Burlington County Institute of Technology

Medford Campus | Westampton Campus

Physics

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

Course Description

Physics is a science that studies matter and energy and their interactions. Through guided, cooperative, and independent inquiry-based activities, students apply their understanding of kinematics, energy, and waves by designing experiments, evaluating data, and engineering solutions to solve real-world problems. Additionally, physics requires students to effectively communicate their claims and evidence to a variety of audiences. It exposes students to additional college and career opportunities in science, technology, engineering and math (STEM) fields. These skills and opportunities will make our students productive citizens in the 21st century.

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Pacing Guide

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Unit 1 – Motion (Kinematics)	HS-PS2-1, 3	Weeks 1-4
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Unit 3 – Energy	HS-PS3-1, 2, 3, 4, 5	Weeks 9-12
Unit 4 – Electricity/ Magnetism	HS-PS1-3 HS-PS2-4, 5 HS-PS3-1, 2, 3, 5 HS-PS4-1, 3	Weeks 13-15
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Curriculum Maps

Unit 1: Motion (Kinematics)
Desired Outcomes

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.
- 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.

Established Goals

- Students use multiple representations of one and two dimensional motion to analyze the changes in motion of a system and to make predictions.

Science and Engineering Practices	***Disciplinary Core Ideas***	***Crosscutting Concepts***
Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models	**PS2.A: Forces and Motion** • Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1) • If a system interacts with objects outside itself, the total momentum of the system can change; however, any	**Cause and Effect** • Empirical evidence is 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.

(e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-PS2-1) **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. • 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),(HS-PS2-4) • Laws are statements or descriptions of the	such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-3)	(HS-PS2-3)

relationships among observable phenomena. (HS-PS2-1),(HS-PS2-4)		

Enduring Understandings:

- An object's motion in one dimension can be expressed and analyzed using multiple representations
- Motion is relative to its observer
- Kinematics describe the motion of all objects
- Constant velocity in one dimension is a result of zero acceleration

Essential Questions:

- How can you tell an object is moving?
- How can a person be still, moving at constant velocity and accelerating at the same time?
- How can you predict the motion or changes of motion of an object?
- What factors affect the rate of motion?
- How can we determine if we have enough time to get from point A to point B?

Students will know:

- Newton's laws predict the motion of most objects.
- Students know how to solve problems that involve constant speed and average speed.
- Students know that when forces are balanced, no acceleration occurs; thus an object continues to move at a constant speed or stays at rest (Newton's first law).
- Students know how to apply the law F=ma to solve one-dimensional motion problems that involve constant forces (Newton's second law).

Students will be able to:

- Use multiple representations (e.g., diagrams, charts, graphs, mathematical, verbal, written) to prove scenarios in terms of kinematics.
- Differentiate between the physical quantities of position, displacement, distance and path length, velocity and speed, acceleration and time (both clock readings and time intervals), and the use of reference frames as an indicator for a particular motion; analyze data from a moving system to draw conclusions;
- Derive a mathematical representation of the motion of a system from velocity vs. time and acceleration vs. time graphs;

	- Apply concepts of graphical and mathematical representations to predict the position or motion of a system; - Analyze dot diagrams, motion diagrams, tables, position vs. time graphs, and velocity vs. time graphs; - Compare indices and rates to justify which ratio is fastest, steepest, etc. - Differentiate between a vector quantity and a scalar quantity and give examples of each.
Assessment Evidence	
Suggested Performance Tasks: - The Physics 500: Students design and perform an experiment to solve a problem citing evidence in order to analyze the motion and to predict the changes in motion relative to a specific frame of reference. (Engineering Practice) - Solving a real world problem: Do we have enough time to get from point A to point B? Experimental design.(Engineering Practice) - Constant velocity cars: Using constant velocity cars, students will conduct an investigation determining the velocity of the cars. Analyze and graph results.(Engineering Practice) - Vector Treasure Hunt: Students develop a	**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

set directions from point A to point B using vector concepts of displacement and velocity and scalar quantities of distance and speed.	○ Warmups / exit tickets ○ Written assessments to include problems and conceptual questions ○ Scientific journal response: Students read various scientific articles, watch documentaries or movie clips for their response ○ Graphical Analysis: Students present data from a system. They will draw conclusions and make predictions based on evidence from their data sources. (Engineering Practice)

Learning Plan

Learning Activities:

- Demonstration videos, video clips
- Guided reading from various sources to determine validity
- Notes
- Lab activities- guided and inquiry; real and virtual; problem based ; use of technology (little bits)
- Creating infographics of information presented or student research.
- Cooperative activities: Concept mapping, alphabet boxes, Frayer model for vocabulary and, Jigsaw, group presentations

Related Standards

Interdisciplinary connections

ELA

- RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS2-1)
- RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media

(e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1)

- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-1), (HS-PS2-5)

Mathematics

- MP.2 Reason abstractly and quantitatively. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4)
- MP.4 Model with mathematics. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4)
- 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. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4), (HS-PS2-5) HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4), (HS-PS2-5)
- HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4), (HS-PS2-5)
- HSA-SSE.A.1 Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1), (HS-PS2-4)
- HSA-SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1), (HS-PS2- 4)
- HSA-CED.A.1 Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1), (HS-PS2-2)
- HSA-CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-PS2- 1), (HS-PS2-2)
  - ⇒ Example: Use units as a way to understand how Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration. Choose and interpret units consistently in Newton's second law of motion, and choose and interpret the scale and origin in graphs and data displays representing the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
- HSA-CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1), (HS-PS2-2)
- HSF-IF.C.7 Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases. (HS-PS2- 1)

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: Constant velocity cars- Using constant velocity cars, students will conduct an investigation

determining the velocity of the cars. Students will organize data, make computations with formulas, and analyze and graph results in Google Sheets.

