PUBLIC SCHOOLS OF EDISON TOWNSHIP

OFFICE OF CURRICULUM AND INSTRUCTION

Physics 1-2

Length of Course:	Term
Elective/Required:	Required
Schools:	High School
Eligibility:	Grade 11-12
Credit Value:	5 Credits
Date Approved:	August 23, 2022

TABLE OF CONTENTS

Modifications will be made to accommodate IEP mandates for classified students.

STATEMENT OF PURPOSE

The Physics 1-2 curriculum is a comprehensive survey of physics that meets local objectives and contributes to the accomplishment of the state and national standards. The program was chosen to complement the flow and sequence of scientific studies from Chemistry and is an elective course for Grade 11 or Grade 12 science. All students will understand that physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science. An overarching goal for learning in physics is to help students see that there are mechanisms of cause and effect in all systems and processes that can be understood through a common set of physical quantities and principles. The focus of the Physics 1-2 course is to develop and nurture the skills necessary to problem solve, design experiments, analyze assumptions, and evaluate the validity of scientific claims. The final goal is to combine these skills to provide students with a strong ability to collaborate with each other in determining and solving societal issues, such as energy production/usage.

The curriculum guide was revised/updated by:
Kruti Singh (EHS)
Christopher McKnight (EHS)

Coordinated by:
Laurie Maier (Science Supervisor)

COURSE OBJECTIVES

By the end of the Physics 1-2 course, students will be able to:

Motion and Stability: Forces and Interactions

- **(NJSLS/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.
- **(NJSLS/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.
- **(NJSLS/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.
- **(NJSLS/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.
- **(NJSLS/HS-PS2-5)** Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.

Energy

- **(NJSLS/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.
- **(NJSLS/HS-PS3-2)** Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
- **(NJSLS/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.
- **(NJSLS/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.

Waves And Their Applications In Technologies For Information Transfer

- **(NJSLS/HS-PS4-1**) Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.
- **(NJSLS/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.
- **(NJSLS/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.

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

Earth's Place In The Universe

- **(NJSLS/HS-ESS1-4)** Use mathematical or computational representations to predict the motion of orbiting objects in the solar system

ELA/ Literacy
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)
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)
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.
WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-1),(HS-PS2-5)
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.

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)
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)

Technology
8.1.12.A.2 Produce and edit a multi-page digital document for a commercial or professional audience and present it to peers and/or professionals in that related area for review

Career Ready Practices
CRP4. Communicate clearly and effectively and with reason
CRP8. Utilize critical thinking to make sense of problems and persevere in solving them
CRP11. Use technology to enhance productivity.

TIMELINE AND PACING GUIDE

Marking Period 1:

Measurement
- SI units
- dimensional analysis
- significant digits and scientific notation
- scientific method
- precision and accuracy
- graphical analysis

Kinematics
- reference frames
- vectors, scalars
- position, displacement
- average velocity
- uniform acceleration
- free fall
- projectile motion
- relative velocity

Quarterly Exam 1

Marking Period 2:

Dynamics
- force, mass
- four fundamental forces
- Newton's Laws of Motion
- particular forces (weight, normal, tension, drag, friction)
- gravitational force

Circular Motion
- kinematics
- dynamics
  - horizontal circular motion

Momentum
- momentum
- impulse
- momentum conservation

Quarterly Exam 2

Marking Period 3:

Work and Energy
- work (constant force)
- mechanical energy
- energy conversions
- energy conservation
- power

Mechanical Waves
- wave motion
- mechanical waves
- wave characteristics
  - amplitude
  - wavelength
  - frequency
  - period
  - wave speed

Sound vs. Light Waves
- sound is a longitudinal wave
- light is an electromagnetic wave
- amplitude is loudness for sound
- amplitude is brightness/intensity for light
- frequency is pitch for sound
- frequency is color for light

Quarterly Exam 3

Marking Period 4:

Electrostatics
- electrostatic charge
- nature of materials
- Coulomb's Law

DC Circuits
- simple circuits
- series circuits
- parallel circuits

Electromagnetism
- magnetism
  - magnetic force

magnetic field
magnetic force on…
… charged particle
… current carrying wire

Quarterly Exam 4

Unit 1: Measurement

TARGETED STATE STANDARDS:

ELA/ Literacy

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)

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)

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)

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)

Career Ready Practices

CRP4. Communicate clearly and effectively and with reason

CRP8. Utilize critical thinking to make sense of problems and persevere in solving them

CRP11. Use technology to enhance productivity.

