proposed solutions to complex real-world problems, taking into account various criteria and constraints, and interactions within and between relevant systems.	and evaluate the impact of proposed solutions to complex real-world problems, considering multiple criteria and constraints, and the interactions within and between relevant systems?
Students will know: ○ Big Bang Theory & Life Span of a Star ○ Evidence to support the Big Bang Theory ○ Expansion of life span of a star ○ Predict the motion of orbiting objects using Newton's and Kepler's Laws	**Students will be able to:** ○ Use data obtained from various sources to construct a model of the sun's life cycle ○ Use reliable resources to understand the process of nuclear fusion, its current uses on Earth, and its role in the formation of our universe ○ Perform mathematical computations that will allow for the graphing of planetary motion (i.e. Kepler's Laws)

Assessment Evidence

Suggested Performance Tasks: ○ Solar System Explorer Gizmo ○ Big Bang Theory- Activity ○ Earth Moon System ○ Star Spectra Gizmo	**Required District/State Assessments:** ○ District marking period assessments ○ SGO assessments **Suggested Formative/Summative Assessments:** ○ Lab/activity report ○ Practice Worksheets ○ Section Quizzes

	○ Chapter Tests ○ Short/extended constructed response items from ELA NJGPA/NJSLA and Science NJSLA ○ Projects ○ Journals ○ Observation ○ Graphic organizers/concept mapping ○ Presentations ○ Warmups / exit tickets

Learning Plan

Learning Activities:

- Online demonstration videos
- In class demonstration
- Guided readings on background and procedures
- Case studies

Related Standards

Interdisciplinary connections

- English Language Arts
  - ⇒ WHST.9-10.1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant sufficient textual and non-textual evidence.
  - ⇒ WHST.9-10.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
  - ⇒ WHST.9-10.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
  - ⇒ WHST.9-10.6. Use technology, including the Internet, to produce, share, and update writing products,

taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

- Math
  - ⇒ HSN-RN.A.2 Rewrite expressions involving radicals and rational exponents using the properties of exponents.
    - Example: Students will apply Kepler's Third Law of Motion and solve some expressions requiring fractional exponents in an interesting modeling context. Like many physical laws, Kepler's third law of planetary motion is an approximation, one with remarkable accuracy. https://tasks.illustrativemathematics.org/content-standards/HSN/RN/A/2/tasks/1842
  - ⇒ HS-N.Q.A.1 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-N.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
  - ⇒ HS-N.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Technology (NJSLS Computer Science and Design Thinking)

- 8.1.12.DA.1: Create interactive data visualizations using software tools to help others better understand real world phenomena, including climate change.
  - ⇒ Example: In this lesson, students use spreadsheets to model and predict the orbital motion of celestial bodies in the solar system, aligning with the standards HS-ESS1-4 and HS-ETS1-4. They organize solar system data and set up calculations in the spreadsheet to simulate orbits based on gravitational forces, distances from the sun, and orbital periods. Students visualize and analyze the data through graphs, considering the patterns observed and reflecting on the connections to enduring understandings and essential questions about the Big Bang theory, the life span of stars, and scientific evidence. The lesson promotes computational thinking and demonstrates the application of spreadsheets in understanding celestial phenomena.

NJ SEL Competencies

- Self-Management: Recognize the skills needed to establish and achieve personal and educational goals
- Relationship Skills: Identify who, when, where, or how to seek help for oneself or others when needed

Culturally Relevant Connections

- Study the life and achievements of Dr. Mae Jemison and Dr. Amelia Ortiz-Gil
- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tools such as SKYPE, experts from the community helping with a project, journal articles, and biographies.
- Provide multiple grouping opportunities for students to share their ideas and to encourage work among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).
- Structure the learning around explaining or solving a social or community-based issue.

Accommodations

Special Education/ 504/ At Risk Students Accommodations & Modifications:

- Peer tutoring
- Extended time
- Timelines with due dates
- Adequate wait time
- Frequent breaks, if needed
- Brief and concrete directions
- Graphic organizers
- Note taking assistance
- Study guides
- Emphasize multi-sensory learning

ELL:

- Graphic organizers
- Cooperative learning structures, such as Think-Pair-Share
- Wordbanks
- Sentence Starters
- Pictures

Enrichment

- Extended learning goals:
  - ⇒ Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tools such as Zoom, experts from the community helping with a project, journal articles, and biographies.
  - ⇒ Provide multiple grouping opportunities for students to share their ideas and to encourage work

among various backgrounds and cultures (e.g. multiple representation and multimodal experiences).

⇒ Structure the learning around explaining or solving a social or community-based issue.

Unit 2: History of the Earth

Desired Outcomes

Established Goals: NJSLS

Earth and Space Sciences (ESS):

- HS-ESS1-6 Apply scientific reasoning and evidence from ancient Earth materials, meteorites, and other planetary surfaces to construct an account of Earth's formation and early history.
- HS-ESS1-5 Evaluate evidence of the past and current movements of continental and oceanic crust and the theory of plate tectonics to explain the ages of crustal rocks.
- HS-ESS2-1 Develop a model to illustrate how Earth's internal and surface processes operate at different spatial and temporal scales to form continental and ocean-floor features.

Physical Sciences (PS):

- HS-PS4-1 Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. [Clarification Statement: Examples of data could include electromagnetic radiation traveling in a vacuum and glass, sound waves traveling through air and water, and seismic waves traveling through the Earth.] [Assessment Boundary : Assessment is limited to algebraic relationships and describing those relationships qualitatively .]

Science and Engineering Practices	***Disciplinary Core Ideas***	***Crosscutting Concepts***
Constructing Explanations and Designing Solutions Constructing explanations and	**ESS1.C: The History of Planet Earth** • Continental rocks, which can be older than 4 billion years,	**Patterns** • Empirical evidence is needed to identify patterns.

designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories • Apply scientific reasoning to link evidence to the claims to assess the extent to which the reasoning and data support the explanation or conclusion. (HS-ESS1-6) **Engaging in Argument from Evidence** Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may also come from current scientific or historical episodes in science. • Evaluate evidence behind currently accepted explanations or solutions to determine the merits of arguments. (HS-ESS1-5)	are generally much older than the rocks of the ocean floor, which are less than 200 million years old. (HS-ESS1-5) • Although active geologic processes, such as plate tectonics and erosion, have destroyed or altered most of the very early rock record on Earth, other objects in the solar system, such as lunar rocks, asteroids, and meteorites, have changed little over billions of years. Studying these objects can provide information about Earth's formation and early history. (HS-ESS1-6) **ESS2.A: Earth Materials and Systems** • Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HSESS2-1) **ESS2.B: Plate Tectonics and Large-Scale System Interactions** • Plate tectonics is the unifying theory that explains the past and current movements of the rocks at Earth's surface	(HS-ESS1-5) **Stability and Change** • Much of science deals with constructing explanations of how things change and how they remain stable. (HS-ESS1-6) • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS2-1) **Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS4-1)

Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). ● Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-ESS2-1) **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	and provides a framework for understanding its geologic history. Plate movements are responsible for most continental and ocean-floor features and for the distribution of most rocks and minerals within Earth's crust. (ESS2.B Grade 8 GBE) (HS-ESS2-1) **PS4.A: Wave Properties** ● The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (HS-PS4-1)	

representations of phenomena or design solution to describe and/or support claims and/or explanations. (HS-PS4-1) **Connections to Nature of Science Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-ESS1-6) • Models, mechanisms, and explanations collectively serve as tools in the development of a scientific theory. (HS-ESS1-6)		

Enduring Understandings:

- Earth's formation and early history can be reconstructed through scientific reasoning and evidence gathered from ancient Earth materials, meteorites, and planetary surfaces (HS-ESS1-6).
- The movement of continental and oceanic crust, along with the theory of plate tectonics, provides evidence to explain the ages of crustal rocks and the dynamic nature of Earth's surface (HS-ESS1-5).
- Earth's internal and surface processes operate at various spatial and temporal scales, contributing to the formation of continental and ocean-floor features (HS-ESS2-1).
- Mathematical representations can be used to establish relationships among frequency, wavelength, and speed of waves traveling in different media, such as electromagnetic radiation, sound waves, and seismic waves (HS-PS4-1).