NJ SEL Competencies

- Self-Awareness: Recognize one's feelings and thoughts
- Self-Management: Understand and practice strategies for managing one's own emotions, thoughts, and behaviors

Culturally Relevant Connections

- Use students' life experiences as cultural reference to examples in instructions, such as their music, places in their respective countries, foods, and even choice vocabularies.
- Make posters representing content examples in cultural expressions.
- Develop an asset mapping of the community to harness the partnerships from the community. Ex. invite parents to attend classroom events such as presentations of projects.
- Explore ways to tie local resources to things in the classroom. Ex. community members as guest speakers.
- Value parents by keeping websites updated with current events in the classroom/school
- Have guest speakers of various cultural backgrounds from industry to present to our students.
- Use textbooks or articles from diverse writers.
- Use adaptive learning to refocus content for each student on an individual basis, with the help of technology.
- Project based learning involves an open end approach that allows students to work alone or collaboratively on engaging, intricate curriculum related challenges
- Empower students to tell their stories and reflect upon their similarities and differences to your own: Where are the places of common experience, and where are the places where we need to employ empathy.
- Challenge other teachers to become culturally aware of their students.
- Empower, engage and stimulate students as they are put at the center of the learning process
- Employ experiential learning activities to develop knowledge and skills through direct, firsthand experiences.
- Seek opportunities for professional development on diversity issues.
- Employ inquiry based learning, which encourages students' authentic questions, ideas and analyses.

Accommodations

Special Education/ 504/ At Risk Students Accommodations & Modifications:	**ELL:**
◦ Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understanding. ◦ Use project-based science learning to connect science with observable phenomena. ◦ Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).	◦ Provide multiple literacy strategies ◦ Use of word/picture walls in the classroom displaying a list of key academic vocabulary words for reference (from a specific unit). ◦ Provide graphic organizers ◦ Provide students with visuals aids like pictures and diagrams to illustrate motion in one dimension ◦ Have students work in triads or small groups where they are able to support each other's learning by giving each other input and filling in gaps in background. Students often work best when they have defined roles (surrounding the content they are studying) that they are responsible for. ◦ Incorporate writing activities such as science journals to support the acquisition of academic language in science and to empower students with a resource for later reference.

Enrichment

- Students will pick a Hollywood movie and will point out three (or more) instances of bad physics. They will present this information to a partner in class for critique, describing the inaccuracies both qualitatively and quantitatively.

Unit 2: Forced and Interactions
Desired Outcomes

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.
- HS-PS2-2 : Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
- HS-PS2-3 : Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.
- HS-PS2-4: Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.

Established Goals

- Students represent interactions in multiple ways to analyze or predict changes in motion of a system.
- Students analyze or predict the variables that affect the gravitational field and force between two objects of a certain mass.
- Students apply Newton's Laws of Motion to predict and analyze the circular/orbital motion of a system
- Students use multiple representations to justify or predict changes in momentum within and between systems.

Science and Engineering Practices	***Disciplinary Core Ideas***	***Crosscutting Concepts***
Analyzing and Interpreting Data Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the	**PS1.A: Structure and Properties of Matter** ● The structure and interactions of matter at the	**Patterns** ● Different patterns may be observed at each of the scales at which a system is studied

comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-PS2-1) **Using Mathematics and Computational Thinking** Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical representations of phenomena to describe explanations. (HS-PS2-2),(HS-PS2-4)	bulk scale are determined by electrical forces within and between atoms. (secondary to HS-PS2-6) **PS2.A: Forces and Motion** • Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1) • Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2) • If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2),(HS-PS2-3) **PS2.B: Types of Interactions** • Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4)	and can provide evidence for causality in explanations of phenomena. (HS-PS2-4) **Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2- 1) • 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)

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),(HS-PS2-4) • Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1),(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 magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4)	

Enduring Understandings:

- Dynamics describes the interactions between objects that can predict possible changes in motion.
- Forces are interactions between objects
- Forces can be expressed and analyzed using multiple representations
- Momentum is a physical quantity that remains conserved within a system.
- The momentum of a system can only be changed by exerting an external force for a period of time

Essential Questions:

- How can you accurately predict motion?
- Why can an interaction influence objects differently?
- How can one representation of a system be more useful than another?
- In what situation would the law of conservation of momentum not apply?
- Why will an object in motion not indefinitely remain in motion?

Students will know:

- Newton's Three Laws and the application to Forces.
- Use multiple representations (e.g., diagrams, charts, graphs, mathematical, verbal, written) to prove scenarios in terms of gravitational fields and forces
- Newton's Law of Universal Gravitation provides the mathematical models to describe and predict the effects of gravitational forces between distant objects
- Forces at a distance are explained by fields (gravitational) permeating space that can transfer energy through space.
- 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 the gravitational force between objects.