UNIT OBJECTIVES/ENDURING UNDERSTANDINGS: (Students will be able to…)

Identify and define SI units

Complete dimensional analysis

Write scientific notation

Identify aspects of the scientific method

Differentiate between precision and accuracy

Analyze graphs by identifying independent and dependent variables and demonstrating understanding of linear relationships

ESSENTIAL QUESTIONS:
How do we represent patterns mathematically?

UNIT ASSESSMENT: (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)
Quarterly Exam
Tests and quizzes
Laboratory activities and reports

Concepts	Skills	Progress Indicators	Activities/Strategies Technology Implementation/ Interdisciplinary Connections	Assessment Check Points
PS2.B: Types of Interactions Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. (HS-PS2- 4),(HS-PS2-5)	**Planning and Carrying Out Investigations** Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS2-5) **Analyzing and Interpreting Data** 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** Use	**Patterns** Empirical evidence is needed to identify patterns. (HE-ESS1-5) **Scale, Proportion, and Quantity** Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). (HS-ESS1-4) **Cause and Effect** Systems can be designed to cause a desired effect (HS-PS2-3) **Systems and System Models** Models (e.g., physical, mathematical, computer models) can be used to simulate systems and	*Use appropriate classroom materials, online and textbook resources (i.e. simulations, measurement tools/instruments/software) for presentation, demonstration, classroom and laboratory activities, and problem solving:* Making measurements activity Lab: Finding Pi	**Formative Assessments**: Exit tickets Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

	mathematical representations of phenomena to describe explanations. (HS-PS2-2),(HS-PS2-4) **Constructing Explanations and Designing Solutions** Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3) **Obtaining, Evaluating, and Communicating Information** Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6) **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)	interactions— including energy, matter, and information flows— within and between systems at different scales. (HS-ETS1-4)		

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
Textbook: *Conceptual Physics Custom Edition* (Hewitt) Phet online simulations (https://phet.colorado.edu/en/simulations/category/physics) Gizmos (https://gizmos.explorelearning.com/) PAER Rutgers (http://www.islephysics.net/pt3/) The Physics Classroom (http://www.physicsclassroom.com/) Pivot Interactives (https://www.pivotinteractives.com/) Physics textbooks Experimental equipment pertinent to lab activities	Modifications will be made to accommodate IEP mandates for classified students

Unit 2: Kinematics

TARGETED STATE STANDARDS:

NGSS

NJSLS/HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

[Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object sliding down a ramp, or a moving object being pulled by a constant force.] [Assessment Boundary: Assessment is limited to macroscopic objects moving at non-relativistic speeds.]

ELA/ Literacy

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)

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)

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)

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)

Technology
8.1.12.A.2 Produce and edit a multi-page digital document for a commercial or professional audience and present it to peers and/or professionals in that related area for review

Career Ready Practices
CRP4. Communicate clearly and effectively and with reason
CRP8. Utilize critical thinking to make sense of problems and persevere in solving them
CRP11. Use technology to enhance productivity.

UNIT OBJECTIVES/ENDURING UNDERSTANDINGS: (Students will be able to…)
Motion is relative to a reference frame
An observer in a particular reference frame can describe the linear motion of an object's center of mass using such quantities as position, displacement, distance, velocity, speed, and acceleration

Displacement, velocity and acceleration are all vector quantities
Displacement is a change in position.
Velocity is the rate of change of position as a function of time.
Acceleration is the rate of change of velocity as a function time.
Changes in each property are expressed by subtracting initial values from final values

$$\square = \frac{\square\square}{\square\square}$$

$$\square = \frac{\square\square}{\square\square}$$

A choice of reference frame determines the direction and the magnitude of each of these quantities.

The kinematic equations only apply to constant acceleration situations.

The three kinematic equations describing linear motion with constant acceleration in one and two dimensions are

$$\square = \square_0 + \square\square\square \qquad \square = \square_\square + \square_0\square\square + \frac{1}{2}\square\square\square^{\ 2} \qquad \square^{\ 2} = \square_\square^2 + 2\square\square\square$$

Vectors can be broken into their components and added

Perpendicular vectors are independent of each other

ESSENTIAL QUESTIONS:
How do we define motion? Why is motion relative?
How do we model the motion of objects?
How do we describe objects in free fall?