Essential Questions:

- How can we use ancient Earth materials, meteorites, and planetary surfaces to piece together the story of Earth's formation and early history? (HS-ESS1-6)
- What evidence supports the theory of plate tectonics, and how does it explain the movement of continental and oceanic crust and the ages of crustal rocks? (HS-ESS1-5)
- How do Earth's internal and surface processes, operating at different spatial and temporal scales, contribute to the formation of continental and ocean-floor features? (HS-ESS2-1)
- How can mathematical representations help us understand the relationships between frequency, wavelength, and speed of waves traveling through different media, and how does this knowledge apply to phenomena like electromagnetic radiation, sound waves, and seismic waves? (HS-PS4-1)

Students will know:

- Origin of earth, atmosphere, leading to the evolution of animal life
- Continental drift & sea floor spreading, Convection Currents
- Volcanoes and Lava Flow
- Earthquakes (P & S Waves)

Students will be able to:

- Support a position using various sources of evidence.
- Predict the movement of the continents based on the history of tectonic plate movement.
- Design and construct models to provide solutions and evidence for current environmental issues.
- Design and carry out scientific investigations.

	○ Communicate and defend a scientific argument.

Assessment Evidence

<u>Suggested Performance Tasks:</u> ○ Geologic Time Scale ○ Convection Current Lab (Tectonic Plate Movement) ○ Pangaea Project (using fossil evidence) ○ Lava Flow Lab ○ Earthquake Lab ○ Earthquake Building Project	**<u>Required District/State Assessments:</u>** ○ District marking period assessments ○ SGO assessments **<u>Suggested Formative/Summative Assessments:</u>** ○ Lab/activity report ○ Practice Worksheets ○ Section Quizzes ○ Chapter Tests ○ Short/extended constructed response items from ELA NJGPA/NJSLA and Science NJSLA ○ Projects ○ Journals ○ Observation ○ Graphic organizers/concept mapping ○ Presentations ○ Warmups / exit tickets

Learning Plan

<u>Learning Activities:</u>

- Online demonstration
- Videos
- In class demonstration
- Guided readings on background and procedures

- Case studies

Related Standards

Interdisciplinary connections

- Math
  - ⇒ HSN.Q.A.1 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.
  - ⇒ HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
    - Example: Students will create a model of geological time using metric standard distances to represent length of time.
  - ⇒ HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
- English Language Arts
  - ⇒ WHST.9-10.1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant sufficient textual and non-textual evidence.
  - ⇒ WHST.9-10.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
  - ⇒ WHST.9-10.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
  - ⇒ WHST.9-10.6. Use technology, including the Internet, to produce, share, and update writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

21st Century Skills (NJSLS Career Readiness, Life Literacies, and Key Skills)

- 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3).
  - ⇒ Example: Earthquake Building project. Students will research engineering designs of buildings that are earthquake resistant for the purpose of creating a model of a building that would employ multiple

structural advances. Students will present their findings and designs with Google slide to their peers and choose the most practical design.

NJ SEL Competencies

- Self-Management: Identify and apply ways to persevere or overcome barriers through alternative methods to achieve one's goals
- Relationship Skills: Identify who, when, where, or how to seek help for oneself or others when needed

Culturally Relevant Connections

- Everyone has a Voice: Create a classroom environment where students know that their contributions are expected and valued.
  - ⇒ Example: Norms for sharing are established that communicate a growth mindset for science. All students are capable of sharing observations, discussing investigative data, and otherwise contributing to the classroom community. Students learn new ways of looking at problem solving by working with and listening to each other.

Accommodations

Special Education/ 504/ At Risk Students Accommodations & Modifications:

- Peer tutoring
- Extended time
- Timelines with due dates
- Adequate wait time
- Frequent breaks, if needed
- Brief and concrete directions
- Graphic organizers
- Note taking assistance
- Study guides

ELL:

- Graphic organizers
- Cooperative learning structures, such as Think-Pair-Share
- Word banks
- Sentence Starters
- Pictures

○ Emphasize multi-sensory learning	

Enrichment
○ Extended learning goals: ⇒ Produce a "marketable" toothpaste made from minerals that are used by most people every day. Calcium carbonate and sodium bicarbonate are minerals found in toothpaste. Divide the class into small groups and allow students to brainstorm solutions to make the basic toothpaste recipe more appealing to other children. (Source: Toothpaste with a twist)

Unit 3: Earth Systems

Desired Outcomes

Established Goals: NJSLS

Earth and Space Sciences (ESS)

- HS-ESS2-2 Analyze geoscience data to make the claim that one change to Earth's surface can create feedback that causes changes to other Earth systems.
- HS-ESS2-3 Develop a model based on evidence of Earth's interior to describe the cycling of matter by thermal convection.
- HS-ESS2-6 Develop a quantitative model to describe the cycling of carbon among the hydrosphere, atmosphere, geosphere, and biosphere.
- HS-ESS2-7Construct an argument based on evidence about the simultaneous coevolution of Earth's systems and life on Earth.

Science and Engineering Practices	***Disciplinary Core Ideas***	***Crosscutting Concepts***
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s). ● Develop a model based on evidence to illustrate the	**ESS2.A: Earth Materials and Systems** ● Earth's systems, being dynamic and interacting, cause feedback effects that can increase or decrease the original changes. (HS-ESS2-2) ● Evidence from deep probes and seismic waves, reconstructions of historical changes in Earth's surface	**Energy and Matter** ● The total amount of energy and matter in closed systems is conserved. (HS-ESS2-6) ● Energy drives the cycling of matter within and between systems. (HS-ESS2-3) **Stability and Change** ● Much of science deals with constructing explanations of

relationships between systems or between components of a system. (HS-ESS2- 3),(HS-ESS2-6) **Analyzing and Interpreting Data** Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. ● Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-ESS2-2) **Engaging in Argument from Evidence** Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about the natural and designed world(s). Arguments may	and its magnetic field, and an understanding of physical and chemical processes lead to a model of Earth with a hot but solid inner core, a liquid outer core, a solid mantle and crust. Motions of the mantle and its plates occur primarily through thermal convection, which involves the cycling of matter due to the outward flow of energy from Earth's interior and gravitational movement of denser materials toward the interior. (HS-ESS2-3) **ESS2.D: Weather and Climate** ● Gradual atmospheric changes were due to plants and other organisms that captured carbon dioxide and released oxygen. (HS-ESS2-6),(HS-ESS2-7) **ESS2.E: Biogeology** ● The many dynamic and delicate feedbacks between the biosphere and other Earth systems cause a continual co-evolution of Earth's surface and the life that exists on it. (HS-ESS2-7)	how things change and how they remain stable. (HS-ESS2-7) **Connections to Engineering, Technology, and Applications of Science** **Interdependence of Science, Engineering, and Technology** ● Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise. (HS-ESS2-3) **Influence of Engineering, Technology, and Science on Society and the Natural World** ● New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS2-2)

also come from current scientific or historical episodes in science. • Construct an oral and written argument or counter arguments based on data and evidence. (HS-ESS2-7) **Connections to Nature of Science Scientific Knowledge is Based on Empirical Evidence** • Science knowledge is based on empirical evidence. (HS-ESS2-3) • Science disciplines share common rules of evidence used to evaluate explanations about natural systems. (HS-ESS2-3) • Science includes the process of coordinating patterns of evidence with current theory. (HS-ESS2-3)		

Enduring Understandings:	Essential Questions:
○ Changes to Earth's surface can initiate feedback loops that impact and cause changes to other Earth systems, demonstrating the interconnected nature of Earth's systems (HS-ESS2-2). ○ Earth's interior undergoes thermal	○ How does a change in Earth's surface trigger feedback mechanisms that cause alterations in other Earth systems? (HS-ESS2-2) ○ What evidence supports the model of thermal convection within Earth's interior, and how does this process contribute to the cycling of matter?