Students will be able to:

- Use multiple representations to support scenarios in terms of dynamics
- Apply the concept of force as an interaction between two objects
- Analyze data from the physical quantities of acceleration, net force, mass, weight, and friction
- Prove the correlation between the restoring force and change in length of elastic material, gravitational forces, weight, and mass
- Interpret motion and force diagrams
- Analyze a system using multiple representations of the system
- Support conditions necessary to keep a system moving in a circular path
- Formulate solutions to various scenarios by applying newton's laws and kinematics to circular motions

○ Kepler's Laws and their applications ○ Momentum is conserved.	○ Use problem solving strategies to formulate solutions to complex problems ○ Explain kinematics newton's laws and energy in relation to momentum ○ Differentiate between elastic, inelastic, head on and glancing collisions
Assessment Evidence	
<u>Suggested Performance Tasks:</u> ○ Students use data to predict the force of gravity between two objects (solar system) ○ Students analyze data to predict the mass of an object using multiple data sources/representations ○ Egg drop experiment: design a container so an egg will not break. Students determine the force, the impulse from experimental data ○ Students design, evaluate and refine a device to test whether momentum is conserved.	**<u>Required District/State Assessments:</u>** ○ District marking period assessments ○ SGO assessments **<u>Suggested Formative/Summative Assessments:</u>** ○ Lab/activity report ⇒ Problem solving activities to demonstrate understanding of Newton's laws ⇒ Friction and coefficient of friction using observational experiments ⇒ Centripetal Force Lab ⇒ Pendulum Lab ○ 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 ⇒ Force diagrams and equilibrium using Force Tables ⇒ Students use free body diagrams that depict the different interaction forces acting on various objects ○ Presentations ○ Warmups / exit tickets

Learning Plan

Learning Activities:

- Demonstration videos, video clips
- Guided reading from various sources to determine validity
- Notes
- Lab activities- guided and inquiry; real and virtual; problem based ; use of technology (little bits)
- Cooperative activities: Jigsaw, group presentations

Related Standards

Interdisciplinary connections

ELA/Literacy

- RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS2-1),(HS-PS2-6)
- RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1)
- WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize

multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS2-3),(HS-PS2-5)

- WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS2-5)
- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-1),(HS-PS2-5)

Mathematics

- MP.2 Reason abstractly and quantitatively. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)
- MP.4 Model with mathematics. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)
- 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. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5),(HS-PS2-6)
- HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5),(HS-PS2-6)
    - ⇒ Example: Use symbols to represent Newton's law of gravitation, Coulomb's Law, gravitational forces between two objects in a system, and electrostatic forces between two objects in a system and manipulate the representing symbols. Make sense of quantities and relationships to describe and predict the gravitational and electrostatic forces between two objects in a system.
- HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5),(HS-PS2-6)
- HSA-SSE.A.1 Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1),(HS-PS2-4)
- HSA-SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1),(HS-PS2- 4) HSA-CED.A.1 Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1),(HS-PS2-2)
- HSA-CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-PS2- 1),(HS-PS2-2)
- HSA-CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1),(HS-PS2-2)
- HSF-IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. (HS-PS2-1)

- HSS-ID.A.1 Represent data with plots on the real number line (dot plots, histograms, and box plots). (HS-PS2-1)

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).
    - ⇒ Egg drop experiment: Students will apply problem-solving and engineering strategies to design a container so an egg will not break. Students determine the force, the impulse from experimental data.

NJ SEL Competencies

- Social Awareness: Recognize and identify the thoughts, feelings, and perspectives of others
- Responsible-Decision Making: Develop, implement, and model effective problem-solving and critical thinking skills

Culturally Relevant Connections

- Provide opportunities for students to connect with people of similar backgrounds (e.g. conversations via digital tools such as Zoom meetings, 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:

- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to

ELL:

- Use of word/picture walls in the classroom displaying a list of key academic vocabulary words for reference (from a specific unit).
- Provide students with visuals aids like pictures

demonstrate their understanding. ○ Use project-based science learning to connect science with observable phenomena.	and diagrams to help illustrate forces and interactions ○ Have students work in triads or small groups where they are able to support each other's learning by giving each other input and filling in gaps in background. Students often work best when they have defined roles

Enrichment
○ Challenge students to design a video demonstrating Newton's three laws. They must explain how each of the laws is being represented both qualitatively and quantitatively.

Unit 3: Energy

Desired Outcomes

NJSLS

Physical Sciences (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.
- HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).
- HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
- HS-PS3-4 Plan and conduct an investigation to provide evidence that the transfer of thermal energy when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system(Law of Thermodynamics)
- HS-PS3-5 Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

Established Goals

- Distinguish between types of energy and show using multiple representations
- Differentiate between conserved energy and constant energy
- Critique the importance of defining a system with quantifying energy types
- Identify when work is done on a system
- Apply kinematics and Newton's laws to work and energy to predict how changes to the variable in the system will affect the system

- Use problem solving strategies and reasoning skills to formulate solutions to complex problems.