UNIT ASSESSMENT: (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)
Quarterly Exam
Tests and quizzes
Laboratory activities and reports

Concepts	Skills	Progress Indicators	Activities/Strategies Technology Implementation/ Interdisciplinary Connections	Assessment Check Points
PS2.B: Types of Interactions Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. (HS-PS2- 4),(HS-PS2-5)	**Planning and Carrying Out Investigations** Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS2-5) **Analyzing and Interpreting Data** 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	**Patterns** Empirical evidence is needed to identify patterns. (HE-ESS1-5) **Scale, Proportion, and Quantity** Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). (HS-ESS1-4) **Cause and Effect** Systems can be designed to cause a desired effect (HS-PS2-3) **Systems and System Models** Models (e.g., physical, mathematical, computer models) can be used to simulate systems and	*Use appropriate classroom materials, online and textbook resources (i.e. simulations, measurement tools/instruments/software) for presentation, demonstration, classroom and laboratory activities, and problem solving:* Express the motion of an object in one dimension using multiple representations (i.e. narrative, dot diagram, video analysis, data table, graphical and mathematical representations). Design an experimental investigation of the motion of an object. Make predictions about the motion of a system based on the fact that acceleration is equal to the	**Formative Assessments**: Exit tickets Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

	design solution. (HS-PS2-1) **Using Mathematics and Computational Thinking** Use mathematical representations of phenomena to describe explanations. (HS-PS2-2),(HS-PS2-4) **Constructing Explanations and Designing Solutions** Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3) **Obtaining, Evaluating, and Communicating Information** Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6)	interactions— including energy, matter, and information flows— within and between systems at different scales. (HS-ETS1-4)	change in velocity per unit time, and velocity is equal to the change in position per unit time.	

	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)			

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
Textbook: *Conceptual Physics Custom Edition* (Hewitt) Phet online simulations (https://phet.colorado.edu/en/simulations/category/physics) Gizmos (https://gizmos.explorelearning.com/) PAER Rutgers (http://www.islephysics.net/pt3/) The Physics Classroom (http://www.physicsclassroom.com/) Pivot Interactives (https://www.pivotinteractives.com/) Physics textbooks Experimental equipment pertinent to lab activities	Modifications will be made to accommodate IEP mandates for classified students

Unit 3: Dynamics

TARGETED STATE STANDARDS:

NGSS

NJSLS/HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

[Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object sliding down a ramp, or a moving object being pulled by a constant force.]

[Assessment Boundary: Assessment is limited to macroscopic objects moving at non-relativistic speeds.]

ELA/ Literacy

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)

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)

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)

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)

Technology
8.1.12.A.2 Produce and edit a multi-page digital document for a commercial or professional audience and present it to peers and/or professionals in that related area for review

Career Ready Practices
CRP4. Communicate clearly and effectively and with reason
CRP8. Utilize critical thinking to make sense of problems and persevere in solving them
CRP11. Use technology to enhance productivity.

UNIT OBJECTIVES/ENDURING UNDERSTANDINGS: (Students will be able to…)
A system is an object or a collection of objects. Objects are treated as having no internal structure.

Forces are described by vectors

Force diagrams are useful tools for visualizing forces being exerted on a single object and writing the equations that represent a physical situation

A force exerted on an object is always due to the interaction of that object with another object

Newton's First Law and Second Law of Motion: The acceleration of an object interacting with other objects can be predicted by:

$$a = \frac{\Sigma F}{m}$$

If an object of interest interacts with several other objects, the net force is the vector sum of the individual forces

Force and acceleration are both vectors, with acceleration in the same direction as the net force.

Newton's Third Law of Motion: If one object exerts a force on a second object, the second object always exerts a force of equal magnitude on the first object in the opposite direction

$$F_{2 \text{ on } 1} = -F_{1 \text{ on } 2}$$

Objects and systems have properties of inertial mass and gravitational mass that are experimentally verified to be the same and that satisfy conservation principles.

Inertial mass is the property of an object or a system that determines how its motion changes when it interacts with other objects or systems.

Gravitational mass is the property of an object or a system that determines the strength of the gravitational interaction with other objects or

systems.