convection, leading to the cycling of matter and energy within the planet (HS-ESS2-3). ○ The carbon cycle involves the movement and exchange of carbon among the hydrosphere, atmosphere, geosphere, and biosphere, and can be quantitatively modeled (HS-ESS2-6). ○ Earth's systems and life on Earth have coevolved, with interactions and feedbacks between them shaping the planet's history and current state (HS-ESS2-7).	(HS-ESS2-3) ○ How can we develop a quantitative model to represent the movement of carbon among the hydrosphere, atmosphere, geosphere, and biosphere? (HS-ESS2-6) ○ What evidence can be used to construct an argument about the coevolution of Earth's systems and life on Earth, and how do these interactions shape the planet? (HS-ESS2-7)
Students will know: ○ How Earth's major spheres, geosphere, biosphere, atmosphere, and hydrosphere interact with each other. ○ Water cycle, rock cycle, properties of water ○ Carbon cycle	**Students will be able to:** ○ Utilize information from graphs to draw conclusions about the changes occurring in earth systems ○ Construct models incorporating various forms of technology using data obtained from various resources ○ Design and carry out scientific investigations ○ Communicate and defend a scientific argument
Assessment Evidence	
Suggested Performance Tasks: ○ Earthquakes Living Lab: Theory of Plate tectonics ○ Water Olympics & Water Cycle ○ Carbon cycle lab ○ Chocolate Rock Cycle ○ Article Reading on Earth's major spheres	**Required District/State Assessments:** ○ District marking period assessments ○ SGO assessments **Suggested Formative/Summative Assessments:** ○ Lab/activity report

	○ Practice Worksheets ○ Section Quizzes ○ Chapter Tests ○ Short/extended constructed response items from ELA NJGPA/NJSLA and Science NJSLA ○ Projects ○ Journals ○ Observation ○ Graphic organizers/concept mapping ○ Presentations ○ Warmups / exit tickets

Learning Plan

Learning Activities:

- Online demonstration videos
- In class demonstration
- Guided readings on background and procedures
- Case studies

Related Standards

Interdisciplinary connections

- ELA
  - ⇒ WHST.9-10.1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant sufficient textual and non-textual evidence.
    - A. Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims,

reasons, and evidence.

B. Develop claim(s) and counterclaims using sound reasoning, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience's knowledge level and concerns.

C. Use transitions (e.g. words, phrases, clauses) to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

D. Establish and maintain a style and tone appropriate to the audience and purpose (e.g. formal and objective for academic writing) while attending to the norms and conventions of the discipline in which they are writing.

E. Provide a concluding paragraph or section that supports the argument presented.

- ⇒ WHST.9-10.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
- ⇒ WHST.9-10.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
- ⇒ WHST.9-10.6. Use technology, including the Internet, to produce, share, and update writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

- Math
    - ⇒ HSN.Q.A.1 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.
    - ⇒ HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
        - Example: Students will examine seismic wave data focusing on frequency and amplitude to determine the severity of the earthquake that occurred and categorize earthquakes on the Richter scale.
    - ⇒ HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

21st Century Skills (NJSLS Career Readiness, Life Literacies, and Key Skills - Technology Literacy)

- 9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.

⇒ Example: Earthquake tracking lab. Students will use an online seismograph simulator to collect data from multiple sites, once the collected data is imputed into a Google sheet the students will then create formulas to calculate the epicenter distance from the seismograph location to pinpoint the location of the Earthquake.

NJ SEL Competencies

- Self-Management: Recognize the impact of one's feelings and thoughts on one's own behavior.
- Social Awareness: Demonstrate an understanding of the need for mutual respect when viewpoints differ.

Climate Change

- Field Testing for Ozone - In this experiment, students will test the levels of tropospheric ozone present in the air. Students will perform the experiment, analyze their data, and learn about ways to reduce tropospheric ozone.

Culturally Relevant Connections

- Run Problem Based Learning Scenarios: Encourage scientifically productive discourse among students by presenting problems that are relevant to them, the school and /or the community.
  ⇒ Example: Using a Place Based Education (PBE) model, students explore science concepts while determining ways to address problems that are pertinent to their neighborhood, school or culture.

Accommodations

Special Education/ 504/ At Risk Students Accommodations & Modifications:	ELL:
○ Peer tutoring ○ Extended time ○ Timelines with due dates	○ Graphic organizers ○ Cooperative learning structures, such as Think-Pair-Share ○ Word banks

○ Adequate wait time ○ Frequent breaks, if needed ○ Brief and concrete directions ○ Graphic organizers ○ Note taking assistance ○ Study guides ○ Emphasize multi-sensory learning	○ Sentence Starters ○ Pictures

Enrichment
○ Extended learning goals: ⇒ What's Causing Sea-Level Rise? Land Ice Vs. Sea Ice: In this activity, students will learn about sea ice and land ice. They will observe ice melting on a solid surface near a body of water and ice melting in a body of water. Prior to the activity, students will predict what each situation will do to the level of water and then compare their prediction to what they observe.

BCIT

Unit 4: Weather and Climate
Desired Outcomes

<u>Established Goals: NJSLS</u>

Earth and Space Sciences (ESS)

- HS-ESS2-4 Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.
- HS-ESS2-5 Plan and conduct an investigation of the properties of water and its effects on Earth materials and surface processes.
- HS-ESS3-5 Analyze geoscience data and the results from global climate models to make an evidence-based forecast of the current rate of global or regional climate change and associated future impacts to Earth systems.
- Engineering, Technology, and Applications of Science (ETS)
- HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

Science and Engineering Practices	***Disciplinary Core Ideas***	***Crosscutting Concepts***
Developing and Using Models Modeling in 9–12 builds on K–8 experiences and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed world(s).	**ESS2.A: Earth Materials and Systems** ● The geological record shows that changes to global and regional climate can be caused by interactions among changes in the sun's energy output or Earth's orbit, tectonic events, ocean	**Cause and Effect** ● Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-ESS2-4) ● Structure and Function ● The functions and properties

• Use a model to provide mechanistic accounts of phenomena. (HS-ESS2-4) **Planning and Carrying Out Investigations** Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-ESS2-5) **Analyzing and Interpreting Data** Analyzing data in 9–12 builds on K–8 experiences and progresses to introducing more detailed statistical analysis, the comparison of data sets	circulation, volcanic activity, glaciers, vegetation, and human activities. These changes can occur on a variety of time scales from sudden (e.g., volcanic ash clouds) to intermediate (ice ages) to very long-term tectonic cycles. (HS-ESS2-4) **ESS2.C: The Roles of Water in Earth's Surface Processes** • The abundance of liquid water on Earth's surface and its unique combination of physical and chemical properties are central to the planet's dynamics. These properties include water's exceptional capacity to absorb, store, and release large amounts of energy, transmit sunlight, expand upon freezing, dissolve and transport materials, and lower the viscosities and melting points of rocks. (HS-ESS2-5) **ESS2.D: Weather and Climate** • The foundation for Earth's global climate systems is the electromagnetic radiation from the sun, as well as its	of natural and designed objects and systems can be inferred from their overall structure, the way their components are shaped and used, and the molecular substructures of its various materials. (HS-ESS2-5) **Stability and Change** • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS3-5) **Connections to Engineering, Technology, and Applications of Science** Influence of Science, Engineering, and Technology on Society and the Natural World • New technologies can have deep impacts on society and the environment, including some that were not anticipated. Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ETS1-1)

for consistency, and the use of models to generate and analyze data. • Analyze data using computational models in order to make valid and reliable scientific claims. (HS-ESS3-5) **Asking Questions and Defining Problems** Asking questions and defining problems in 9–12 builds on K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Analyze complex real-world problems by specifying criteria and constraints for successful solutions. (HS-ETS1-1) **Connections to Nature of Science** **Scientific Knowledge is Based on Empirical Evidence** • Science arguments are strengthened by multiple lines of evidence supporting a single explanation. (HS-ESS2-4) • Science knowledge is based	reflection, absorption, storage, and redistribution among the atmosphere, ocean, and land systems, and this energy's re-radiation into space. (HS-ESS2-4) • Changes in the atmosphere due to human activity have increased carbon dioxide concentrations and thus affect climate. (HS-ESS2-4) **ESS3.D: Global Climate Change** • Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. (HS-ESS3-5) **ETS1.A: Defining and Delimiting Engineering Problems** • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (HS-ETS1-1)	

on empirical evidence. (HS-ESS3-5) **Scientific Investigations Use a Variety of Methods** ● Science investigations use diverse methods and do not always use the same set of procedures to obtain data. (HS-ESS3-5) ● New technologies advance scientific knowledge. (HS-ESS3- 5)	● Humanity faces major global challenges today, such as the need for supplies of clean water and food or for energy sources that minimize pollution, which can be addressed through engineering. These global challenges also may have manifestations in local communities. (HS-ETS1-1)	