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),(HS-PS3-5) **Planning and Carrying Out Investigations** Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan and conduct an investigation individually and	**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	**Cause and Effect** • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS3-5) **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-PS3-4) • 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)

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-PS3-4) **Using Mathematics and Computational Thinking** Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. ● Create a computational model or simulation of a phenomenon, designed device, process, or system.	of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2) **PS3.B: Conservation of Energy and Energy Transfer** ● Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1) ● Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4) ● Mathematical expressions, which quantify how the stored energy in a system depends on its configuration	**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) **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**

(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 trade off considerations. (HS-PS3-3)	(e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1) ● The availability of energy limits what can occur in any system. (HS-PS3-1) ● Uncontrolled systems always evolve toward more stable states— that is, toward more uniform energy distribution (e.g., water flows downhill, objects hotter than their surrounding environment cool down). (HS-PS3-4) **PS3.C: Relationship Between Energy and Forces** ● When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5) **PS3.D: Energy in Chemical Processes** ● Although energy cannot be destroyed, it can be	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)

	converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3),(HS-PS3-4)	

Enduring Understandings:	**Essential Questions:**
○ Since energies can be stored, transformed, or transferred in a variety of ways it can be used to solve real-world problems. ○ Energy is a physical quantity that remains conserved within a system during interactions. ○ External interactions exerted on a system cause changes in the total energy of a system.	○ How can the law of conservation of energy be used to solve problems? ○ How do real-world situations prove the law of conservation of energy? ○ When is it beneficial to cause external interactions to a system?
Students will know: ○ Energy is a quantitative property of a system that depends on the motion and interactions within that system. ○ 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. ○ Energy cannot be created or destroyed but can be transported from one place to another and transferred between systems. ○ Mathematical expressions, which quantify how the stored energy in a system depends on its	**Students will be able to:** ○ Develop and use models based on evidence to illustrate that energy cannot be created or destroyed. It only moves between one place and another place, between objects and/or fields, or between systems. ○ Use mathematical expressions to quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compressions of a spring) and how kinetic energy depends on mass and speed. ○ Use mathematical expressions and the concept of conservation of energy to predict and describe

configuration. ○ Kinetic energy depends on mass and speed. ○ The availability of energy limits what can occur in any system. ○ Energy manifests itself in multiple ways, such as motion, light, sound and thermal energy.	system behavior. ○ Use basic algebraic expressions or computations to create a computational model to calculate the change in the energy of one component in a system (limited to two or three components) when the change in energy of the other component(s) and energy flows in and out of the system are known. ○ Explain the meaning of mathematical expressions used to model the change in the energy of one component in a system (limited to two or three components) when the change in energy of the other component(s) and out of the system are known.· ○ Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. ○ Analyze a device to convert one form of energy into another form of energy by specifying criteria and constraints for successful solutions. ○ Use mathematical models and/or computer simulations to predict the effects of a device that converts one form of energy into another form of energy. ○ Synthesize the work-kinetic energy theorem by combining the equations for Newton's second law, work, and acceleration ○ Identify and quantify the various types of energies within a system of objects in a well-defined state, such as elastic potential energy, gravitational potential energy, kinetic energy, and thermal

	energy and represent how these energies may change over time. ○ Calculate changes in kinetic energy and gravitational potential energy of a system using representations of that system. ○ When two objects interacting through a field change relative position, the energy stored in the field is change.

Assessment Evidence

Suggested Performance Tasks: ○ Students analyze data expressed in multiple representations to predict the changes of energy in a system and determine if the energy of a system has been conserved. ○ Students use a mathematical representation of the system in order to calculate the kinetic energy or velocity at some point within the bounds of the graph. ○ Students justify their claims with a written explanation, relevant calculations, and by citing evidence. ○ Students design an experiment to test whether the energy of an isolated system is constant. (Roller Coaster or egg drop) ○ Students hypothesize/predict what the data will appear like using preliminary models.	**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:

- Rube-Goldberg Device
- Roller Coaster Physics
- Energy Skate Park: Basics: Learn about conservation of energy with a skater gal! Explore different tracks and view the kinetic energy, potential energy and friction as she moves. Build your own tracks, ramps, and jumps for the skater.
- Work and Energy Workbook Labs: The lab description pages describe the question and purpose of each lab and provide a short description of what should be included in the student lab report.
- Case Studies: Space, Tsunami, Earthquakes, Hurricane

Related Standards

Interdisciplinary connections

ELA/Literacy

- RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS3-4)
- WHST.9-12.7 Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation. (HS-PS3-3), (HS-PS3-4),(HS-PS3-5)
- WHST.11-12.8 Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation. (HS-PS3-4),(HS-PS3-5)
- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS3-4),(HS-PS3-5)

- SL.11-12.5 Make strategic use of digital media (e.g., textual, graphical, audio, visual, and interactive elements) in presentations to enhance understanding of findings, reasoning, and evidence and to add interest. (HS-PS3-1),(HS-PS3-2),(HS-PS3-5)

Mathematics

- MP.2 Reason abstractly and quantitatively. (HS-PS3-1),(HS-PS3-2),(HS-PS3-3),(HS-PS3-4),(HS-PS3-5)
- MP.4 Model with mathematics. (HS-PS3-1),(HS-PS3-2),(HS-PS3-3),(HS-PS3-4),(HS-PS3-5)
- 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. (HS-PS3-1),(HS-PS3-3)
- HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS3-1),(HS-PS3-3)
  - ⇒ Example: Define appropriate quantities for the purpose of descriptive modeling of a device to convert one form of energy into another form of energy.
- HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS3-1),(HS-PS3-3)

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

- 9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.
  - ⇒ Example: Students will complete a lab studying the effect varying the angle of incline has upon the force needed to pull a cart up a hill at a constant speed to the same height and what effect the varying incline has upon the work done. Students will organize their data in tables and graphs in a spreadsheet on Google Sheets.