Enduring Understandings:

- Variations in the flow of energy into and out of Earth's systems have a direct impact on climate and can result in changes over time (HS-ESS2-4).
- Water possesses unique properties that influence Earth materials and surface processes, playing a crucial role in shaping the planet's features (HS-ESS2-5).
- Geoscience data and climate models provide valuable insights to make evidence-based forecasts regarding the current rate of global or regional climate change and predict associated impacts on Earth systems (HS-ESS3-5).
- Analyzing major global challenges requires

Essential Questions:

- How does the variation in the flow of energy into and out of Earth's systems drive changes in climate patterns and conditions? (HS-ESS2-4)
- What are the properties of water that contribute to its effects on Earth materials and surface processes, and how do these properties shape the planet's landscapes? (HS-ESS2-5)
- How can we use geoscience data and global climate models to analyze and forecast the current rate of climate change and predict future impacts on Earth systems? (HS-ESS3-5)
- When addressing a major global challenge, how do we identify and specify the qualitative and quantitative criteria and constraints for solutions that meet societal needs and wants? (HS-ETS1-1)

identifying qualitative and quantitative criteria and constraints for solutions that effectively address societal needs and wants (HS-ETS1-1).	
Students will know: ○ Collection & interpretation of weather & climate data relates to biomes, atmospheric & oceanic circulation are affected ○ Natural global climate change ○ Global climate change as driven by the carbon cycle ○ Collection & interpretation of data to forecast global climate change	**Students will be able to:** ○ Using previous climate change information, students will predict future changes to Earth's surface and the resulting climate changes ○ Construct models incorporating various forms of technology using data obtained from various resources ○ Design and carry out scientific investigations ○ Communicate and defend a scientific argument
Assessment Evidence	
Suggested Performance Tasks: ○ Ice Cores: Exploring the History of Climate Change ○ TOTE ○ Biomes Activity- Cities	**Required District/State Assessments:** ○ District marking period assessments ○ SGO assessments **Suggested Formative/Summative Assessments:** ○ Lab/activity report ○ Practice Worksheets ○ Section Quizzes ○ Chapter Tests ○ Short/extended constructed response items from ELA NJGPA/NJSLA and Science NJSLA ○ Projects ○ Journals

	○ Observation ○ Graphic organizers/concept mapping ○ Presentations ○ Warmups / exit tickets

Learning Plan

Learning Activities:

- Online demonstration videos
- In class demonstration
- Guided readings on background and procedures
- Case studies

Related Standards

Interdisciplinary connections

- ELA
  - ⇒ WHST.9-10.1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant sufficient textual and non-textual evidence.
    - A. Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence.
    - B. Develop claim(s) and counterclaims using sound reasoning, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience's knowledge level and concerns.
    - C. Use transitions (e.g. words, phrases, clauses) to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.
    - D. Establish and maintain a style and tone appropriate to the audience and purpose (e.g. formal

and objective for academic writing) while attending to the norms and conventions of the discipline in which they are writing.

E. Provide a concluding paragraph or section that supports the argument presented.

- ⇒ WHST.9-10.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
  - Example: Carbon footprint activity. Students will complete the carbon footprint activity that uses information collected from each student to generate their individual level of carbon use. Each student will write a pledge describing their current impacts on the environment, which steps they will take to reduce their own footprint and how they plan on accomplishing them.
- ⇒ WHST.9-10.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

- Math
  - ⇒ HSN.Q.A.1 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.
  - ⇒ HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
  - ⇒ HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

<u>21st Century Skills (NJSLS Career Readiness, Life Literacies, and Key Skills - Technology Literacy)</u>

- 9.4.12.CT.1: Identify problem-solving strategies used in the development of an innovative product or practice (e.g., 1.1.12acc.C1b, 2.2.12.PF.3).
  - ⇒ Example: Students will research how mobile phones are used in the collection of seismic data in high frequency earthquake locations, students will then propose a creative use for cell phones in tracking other climate or weather events and present their ideas to their peers.

<u>NJ SEL Competencies</u>

- Responsible Decision-Making: Evaluate personal, ethical, safety and civic impact of decisions
- Self-Awareness: Recognize the importance of self-confidence in handling daily tasks and challenges

Culturally Relevant Connections	
○ Highlight the field contributions of Pancheti Koteswaram and Atsumu Ohmura ○ Encourage Student Leadership: Create an avenue for students to propose problem solving strategies and potential projects. ⇒ Example: Students can deepen their understanding of engineering criteria and constraints by creating design challenges together and deciding if the problems fit the necessary criteria. This experience will allow students to discuss and explore their current level of understanding by applying the concepts to relevant real-life experiences.	
Accommodations	
Special Education/ 504/ At Risk Students Accommodations & Modifications: ○ Peer tutoring ○ Extended time ○ Timelines with due dates ○ Adequate wait time ○ Frequent breaks, if needed ○ Brief and concrete directions ○ Graphic organizers ○ Note taking assistance ○ Study guides ○ Emphasize multi-sensory learning	**ELL:** ○ Graphic organizers ○ Cooperative learning structures, such as Think-Pair-Share ○ Word banks ○ Sentence Starters ○ Pictures
Enrichment	
○ Extended learning goals: ⇒ Research the projected temperature for two different cities for 10 days. You may look up weather.com to help you with the 10 day forecast. Analyze the data and make at least 3 graphs that will portray the different weather patterns for the two cities. ⇒ Investigate how axial tilt affects how the Sun's rays strike Earth and create seasons. Create a presentation explaining how a change in the axial tilt could affect weather and climate for a biome?	

Unit 5: Energy
Desired Outcomes
Established Goals: NJSLS Physical Science (PS): ○ HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known. [Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.] [Assessment Boundary : Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy , kinetic energy , and/or the energies in gravitational, magnetic, or electric fields.] ○ 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). [Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy , the energy stored due to position of an object above the earth, and the energy stored between two electrically -charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.] ○ HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.* [Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include the use of renewable energy forms and efficiency .] [Assessment Boundary : Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.] ○ HS-PS2-5 Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current. [Assessment Boundary: Assessment is limited to designing and conducting investigations with provided materials and tools.]

Science and Engineering Practices	*Disciplinary Core Ideas*	*Crosscutting Concepts*
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-2) **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.	**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 modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative	**Systems and System Models** • Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HS-PS3-1) **Energy and Matter** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HS-PS3-3) • Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2) **Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-5)

● Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-PS3-1) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 9– 12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. ● Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS3-3) **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	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) ● Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the	**Connections to Engineering, Technology, and Applications of Science** Influence of Science, Engineering, and Technology on Society and the Natural World ● Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS3-3) **Connections to Nature of Science** Scientific Knowledge Assumes an Order and Consistency in Natural Systems ● Science assumes the universe is a vast single system in which basic laws are consistent. (HS-PS3-1)

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)	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) **PS3.D: Energy in Chemical Processes** • Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3) **PS2.B: Types of Interactions** • Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-5)	

Enduring Understandings:

- Energy can be modeled and calculated using computational models, allowing us to understand the changes in energy within a system.
- Energy at the macroscopic scale can be explained by considering both the motion of particles and the relative positions of particles.
- Devices can be designed and refined to convert one form of energy into another, and their effectiveness can be evaluated qualitatively and quantitatively.
- Electric currents and changing magnetic fields are interconnected phenomena, and they can produce each other through their interactions.

Essential Questions:

- How can computational models be used to calculate the change in energy within a system when energy flows in and out of the system are known? What are the mathematical expressions used in these models, and what do they represent?
- How can energy at the macroscopic scale be accounted for by considering the motions and relative positions of particles? What are some examples of phenomena that illustrate this relationship?
- How can devices be designed and refined to convert one form of energy into another? What constraints need to be considered, and how can the efficiency of these devices be evaluated?
- What evidence supports the connection between electric currents and magnetic fields? How can investigations be designed and conducted to demonstrate this relationship?

Students will know:

- Definition of work, including when it is positive, negative, or zero.
- How to apply the work-energy theorem.
- The concept of a conservative force.
- The concept of potential energy.
- The concepts of mechanical energy and of total energy.
- Conservation of energy.
- The definition of power.

Students will be able to:

- Calculate the work done by a specified constant force on an object that undergoes a specified displacement.
- Calculate the change in kinetic energy or speed that results from performing a specified amount of work on an object.
- Calculate the work performed by the net force, or by each of the forces that make up the net force on an object that undergoes a specified change in

	speed or kinetic energy. ○ Recognize and solve problems that call for application of both conservation of energy and Newton's Laws.
Assessment Evidence	
<u>Suggested Performance Tasks:</u> ○ Lab calculations and manipulations	**<u>Required District/State Assessments:</u>** ○ District marking period assessments ○ SGO assessments **<u>Suggested Formative/Summative Assessments:</u>** ○ Lab/activity report ○ Practice Worksheets ○ Section Quizzes ⇒ Work and Energy Quiz ⇒ Power Quiz ○ Chapter Tests ⇒ Energy Test ○ Short/extended constructed response items from ELA NJGPA/NJSLA and Science NJSLA ○ Projects ○ Journals ○ Observation ○ Graphic organizers/concept mapping ○ Presentations ○ Warmups / exit tickets
Learning Plan	

Learning Activities:

- In class demonstrations
- Collaborative problem solving
- Jigsaw activity
- Integrated formative assessment classroom polling

Related Standards

Interdisciplinary connections

- ELA
  - ⇒ WHST.9-10.1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant sufficient textual and non-textual evidence.
    - A. Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence.
    - B. Develop claim(s) and counterclaims using sound reasoning, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience's knowledge level and concerns.
    - C. Use transitions (e.g. words, phrases, clauses) to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.
    - D. Establish and maintain a style and tone appropriate to the audience and purpose (e.g. formal and objective for academic writing) while attending to the norms and conventions of the discipline in which they are writing.
    - E. Provide a concluding paragraph or section that supports the argument presented.
  - ⇒ WHST.9-10.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
  - ⇒ WHST.9-10.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

- ⇒ WHST.9-10.6. Use technology, including the Internet, to produce, share, and update writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.
- Math
  - ⇒ HSN.Q.A.1 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.
  - ⇒ HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
    - Examples: Students will use aspects of the electromagnetic spectrum to determine the specific wavelengths used in the visible light spectrum and how they interact with earth systems.
  - ⇒ HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

Technology (NJSLS Computer Science and Design Thinking)

- 8.1.12.DA.1: Create interactive data visualizations using software tools to help others better understand real world phenomena, including climate change.
  - ⇒ Example: Using a Digital graphing application, students will depict the inverse relationship that exists between frequency and wavelength when investigating the Electromagnetic Spectrum

NJ SEL Competencies

- Self-Management: Understand and practice strategies for managing one's own emotions, thoughts and behaviors
- Self-Awareness: Recognize the importance of self-confidence in handling daily tasks and challenges

Culturally Relevant Connections

- Present New Concepts Using Student Vocabulary: Use student diction to capture attention and build understanding before using academic terms.
  - ⇒ Example: Teach science vocabulary in various modalities for students to remember. Use multi-modal activities, analogies, realia, visual cues, graphic representations, gestures, pictures and cognates. Directly explain and model the idea of vocabulary words having multiple meanings. Students can

create the Word Wall with their definitions and examples to foster ownership.

Accommodations

Special Education/ 504/ At Risk Students Accommodations & Modifications:	**ELL:**
○ Peer tutoring ○ Extended time ○ Timelines with due dates ○ Adequate wait time ○ Frequent breaks, if needed ○ Brief and concrete directions ○ Graphic organizers ○ Note taking assistance ○ Study guides ○ Emphasize multi-sensory learning	○ Graphic organizers ○ Cooperative learning structures, such as Think-Pair-Share ○ Wordbanks ○ Sentence Starters ○ Pictures

Enrichment

- Extended learning goals:
  - ⇒ Solar Cell Energy Nationwide (Activity Source: Adapted with permission by NASA): In this activity, students use NASA data to determine areas of the country that are most likely to produce solar energy by analyzing differences in incoming solar radiation graphs. See NASA.gov for the activity.

Unit 6: Human Sustainability

Desired Outcomes

<u>Established Goals: NJSLS</u>

Earth and Space Sciences (ESS)

- HS-ESS3-1 Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.
- HS-ESS3-2 Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios.
- HS-ESS3-3 Create a computational simulation to illustrate the relationships among management of natural resources, the sustainability of human populations, and biodiversity.
- HS-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on climate change and other natural systems.
- HS-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity (i.e., climate change).

Engineering, Technology, and Applications of Science (ETS)

- HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Science and Engineering Practices	***Disciplinary Core Ideas***	***Crosscutting Concepts***
Using Mathematics and Computational Thinking Mathematical and computational thinking in 9-12 builds on K-8	**ESS2.D: Weather and Climate** ● Current models predict that, although future regional climate changes will be	**Cause and Effect** ● Empirical evidence is required to differentiate between cause and

experiences and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-ESS3-3) • Use a computational representation of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-ESS3-6) **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	complex and varied, average global temperatures will continue to rise. The outcomes predicted by global climate models strongly depend on the amounts of human-generated greenhouse gases added to the atmosphere each year and by the ways in which these gases are absorbed by the ocean and biosphere. (secondary to HS-ESS3-6) **ESS3.A: Natural Resources** • Resource availability has guided the development of human society. (HS-ESS3-1) • All forms of energy production and other resource extraction have associated economic, social, environmental, and geopolitical costs and risks as well as benefits. New technologies and social regulations can change the balance of these factors. (HS-ESS3-2) **ESS3.B: Natural Hazards** • Natural hazards and other geologic events have shaped	correlation and make claims about specific causes and effects. (HS-ESS3-1) **Systems and System Models** • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined and their inputs and outputs analyzed and described using models. (HS-ESS3-6) **Stability and Change** • Change and rates of change can be quantified and modeled over very short or very long periods of time. Some system changes are irreversible. (HS-ESS3-3) • Feedback (negative or positive) can stabilize or destabilize a system. (HS-ESS3-4) **Connections to Engineering, Technology, and Applications of Science** Influence of Engineering, Technology, and Science on Society and the Natural World • Modern civilization depends

scientific knowledge, principles, and theories. • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS3-1) • Design or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-ESS3-4),(HS-ETS1-2) **Engaging in Argument from Evidence** Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and	the course of human history; [they] have significantly altered the sizes of human populations and have driven human migrations. (HS-ESS3-1) **ESS3.C: Human Impacts on Earth Systems** • The sustainability of human societies and the biodiversity that supports them requires responsible management of natural resources. (HS-ESS3-3) • Scientists and engineers can make major contributions by developing technologies that produce less pollution and waste and that preclude ecosystem degradation. (HS-ESS3-4) **ESS3.D: Global Climate Change** • Through computer simulations and other studies, important discoveries are still being made about how the ocean, the atmosphere, and the biosphere interact and are modified in response to human activities. (HS-ESS3-6) **ETS1.C: Optimizing the Design**	on major technological systems. (HS-ESS3-1),(HSESS3-3) • Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HSESS3-2),(HS-ESS3-4) • New technologies can have deep impacts on society and the environment, including some that were not anticipated. (HS-ESS3-3) • Analysis of costs and benefits is a critical aspect of decisions about technology. (HS-ESS3-2) **Connections to Nature of Science** Science is a Human Endeavor • Science is a result of human endeavors, imagination, and creativity. (HS-ESS3-3) Science Addresses Questions About the Natural and Material World • Science and technology may raise ethical issues for which science, by itself, does not provide answers and solutions. (HS-ESS3-2)

designed world(s). Arguments may also come from current scientific or historical episodes in science. ● Evaluate competing design solutions to a real-world problem based on scientific ideas and principles, empirical evidence, and logical arguments regarding relevant factors (e.g. economic, societal, environmental, ethical considerations). (HS-ESS3-2)	**Solution** ● Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS-ETS1-2)	● Science knowledge indicates what can happen in natural systems—not what should happen. The latter involves ethics, values, and human decisions about the use of knowledge. (HS-ESS3-2) ● Many decisions are not made using science alone, but rely on social and cultural contexts to resolve issues. (HS-ESS3-2)