<u>NJ SEL Competencies</u>

- Responsible Decision-Making: Develop, implement, and model effective problem-solving and critical thinking skills
- Relationship Skills: Utilize positive communication and social skills to interact effectively with others

<u>Climate Change</u>

- Definitions of Energy: Introduce the concept of energy and its various forms, including how energy is transferred and transformed. Relate this to climate change by explaining how human activities, such as the burning of fossil fuels, release energy and contribute to greenhouse gas emissions.

- Conservation of Energy and Energy Transfer: Explore the transfer and transformation of energy in the context of climate change. Discuss how energy from the Sun is absorbed by the Earth and re-radiated back as infrared radiation, which is affected by greenhouse gases.

Culturally Relevant Connections

- Value parents by keeping websites updated with current events in the classroom/school
- Have guest speakers of various cultural backgrounds from industry to present to our students.
- Empower students to tell their stories and reflect upon their similarities and differences to your own: Where are the places of common experience, and where are the places where we need to employ empathy.
- Employ inquiry based learning, which encourages students' authentic questions, ideas and analyses.

Accommodations

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

- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understandings.
- Use project-based science learning to connect science with observable phenomena.

ELL:

- Use of word/picture walls in the classroom displaying a list of key academic vocabulary words for reference (from a specific unit).
- Provide students with visuals aids like pictures and diagrams to help illustrate the conservation of energy
- Have students work in triads or small groups where they are able to support each other's learning by giving each other input and filling in gaps in background. Students often work best when they have defined roles
- Incorporate writing activities such as science journals to support the acquisition of academic language in science and to empower students with a resource for later reference

Enrichment
○ Challenge students to design a device that converts potential energy into some other form of energy. Encourage students to be creative If time allows, you may want to have students build their devices.

Unit 4: Electricity/Magnetism

Desired Outcomes

NJSLS

Physical Sciences (PS):

- HS-PS1-3 Plan and conduct an investigation to gather evidence to compare the structure to infer the strength of electrical forces between particles.
- HS-PS2-4 Use mathematical representations of Coulomb's Law to describe and predict the electrostatic forces between objects.
- HS-PS2-5 Make predictions about the sign and relative quantity of net charge of objects or systems after various charging processes.
- HS-PS3-1 Create a computational model to calculate the change in energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
- HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative positions of particles (objects).
- HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
- HS-PS3-5 Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.
- 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.]
- HS-PS4-3 Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other. [Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, interference, diffraction, and photoelectric effect.] [Assessment Boundary: Assessment

does not include using quantum theory.]

Established Goals

- Students will investigate macroscopic interactions on a microscopic level in order to formulate hypotheses and draw conclusions about electrostatic interactions between objects.
- Students will represent electrically charged interactions in multiple ways in order to analyze data and predict the motion of a particular system.
- Students will investigate circuits to hypothesize and draw conclusions about the rate of energy transfer of electrical (ohmic) components.
- Students will represent electromagnetic interactions in multiple ways in order to analyze and predict the relationship between electric and magnetic fields.

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),(HS-PS3-5)	**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)	**Cause and Effect** • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS3-5),(HS-PS2-5),(HS-PS 4-1) **Systems and System Models** • Models can be used to predict the behavior of a

Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9–12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. ● Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-PS3-1),(HS-PS2-4),(HS-PS 4-1) **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	● 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 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	system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HS-PS3-1),(HS-PS4-3) **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),(HS-PS1-3) ● 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) **Patterns** ● Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS2-4) **Connections to Engineering, Technology, and Applications of Science** Influence of Science, Engineering,

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 trade off considerations. (HS-PS3-3) **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-PS1-3),(HS-PS2-5)	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 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.C: Relationship Between Energy and Forces** • When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5) **PS3.D: Energy in Chemical**	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)

Engaging in Argument from Evidence Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed worlds. Arguments may also come from current scientific or historical episodes in science. ● Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (HS-PS4-3) **Connections to Nature of Science** Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena ● Theories and laws provide explanations in science. (HS-PS2-4) ● Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-4) ● A scientific theory is a	**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) **PS1.A: Structure and Properties of Matter** ● A stable molecule has less energy than the same set of atoms separated; one must provide at least this energy in order to take the molecule apart. (HS-PS1-4) **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	

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. (HSPS4-3)	electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4),(HS-PS2-5) **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) ● [From the 3–5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) (HS-PS4-3) **PS4.B: Electromagnetic Radiation**	

	• Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (HS-PS4-3)	

Enduring Understandings:

- Electrical interactions occur between charged objects and are fundamentally different than interactions between magnetic poles.
- Electrically charged particles can move freely inside certain materials and in other materials the charged particles can only redistribute slightly.
- Electrical circuits provide a mechanism of transferring and transforming electrical energy.
- Magnetic fields are produced by permanent magnets and electric currents, which mediate interactions between magnetic materials and moving charges.
- Electric current can be induced by a changing magnetic field and a change in electric fields can induce a change in the magnetic field.