Enduring Understandings:

- Human activity is influenced by the availability of natural resources, natural hazards, and changes in climate, which can have significant impacts on societies and ecosystems.
- Evaluating competing design solutions for energy and mineral resource development requires considering cost-benefit ratios to make informed decisions.
- The management of natural resources, the sustainability of human populations, and biodiversity are interconnected, and computational simulations can illustrate these relationships.
- Technological solutions can be evaluated and refined to mitigate the impacts of

Essential Questions:

- How does the availability of natural resources, occurrence of natural hazards, and changes in climate influence human activities and shape societies?
- How can competing design solutions for energy and mineral resource development be evaluated based on cost-benefit ratios? What factors should be considered in making these evaluations?
- How can computational simulations help illustrate the relationships among natural resource management, human population sustainability, and biodiversity? What insights can be gained from these simulations?
- How can technological solutions be evaluated and refined to minimize the impacts of human activities on climate change and other natural

human activities on climate change and other natural systems. ○ Human activity, particularly related to climate change, is modifying the relationships among Earth systems, and computational representations can illustrate these changes. ○ Complex real-world problems can be solved through engineering by breaking them down into smaller, more manageable problems.	systems? What considerations are important in this process? ○ How are human activities, particularly climate change, modifying the relationships among Earth systems? How can computational representations help illustrate these changes and inform decision-making? ○ How can complex real-world problems be effectively addressed through engineering? What strategies can be employed to break down these problems into smaller, more manageable components?
<u>Students will know:</u> ○ Interpreting data how availability of natural resources, occurring natural hazards and climate change have influenced human activity ○ Best management practices for resource mining and fossil fuels ○ Analyze data to determine relationships among natural resources, human populations & biodiversity ○ Using data to reduce the impact of human activities on natural systems ○ How human activity is affecting natural systems	**<u>Students will be able to:</u>** ○ Support a position using various sources of evidence ○ Diagram patterns of change both locally and globally ○ Research primary source documents pertaining to biodiversity, natural resources, and alternative energy sources ○ Design and construct models to provide solutions and evidence for current environmental issues ○ Design and carry out scientific investigations. ○ Communicate and defend a scientific argument.
Assessment Evidence	
<u>Suggested Performance Tasks:</u> ○ TOTE ○ Rolling blackouts &	**<u>Required District/State Assessments:</u>** ○ District marking period assessments ○ SGO assessments

○ Environmental Impacts ○ Patterns of Natural Resources at ○ Dig Into Mining.com ○ Research Project: Mining Practices ○ Alternative Energies- Windmill Project	**Suggested Formative/Summative Assessments:** ○ Lab/activity report ○ Practice Worksheets ○ Section Quizzes ○ Chapter Tests ○ Short/extended constructed response items from ELA NJGPA/NJSLA and Science NJSLA ○ Projects ○ Journals ○ Observation ○ Graphic organizers/concept mapping ○ Presentations ○ Warmups / exit tickets

Learning Plan

Learning Activities:

- Online demonstration videos
- In class demonstration
- Guided readings on background and procedures
- Case studies
- The Tragedy of the Commons - Goldfish Activity

Related Standards

Interdisciplinary connections

- ELA
  - ⇒ WHST.9-10.1. Write arguments to support claims in an analysis of substantive topics or texts, using valid

reasoning and relevant sufficient textual and non-textual evidence.

A. Introduce precise claim(s), distinguish the claim(s) from alternate or opposing claims, and create an organization that establishes clear relationships among the claim(s), counterclaims, reasons, and evidence.

B. Develop claim(s) and counterclaims using sound reasoning, supplying data and evidence for each while pointing out the strengths and limitations of both claim(s) and counterclaims in a discipline-appropriate form and in a manner that anticipates the audience's knowledge level and concerns.

C. Use transitions (e.g. words, phrases, clauses) to link the major sections of the text, create cohesion, and clarify the relationships between claim(s) and reasons, between reasons and evidence, and between claim(s) and counterclaims.

D. Establish and maintain a style and tone appropriate to the audience and purpose (e.g. formal and objective for academic writing) while attending to the norms and conventions of the discipline in which they are writing.

E. Provide a concluding paragraph or section that supports the argument presented.

⇒ WHST.9-10.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.

⇒ WHST.9-10.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.

⇒ WHST.9-10.6. Use technology, including the Internet, to produce, share, and update writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.

- Math
  - ⇒ HSN.Q.A.1 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.
  - ⇒ HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
  - ⇒ HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.
    - Example: Human population Distribution activity. Students will use current population totals and population distribution graphs to correlate the Environmental impact in a given area to its population demographic.

Career Readiness, Life Literacies, and Key Skills

- 9.4.12.GCA.1: Collaborate with individuals to analyze a variety of potential solutions to climate change effects and determine why some solutions (e.g., political. economic, cultural) may work better than others (e.g., SL.11-12.1., HS-ETS1-1, HS-ETS1-2, HS-ETS1-4, 6.3.12.GeoGI.1, 7.1.IH.IPERS.6, 7.1.IL.IPERS.7, 8.2.12.ETW.3).
  - ⇒ In collaborative groups, students work together to analyze the economic and cultural impact of energy conservation as a climate change solution.

NJ SEL Competencies

- Self-Management: Understand and practice strategies for managing one's own emotions, thoughts and behaviors
- Self-Awareness: Recognize the importance of self-confidence in handling daily tasks and challenges

Climate Change

- Khan Academy: Energy Conservation Methods - Students explore energy conservation as a climate change solution at a personal and societal level.

Culturally Relevant Connections

- Use frequent questioning as a means to keep students involved
- Intentionally address visual, tactile, and auditory learners
- Present relatable real world problems

Accommodations

Special Education/ 504/ At Risk Students Accommodations & Modifications:	ELL:
○ Peer tutoring ○ Extended time	○ Graphic organizers ○ Cooperative learning structures, such as Think-Pair-Share

○ Timelines with due dates ○ Adequate wait time ○ Frequent breaks, if needed ○ Brief and concrete directions ○ Graphic organizers ○ Note taking assistance ○ Study guides ○ Emphasize multi-sensory learning	○ Word banks ○ Sentence Starters ○ Pictures

Enrichment

- Extended learning goals:
  - ⇒ Conservation in Action (Activity Source: U.S. Fish and Wildlife Service. Adapted with permission): "The more clearly we can focus our attention on the wonders and realities of the universe about us, the less taste we shall have for destruction." --Rachel Carson, 1954. The second full week of October is not only Earth Science Week—it is also National Wildlife Refuge Week! During this time, you are encouraged to consider the legacy of Rachel Carson, an early leader in the environmental conservation movement, and the resource management activities of the U.S. Fish and Wildlife Service (FWS). The following activity is aligned with the National Science Education Standards and offers cross-curricular opportunities to integrate science and English. You may want to set aside some extra time for reading and research. You may also want to visit a national fish hatchery or national wildlife refuge to make the most of this learning opportunity.

Unit 7: Forces and Interaction at Earth's Surface

Desired Outcomes

Established Goals: NJSLS

Physical Sciences (PS):

- HS-PS2-1 Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. [Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.] [Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.]
- HS-PS2-2 Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system. [Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.] [Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension.]
- HS-PS2-3 Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.* [Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.] [Assessment Boundary: Assessment is limited to qualitative evaluations and/or algebraic manipulations.]

Science and Engineering Practices	*Disciplinary Core Ideas*	*Crosscutting Concepts*
Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8	**PS2.A: Forces and Motion** ● Newton's second law	**Cause and Effect** ● Empirical evidence is

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	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)	required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2- 1) • 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)

explanations. (HS-PS2-2) **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) **Connections to Nature of Science** Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena ● Theories and laws provide explanations in science. (HS-PS2- 1) ● Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1), (HS-PS2-4)		

Enduring Understandings:	**Essential Questions:**
○ Newton's second law of motion describes the relationship between the net force acting on a macroscopic object, its mass, and its acceleration. ○ Analysis of data, such as position or velocity as a function of time, can provide evidence to support the claim that Newton's second law accurately describes the motion of objects subjected to a net unbalanced force. ○ The total momentum of a system of objects remains conserved when there is no net force acting on the system. ○ Mathematical representations can be used to support the claim of momentum conservation in interactions between objects, both quantitatively and qualitatively. ○ Scientific and engineering concepts can be applied to design, evaluate, and refine devices that minimize the force on a macroscopic object during a collision. ○ Evaluation and refinement of devices involve assessing their success in protecting objects from damage and making design modifications for improvement.	● How does Newton's second law of motion mathematically relate the net force, mass, and acceleration of a macroscopic object? What is the significance of each variable? ● How can data analysis, such as position or velocity as a function of time, support the claim that Newton's second law accurately describes the motion of objects under the influence of a net unbalanced force? ● What does it mean for the total momentum of a system of objects to be conserved when there is no net force acting on the system? How can this conservation be supported by mathematical representations? ● How do quantitative and qualitative approaches contribute to understanding and explaining the principle of momentum conservation in interactions between macroscopic objects? ● How can scientific and engineering ideas be applied to the design process of devices aimed at minimizing the force on a macroscopic object during a collision? ● What criteria can be used to evaluate the success of such devices in protecting objects from damage, and how can their design be refined based on evaluation results?
Students will know: ○ How to apply the concept of inertia to determine the motion of an object experiencing a net force	**Students will be able to:** ○ Relate force, mass and acceleration using Newton's Second Law.

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and zero net force.
○ Describe inertia using Newton’s First Law.
○ How to solve problems using Newton’s Second Law.
○ How to solve problems by drawing a free body diagram, determining the forces present.
○ How to identify all the different types of force present in a problem.
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○ Algebraically manipulate and utilize the following equations: $\Sigma F = ma$
○ Identify the following forces and illustrate their relative magnitudes and directions when problem solving:
■ Applied Force
■ Normal Force
■ Weight (Gravitational Force)
■ Apparent Weight
■ Tension
■ Friction (Kinetic and Static)
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<tr>
<th colspan="2">Assessment Evidence</th>
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<u>Suggested Performance Tasks:</u>
○ Lab calculations and manipulations
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<u>Required District/State Assessments:</u>
○ District marking period assessments
○ SGO assessments

<u>Suggested Formative/Summative Assessments:</u>
○ Lab/activity report
○ Practice Worksheets
○ Section Quizzes
⇒ Mass and weight quiz
⇒ Newtons second law quiz
○ Chapter Tests
⇒ Forces and Interactions at Earth’s Surface Unit Test
○ Short/extended constructed response items from ELA NJGPA/NJSLA and Science NJSLA
○ Projects
○ Journals
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	○ Observation ○ Graphic organizers/concept mapping ○ Presentations ○ Warmups / exit tickets

Learning Plan

Learning Activities:

- In class demonstrations
- Collaborative problem solving
- Jigsaw activity
- Integrated formative assessment classroom polling

Related Standards

Interdisciplinary connections

- ELA
  - ⇒ WHST.9-10.1. Write arguments to support claims in an analysis of substantive topics or texts, using valid reasoning and relevant sufficient textual and non-textual evidence.
  - ⇒ WHST.9-10.4. Produce clear and coherent writing in which the development, organization, and style are appropriate to task, purpose, and audience.
  - ⇒ WHST.9-10.5. Develop and strengthen writing as needed by planning, revising, editing, rewriting, or trying a new approach, focusing on addressing what is most significant for a specific purpose and audience.
  - ⇒ WHST.9-10.6. Use technology, including the Internet, to produce, share, and update writing products, taking advantage of technology's capacity to link to other information and to display information flexibly and dynamically.
- Math
  - ⇒ HSN.Q.A.1 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.

- Example: Students will use F=ma to determine forces applied on objects in a system, then using the acquired knowledge of force in a system apply M1V1=M2V2 to determine transfer of motion.

⇒ HSN.Q.A.2 Define appropriate quantities for the purpose of descriptive modeling.
⇒ HSN.Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities.

NJ SEL Competencies

- Self-Management: Understand and practice strategies for managing one's own emotions, thoughts and behaviors
- Self-Awareness: Recognize the importance of self-confidence in handling daily tasks and challenges

Culturally Relevant Connections

- Highlight the contributions of Dr. Chien-Shiung Wu and Marie Curie
- Create lessons that connect the content to your students' culture and daily lives.
- Incorporate instructional materials that relate to a variety of cultures
- Instructional Delivery:
- Establish an interactive dialogue to engage all students
- Continuously interact with students and provide frequent feedback

Accommodations

Special Education/ 504/ At Risk Students Accommodations & Modifications:

- Peer tutoring
- Extended time
- Timelines with due dates
- Adequate wait time
- Frequent breaks, if needed
- Brief and concrete directions

ELL:

- Graphic organizers
- Cooperative learning structures, such as Think-Pair-Share
- Wordbanks
- Sentence Starters
- Pictures

○ Graphic organizers ○ Note taking assistance ○ Study guides ○ Emphasize multi-sensory learning	

Enrichment
○ Extended learning goals: ⇒ Finding Slope (Source: Soil Science Society of America): In this activity students will use a Clinometer or Abney level to determine the slope of landscapes around them. Students will determine the best usage or development for the property.

Appendix A: Culturally Relevant Pedagogy Examples

BUILDING EQUITY IN YOUR TEACHING PRACTICE

How do the essential questions highlight the connection between the big ideas of the unit and equity in your teaching practice?

CONTENT INTEGRATION	KNOWLEDGE CONSTRUCTION	PREJUDICE REDUCTION	EQUITABLE PEDAGOGY	EMPOWERING SCHOOL CULTURE
Teachers use examples and content from a variety of cultures & groups.	Teachers help students understand how knowledge is created and influenced by cultural assumptions, perspectives & biases.	Teachers implement lessons and activities to assert positive images of ethnic groups & improve intergroup relations.	Teachers modify techniques and methods to facilitate the academic achievement of students from diverse backgrounds.	Using the other four dimensions to create a safe and healthy educational environment for all.
This unit / lesson is connected to other topics explored with students. There are multiple viewpoints reflected in the content of this unit / lesson. The materials and resources are reflective of the diverse identities and experiences of students. The content affirms students, as well as exposes them to experiences other than their own.	This unit / lesson provides context to the history of privilege and oppression. This unit / lesson addresses power relationships. This unit / lesson help students to develop research and critical thinking skills. This curriculum creates windows and mirrors* for students.	This unit / lesson help students question and unpack biases & stereotypes. This unit / lesson help students examine, research and question information and sources. The curriculum encourage discussion and understanding about the groups of people being represented. This unit / lesson challenges dominant perspectives.	The instruction has been modified to meet the needs of each student. Students feel respected and their cultural identities are valued. Additional supports have been provided for students to become successful and independent learners. Opportunities are provided for student to reflect on their learning and provide feedback.	There are opportunities for students to connect with the community. My classroom is welcoming and supportive for all students? I am aware of and sensitive to the needs of my students and their families. There are effective parent communication systems established. Parents can talk to me about issues as they arise in my classroom.

Developed by Karla E. Vigil. Adapted with permission from James A. Banks, CULTURAL DIVERSITY AND EDUCATION: FOUNDATIONS, CURRICULUM, AND TEACHING (6th edition). New York: Routledge, 2016, page 5 and Gordon School Institute on Multicultural Practice.