Essential Questions:

- Why do objects carry charges?
- How does the molecular structure dictate a material's electrical properties?
- How do you choose the best mechanism to transfer and transform electricity?
- To what extent can you predict interactions in magnetic fields?
- Why does there exist a relationship between electrical currents and magnetic fields?

<u>Students will know:</u>	**<u>Students will be able to:</u>**
○ 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. ○ When two objects interacting through a field change relative position, the energy stored in the field is changed. ○ Cause-and-effect relationships between electrical and magnetic fields can be predicted through an understanding of inter- and intramolecular forces (protons and electrons).	○ Plan and conduct an investigation individually and collaboratively to produce data that can serve as the basis for evidence that an electric current can produce a magnetic field. ○ Plan and conduct an investigation individually and collaboratively to produce data that can serve as the basis for evidence that a changing magnetic field can produce an electric current. ○ In experimental design, decide on the types, amounts, and accuracy of data needed to produce reliable measurements, consider limitations on the precision of the data, and refine the design accordingly. ○ Collect empirical evidence to support the claim that an electric current can produce a magnetic field. ○ Collect empirical evidence to support the claim that a changing magnetic field can produce an electric current. ○ Develop and use an evidence-based model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction. ○ Suggest and predict cause-and-effect relationships for two objects interacting through electric or magnetic fields.

Assessment Evidence

Suggested Performance Tasks:	**Required District/State Assessments:**
○ Design an experiment to determine if magnetic interactions are the same as electrical interactions. Data from the experiment will be expressed using multiple representations and analyzed to draw conclusions. Students will cite evidence from the experiment to justify their claims. ○ Students will analyze different interactions between a charged object and a conducting/non-conducting material. Students analyze data to prove the presence/absence of net charge on an object. Students will cite evidence from the experiment to justify their claims. ○ Given the direction of current through a conducting wire, predict and test the interaction that occurs between the known poles of a strong (horseshoe) magnet and the wire that is placed between the poles. ○ Students construct a homo-polar motor with a length of wire, a battery, and a neodymium magnet. Students diagram the current, the magnetic field, and the resulting force exerted on the wire. Students hypothesize the result of flipping the battery or the magnet and justify their predictions.	○ 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:

- Demonstration videos, video clips
- Guided reading from various sources to determine validity
- Notes
- Lab activities- guided and inquiry; real and virtual; problem based ; use of technology (little bits)
- Design and build a motor or generator. They might also observe a premade toy motor.
- Student models might be mathematical models, drawings, diagrams, or text.
- Magnets and Electromagnets: Explore the interactions between a compass and bar magnet. Discover how you can use a battery and wire to make a magnet! Can you make it a stronger magnet? Can you make the magnetic field reverse?
- Charges and Fields: Move point charges around on the playing field and then view the electric field, voltages, equipotential lines, and more. Students might also conduct short or more sustained research projects around the concepts of electric current and magnetic fields. They should collect relevant data from a broad spectrum of sources, examine adequate evidence, and construct rigorous explanations for how electric currents produce magnetic fields and how changing magnetic fields can produce electric currents.
- Faraday's Law: Investigate Faraday's law and how a changing magnetic flux can produce a flow of electricity!
- Cooperative activities: Jigsaw, group presentations

Related Standards

Interdisciplinary connections

ELA

- RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS2-1)
- RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1)
- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-1),

(HS-PS2-5)

Mathematics

- MP.2 Reason abstractly and quantitatively. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4)
- MP.4 Model with mathematics. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4)
- 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. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4), (HS-PS2-5)
- HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4), (HS-PS2-5)
- HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4), (HS-PS2-5)
- HSA-SSE.A.1 Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1), (HS-PS2-4), (HS-PS4-3)
    - ⇒ Example: Interpret expressions that represent the wave model and particle model of electromagnetic radiation in terms of the usefulness of the model depending on the situation.
- HSA-SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1), (HS-PS2- 4)
- HSA-CED.A.1 Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1), (HS-PS2-2)
- HSA-CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-PS2- 1), (HS-PS2-2)
- HSA-CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1), (HS-PS2-2)
- HSF-IF.C.7 Graph functions expressed symbolically and show key features of the graph, by in hand in simple cases and using technology for more complicated cases. (HS-PS2- 1)

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

- 9.4.12.TL.2: Generate data using formula-based calculations in a spreadsheet and draw conclusions about the data.
    - ⇒ Example: Students will design an experiment to determine if magnetic interactions are the same as electrical interactions. Data from the experiment will be organized and analyzed in a spreadsheet to draw conclusions. Students will cite data from the experiment to justify their claims.

NJ SEL Competencies

- Self-Awareness: Recognize one's personal traits, strengths, and limitations
- Self-Management: Identify and apply ways to persevere or overcome barriers through alternative methods to achieve one's goals

Culturally Relevant Connections

- Use students' life experiences as cultural reference to examples in instructions, such as their music, places in their respective countries, foods, and even choice vocabularies.
- Make infographics representing content examples in cultural expressions.
- Explore ways to tie local resources to things in the classroom. Ex. community members as guest speakers.
- Value parents by keeping websites updated with current events in the classroom/school
- Have guest speakers of various cultural backgrounds from industry to present to our students.
- Use textbooks or articles from diverse writers.
- Use adaptive learning to refocus content for each student on an individual basis, with the help of technology.
- Project based learning involves an open end approach that allows students to work alone or collaboratively on engaging, intricate curriculum related challenges
- Empower students to tell their stories and reflect upon their similarities and differences to your own: Where are the places of common experience, and where are the places where we need to employ empathy.
- Empower, engage and stimulate students as they are put at the center of the learning process
- Employ experiential learning activities to develop knowledge and skills through direct, firsthand experiences.
- Employ inquiry based learning, which encourages students' authentic questions, ideas and analyses.

Accommodations

Special Education/ 504/ At Risk Students Accommodations & Modifications:	ELL:
○ Engage students with a variety of Science and Engineering practices to provide students with	○ Provide multiple literacy strategies ○ Use of word/picture walls in the classroom displaying a list of key academic vocabulary words

multiple entry points and multiple ways to demonstrate their understanding. ○ Use project-based science learning to connect science with observable phenomena. ○ Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).	for reference (from a specific unit). ○ Provide graphic organizers ○ Provide students with visuals aids like pictures and diagrams to illustrate motion in one dimension ○ Have students work in triads or small groups where they are able to support each other's learning by giving each other input and filling in gaps in background. Students work with defined roles that they are responsible for. ○ Incorporate writing activities such as science journals to support the acquisition of academic language in science and to empower students with a resource for later reference.

Enrichment

- Students will pick a Hollywood movie and will point out three (or more) instances of bad physics. They will present this information to a partner in class for critique, describing the inaccuracies both qualitatively and quantitatively.

Unit 5: Waves

Desired Outcomes

NJSLS

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.
- HS-PS4-2: Evaluate questions about the advantages of using a digital transmission and storage of information.
- HS-PS4-3: Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.
- HS-PS4-4: Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.
- HS-PS4-5:Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy

Established Goals

- Students apply the concepts associated with waves and wave motion to solve advanced problems and scenarios
- Students communicate ideas and concepts using multiple representations
- Students differentiate between the wave interactions
- Students predict how the wave should behave when encountering barriers and other waves
- Students formulate solutions to complex problems pertaining to speed of a wave, wavelength, frequency, period, and standing waves
- Students differentiate between frequency and pitch, volume and intensity, and tonality/timbre and harmonics
- Students apply the Doppler effect to real life scenarios.

Science and Engineering Practices	*Disciplinary Core Ideas*	*Crosscutting Concepts*
Asking Questions and Defining Problems Asking questions and defining problems in grades 9–12 builds from grades K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. ● Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. (HS-PS4-2) **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	**PS3.D: Energy in Chemical Processes** ● Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. (secondary to HS-PS4-5) **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) ● Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. (HS-PS4-2),(HSPS4-5) ● [From the 3–5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative	**Cause and Effect** ● Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS4-1) ● Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS4-4) ● Systems can be designed to cause a desired effect. (HS-PS4-5) **Systems and System Models** ● Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions— including energy, matter, and information flows—within and between systems at different scales. (HS-PS4-3)

mathematical models of basic assumptions. • Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-PS4-1) **Engaging in Argument from Evidence** Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed worlds. Arguments may also come from current scientific or historical episodes in science. • Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (HS-PS4-3) **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to	position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) (HS-PS4-3) **PS4.B: Electromagnetic Radiation** • Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (HS-PS4-3) • When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays,	**Stability and Change** • Systems can be designed for greater or lesser stability. (HS-PS4-2) **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). (HS-PS4-5) **Influence of Engineering, Technology, and Science on Society and the Natural World** • Modern civilization depends on major technological systems. (HS-PS4-2),(HSPS4-5) • Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HSPS4-2)

evaluating the validity and reliability of the claims, methods, and designs. ● Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible. (HS-PS4-4) ● Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS4-5) **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	gamma rays) can ionize atoms and cause damage to living cells. (HS-PS4-4) ● Photoelectric materials emit electrons when they absorb light of a high-enough frequency. (HS-PS4-5) **PS4.C: Information Technologies and Instrumentation** ● Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. (HS-PS4-5)	

new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HSPS4-3)		

Enduring Understandings: ○ Waves, including both mechanical, light, and electromagnetic, can transfer energy when they interact with matter. ○ There are four wave interactions that can be applied to all waves.	**Essential Questions:** ○ How do you know if a phenomenon is a wave if you cannot see it? ○ Do waves interact in predictable ways? ○ Is light a particle or a wave?
Students will know: ○ 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. ○ Information can be digitized in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. ○ Waves can add or cancel one another as they cross, depending on their relative phase but they emerge unaffected by each other. ○ Empirical evidence is required to differentiate between cause and correlation and to make a claim regarding relationships among the frequency, wavelength, and speed of waves	**Students will be able to:** ○ Identify and describe the characteristics of waves. ○ Identify nodes and antinodes ○ Use math to show the relationship between frequency, wavelength, and speed in different media ○ Understand period with respect to frequency ○ Use evidence to describe the cause/effect between wave speed in a particular media through which it trails