Appendix B: English Language Learners

WIDA Levels:

At the given level of English language proficiency, English language learners will process, understand, produce or use

6- Reaching	• Specialized or technical language reflective of the content areas at grade level • A variety of sentence lengths of varying linguistic complexity in extended oral or written discourse as required by the specified grade level • Oral or written communication in English comparable to proficient English peers
5- Bridging	• Specialized or technical language of the content areas • A variety of sentence lengths of varying linguistic complexity in extended oral or written discourse, including stories, essays or reports • Oral or written language approaching comparability to that of proficient English peers when presented with grade level material.
4- Expanding	• Specific and some technical language of the content areas • A variety of sentence lengths of varying linguistic complexity in oral discourse or multiple, related sentences or paragraphs • Oral or written language with minimal phonological, syntactic or semantic errors that may impede the communication, but retain much of its meaning, when presented with oral or written connected discourse, with sensory, graphic or interactive support
3- Developing	• General and some specific language of the content areas • Expanded sentences in oral interaction or written paragraphs • Oral or written language with phonological, syntactic or semantic errors that may impede the communication, but retain much of its meaning, when presented with oral or written, narrative or expository descriptions with sensory, graphic or interactive support
2- Beginning	• General language related to the content area • Phrases or short sentences • Oral or written language with phonological, syntactic, or semantic errors that often impede of the communication when presented with one to multiple-step commands, directions, or a series of statements with sensory, graphic or interactive support
1- Entering	• Pictorial or graphic representation of the language of the content areas • Words, phrases or chunks of language when presented with one-step commands directions, WH-, choice or yes/no questions, or statements with sensory, graphic or interactive support

Language Development Supports For English Language Learners To Increase Comprehension and Communication Skills

Environment

- Welcoming and stress-free
- Respectful of linguistic and cultural diversity
- Honors students' background knowledge
- Sets clear and high expectations
- Includes routines and norms
- Is thinking-focused vs. answer-seeking
- Offers multiple modalities to engage in content learning and to demonstrate understanding
- Includes explicit instruction of specific language targets
- Provides participation techniques to include all learners
- Integrates learning centers and games in a meaningful way
- Provides opportunities to practice and refine receptive and productive skills in English as a new language
- Integrates meaning and purposeful tasks/activities that:
  - Are accessible by all students through multiple entry points
  - Are relevant to students' lives and cultural experiences
  - Build on prior mathematical learning
  - Demonstrate high cognitive demand
  - Offer multiple strategies for solutions
  - Allow for a language learning experience in addition to content

Sensory Supports*	Graphic Supports*	Interactive Supports*	Verbal and Textual Supports
• Real-life objects (realia) or concrete objects • Physical models • Manipulatives • Pictures & photographs • Visual representations or models such as diagrams or drawings • Videos & films • Newspapers or magazines • Gestures • Physical movements • Music & songs	• Graphs • Charts • Timelines • Number lines • Graphic organizers • Graphing paper	• In a whole group • In a small group • With a partner such as *Turn-and-Talk* • In pairs as a group (first, two pairs work independently, then they form a group of four) • In triads • Cooperative learning structures such as *Think-Pair-Share* • Interactive websites or software • With a mentor or coach	• Labeling • Students' native language • Modeling • Repetitions • Paraphrasing • Summarizing • Guiding questions • Clarifying questions • Probing questions • Leveled questions such as *What? When? Where? How? Why?* • Questioning prompts & cues • Word Banks • Sentence starters • Sentence frames • Discussion frames • Talk moves, including *Wait Time*

*from *Understanding the WIDA English Language Proficiency Standards. A Resource Guide*. 2007 Edition.. Board of Regents of the University of Wisconsin System, on behalf of the WIDA Consortium—www.wida.us.

Galina (Halla) Jmourko, ESOL Coach, PGCPS; 2015, Rvsd. 2016

Appendix C: WIDA ELD Standards Integration

ELD-SC 9-12 Explain Interpretive	Interpret scientific explanations by • Defining investigable questions or problems based on observations, information, and/or data about a phenomenon • Paraphrasing central ideas in complex evidence, concepts, processes, and information to help explain how or why a phenomenon occurs • Evaluating the extent to which reasoning, theory and/or models link evidence to claims and support conclusions
ELD-SC 9-12 Explain Expressive	Construct scientific explanations that • Describe reliable and valid evidence from multiple sources about a phenomenon • Establish neutral or objective stance in how results are communicated • Develop reasoning to illustrate and/ or predict the relationships between variables in a system or between components of a system • Summarize and refine solutions referencing scientific knowledge, evidence, criteria, and/or trade-offs
ELD-SC.9-12 Argue Interpretive	Interpret scientific arguments by • Identifying appropriate and sufficient evidence from data, models, and/ or information from investigations of a phenomenon or design solutions • Comparing reasoning and claims based on evidence from competing arguments or design solutions • Evaluating currently accepted explanations, new evidence, limitations (trade-offs), constraints, and ethical issues
ELD-SC.9-12 Argue Expressive	Construct scientific arguments that • Introduce and contextualize topic/ phenomenon in current scientific or historical episodes in science • Defend or refute a claim based on data and evidence • Establish and maintain an appropriate tone and stance (neutral/objective or biased/subjective) • Signal logical relationships among reasoning, evidence, data, and/or models when making and defending a claim, counterclaim, and/or rebuttal

Appendix D: Differentiated Instruction

Strategies to accommodate based on student individual needs::

1. Time/General
   a. Extra time for assigned tasks
   b. Adjust length of assignment
   c. Timeline with due dates for reports and projects
   d. Communication system between home and school
   e. Provide lecture notes/outline

2. Processing
   a. Extra Response time
   b. Have students verbalize steps
   c. Repeat, clarify or reword directions
   d. Mini-breaks between tasks
   e. Provide a warning for transitions
   f. Partnering

3. Comprehension
   a. Precise processes for balanced math instructional model
   b. Short manageable tasks
   c. Brief and concrete directions
   d. Provide immediate feedback
   e. Small group instruction
   f. Emphasize multi-sensory learning

4. Recall
   a. Teacher-made checklist
   b. Use visual graphic organizers
   c. Reference resources to
   d. promote independence
   e. Visual and verbal reminders
   f. Graphic organizers

5. Assistive Technology
   a. Computer/whiteboard
   b. Tape recorder
   c. Video Tape

6. Tests/Quizzes/Grading
   a. Extended time
   b. Study guides
   c. Shortened tests
   d. Read directions aloud

7. Behavior/Attention
   a. Consistent daily structured routine
   b. Simple and clear classroom rules
   c. Frequent feedback

8. Organization
   a. Individual daily planner
   b. Display a written agenda
   c. Note-taking assistance
   d. Color code materials

Appendix E: Enrichment

What is the purpose of enrichment?

The purpose of enrichment is to provide extended learning opportunities and challenges to students who have already mastered, or can quickly master, the basic curriculum. Enrichment gives the student more time to study concepts with greater depth, breadth, and complexity.

- Enrichment also provides opportunities for students to pursue learning in their own areas of interest and strengths.
- Enrichment keeps advanced students engaged and supports their accelerated academic needs.
- Enrichment provides the most appropriate answer to the question, “What do you do when the student already knows it?”

Enrichment is ...	**Enrichment is not...**
• Planned and purposeful • Different, or differentiated, work – not just more work • Responsive to students’ needs and situations • A promotion of high-level thinking skills and making connections within content • The ability to apply different or multiple strategies to the content • The ability to synthesize concepts and make real world and cross curricular connections • Elevated contextual complexity • Sometimes independent activities, sometimes direct instruction • Inquiry based or open-ended assignments and projects • Using supplementary materials in addition to the normal range of resources • Choices for students • Tiered/Multi-level activities with flexible groups (may change daily or weekly)	• Just for gifted students (some gifted students may need intervention in some areas just as some other students may need frequent enrichment) • Worksheets that are more of the same (busywork) • Random assignments, games, or puzzles not connected to the content areas or areas of student interest • Extra homework • A package that is the same for everyone • Thinking skills taught in isolation • Unstructured free time

Appendix F: Resources

Textbook:

Earth Science, Holt McDougal, First edition, 2010, Authors: Allison, DeGaetano, Pasachoff.

Environmental Science, Holt McDougal, First Edition, 2006, Authors: Rinehart, Winston.

Appendix G: Climate Change Curriculum Statement

With the adoption of the 2020 New Jersey Student Learning Standards (NJSLS), New Jersey became the first state in the nation to include climate change across content areas. These standards are designed to prepare students to understand how and why climate change happens, the impact it has on our local and global communities and to act in informed and sustainable ways.

Districts are encouraged to utilize the NJSLS to develop interdisciplinary units focused on climate change that include authentic learning experiences, integrate a range of perspectives and are action oriented. While the 2016 NJSLS-English Language Arts (ELA) and Mathematics do not have specific climate change standards, districts may want to consider how they can design interdisciplinary climate change units that incorporate relevant ELA and mathematics standards.

Components of this are tagged throughout the curriculum as appropriate under the “Related Standards” section in each unit.