traveling in various media. ○ Electromagnetic radiation can be modeled as a wave of changing electric and magnetic fields or as particles called photons. ○ When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. ○ Photoelectric materials emit electrons when they absorb light of a high-enough frequency. ○ Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them.	
Assessment Evidence	
Suggested Performance Tasks: ○ Students hypothesize/predict how the speed of a wave changes as it moves through different materials. Students then analyze data from a given data set or lab experiment. Students cite evidence from data analysis to support	**Required District/State Assessments:** ○ District marking period assessments ○ SGO assessments **Suggested Formative/Summative Assessments:** ○ Lab/activity report

their hypothesis/prediction. ○ Design a musical instrument.	⇒ Waves on a Slinky Activity ⇒ Wave demonstrator Lab ⇒ Research and argumentation: Bridge Analysis/Earthquakes/ ⇒ Tuning forks- make an instrument ○ 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:

- Demonstration videos, video clips: Study various earthquakes and other natural disasters; waves traveling through a roller coaster
- Guided reading from various sources to determine validity
- Notes
- Lab activities- guided and inquiry; real and virtual; problem based ; use of technology (little bits)
- Cooperative activities: Jigsaw, group presentations

Related Standards

Interdisciplinary connections

ELA

- RST.11-12.1 Cite specific textual evidence to support analysis of science and technical texts, attending to important distinctions the author makes and to any gaps or inconsistencies in the account. (HS-PS2-1)
- RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1)
- WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-1), (HS-PS2-5)

Mathematics

- MP.2 Reason abstractly and quantitatively. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4)
- MP.4 Model with mathematics. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4)
- 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. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4), (HS-PS2-5)
- HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4), (HS-PS2-5)
    - ⇒ Example: Make sense of quantities and relationships between the wave model and the particle model of electromagnetic radiation.
- HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS2-1), (HS-PS2-2), (HS-PS2-4), (HS-PS2-5)
- HSA-SSE.A.1 Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1), (HS-PS2-4)
- HSA-SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1), (HS-PS2- 4)
    - ⇒ Example: Represent symbolically that electromagnetic radiation can be described either by a wave model or a particle model and that for some situations one model is more useful than the other, and manipulate the representing symbols.
- HSA-CED.A.1 Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1), (HS-PS2-2)
- HSA-CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-PS2- 1), (HS-PS2-2)
- HSA-CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1), (HS-PS2-2)

- ⇒ Example: Rearrange formulas representing electromagnetic radiation to highlight a quantity of interest, using the same reasoning as in solving equations.
- HSF-IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. (HS-PS2- 1)

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

- 9.4.12.IML.3: Analyze data using tools and models to make valid and reliable claims, or to determine optimal design solutions (e.g., S-ID.B.6a., 8.1.12.DA.5, 7.1.IH.IPRET.8)
  - ⇒ Example: Students hypothesize/predict how the speed of a wave changes as it moves through different materials. Students then analyze data from a given data set or lab experiment. Students cite evidence from data analysis to support their hypothesis/prediction.

NJ SEL Competencies

- Self-Awareness: Recognize one's feelings and thoughts
- Self-Management: Understand and practice strategies for managing one's own emotions, thoughts, and behaviors

Climate Change

- Electromagnetic Radiation: Study the principles of electromagnetic radiation and its interaction with matter. Connect this to climate change by explaining how certain gases, such as carbon dioxide and methane, absorb and re-emit infrared radiation, leading to the greenhouse effect.

Culturally Relevant Connections

- Relationships: Learn about your students' individual cultures; Adapt your teaching to the way your students learn; Develop a connection with challenging students; Communicate and work with parents/guardians on a regular basis (email distribution, newsletter, phone calls, notes, meetings, etc.)
- Curriculum: Incorporate student- centered stories, vocabulary and examples; Incorporate relatable aspects of students' lives; 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; 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:

- Engage students with a variety of Science and Engineering practices to provide students with multiple entry points and multiple ways to demonstrate their understanding.
- Use project-based science learning to connect science with observable phenomena.
- Provide students with multiple choices for how they can represent their understandings (e.g. multisensory techniques-auditory/visual aids; pictures, illustrations, graphs, charts, data tables, multimedia, modeling).

ELL:

- Provide multiple literacy strategies
- Use of word/picture walls in the classroom displaying a list of key academic vocabulary words for reference (from a specific unit).
- Provide graphic organizers
- Provide students with visuals aids like pictures and diagrams to illustrate motion in one dimension
- Have students work in triads or small groups where they are able to support each other's learning by giving each other input and filling in gaps in background. Students often work best when they have defined roles (surrounding the content they are studying) that they are responsible for.
- Incorporate writing activities such as science journals to support the acquisition of academic language in science and to empower students with a resource for later reference.

Enrichment

- How do sunglasses work?

- How to build a spectroscope
- Refractive Index Matching

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*

- 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

Graphic Supports*

- Graphs
- Charts
- Timelines
- Number lines
- Graphic organizers
- Graphing paper

Interactive Supports*

- 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

Verbal and Textual Supports

- 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:

- Holt McDougal Physics. Serway, Faughn. 2012. ISBN: 978-0-547-63632-0
- Houghton Mifflin Harcourt Physics, Serway, Faughan. 2017.

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.