There are fundamental forces in nature

Gravitational forces are exerted at all scales and dominate at the largest distance and mass scale

Electromagnetic forces are exerted at all scales and can dominate at the human scale

The strong force is exerted at nuclear scales and dominates the interactions of nucleons

Field forces result from interaction of one field on another

Gravitational force describes the interaction of one object that has mass with another object that has mass

A gravitational field *g* at the location of an object with mass *m* causes a gravitational force of magnitude *mg* to be exerted on the object in the direction of the field.

On Earth, this gravitational force is called weight

Contact forces result from interaction of one object touching another object, and they arise from interatomic electric forces.

These forces include normal, tension, drag force, and friction

$$|\,|F_{f_s}| \leq |\mu_s F_N|$$

$$|F_{f_k}| = |\mu_k F_N|$$

Normal force and friction force are the perpendicular forces of the surface on an object

ESSENTIAL QUESTIONS:

How can we change the motion of an object?

How do we describe and predict changes in the motion of an object?

UNIT ASSESSMENT: (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)

Quarterly Exam

Tests and quizzes

Laboratory activities and reports

Concepts	Skills	Progress Indicators	Activities/Strategies Technology Implementation/ Interdisciplinary Connections	Assessment Check Points
PS2.A: Forces and Motion Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1) **PS2.B: Types of Interactions** Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. (HS-PS2- 4),(HS-PS2-5)	**Planning and Carrying Out Investigations** Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS2-5) **Analyzing and Interpreting Data** 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	**Patterns** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS2-4) **Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2- 1),(HS-PS2-5) Systems can be designed to cause a desired effect. (HS-PS2-3) **Systems and System Models** When investigating or describing a system, the	*Use appropriate classroom materials, online and textbook resources (i.e. simulations, measurement tools/instruments/software) for presentation, demonstration, classroom and laboratory activities, and problem solving:* Represent forces in diagrams or mathematically using appropriately labeled vectors with magnitude, direction and units during the analysis of a situation. Re-express a force diagram into a mathematical representation, and solve the mathematical representation for the acceleration of the object. Describe a force as an interaction between two	**Formative Assessments**: Exit tickets Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

	design solution. (HS-PS2-1) **Using Mathematics and Computational Thinking** Use mathematical representations of phenomena to describe explanations. (HS-PS2-2),(HS-PS2-4) **Constructing Explanations and Designing Solutions** Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3) **Obtaining, Evaluating, and Communicating Information** Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6)	boundaries and initial conditions of the system need to be defined. (HS-PS2-2) **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-ETS1-4)	objects, and identify both objects for any force. Calculate the gravitational force on an object with mass *m* in a gravitational field of strength *g* in the context of the effects of a net force on objects and systems. Predict the motion of an object subject ot forces exerted by several objects using an application of Newton's Second Law of Motion in a variety of physical situations Express the motion of an object in one dimension using multiple representations (i.e. narrative, dot diagram, video analysis, data table, graphical and mathematical representations).	

	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)			

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
Textbook: *Conceptual Physics Custom Edition* (Hewitt) Phet online simulations (https://phet.colorado.edu/en/simulations/category/physics) Gizmos (https://gizmos.explorelearning.com/) PAER Rutgers (http://www.islephysics.net/pt3/) The Physics Classroom (http://www.physicsclassroom.com/) Pivot Interactives (https://www.pivotinteractives.com/) Physics textbooks Experimental equipment pertinent to lab activities	Modifications will be made to accommodate IEP mandates for classified students

Unit 4: Circular Motion

TARGETED STATE STANDARDS:

NGSS

NJSLS/HS-PS2-1: Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.

[Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object sliding down a ramp, or a moving object being pulled by a constant force.] [Assessment Boundary: Assessment is limited to macroscopic objects moving at non-relativistic speeds.]

ELA/ Literacy

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)

RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)

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)

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)

Technology

8.1.12.A.2 Produce and edit a multi-page digital document for a commercial or professional audience and present it to peers and/or professionals in that related area for review

Career Ready Practices
CRP4. Communicate clearly and effectively and with reason
CRP8. Utilize critical thinking to make sense of problems and persevere in solving them
CRP11. Use technology to enhance productivity.

UNIT OBJECTIVES/ENDURING UNDERSTANDINGS: (Students will be able to…)
For curved and circular motion such as projectiles and orbitals, a system must have a net centripetal force exerted on it perpendicular to the direction of a velocity component toward the center of curvature.

Force and acceleration are both vectors with acceleration in the same direction as the net force

$$a_c = \frac{F_c}{m}$$

Force diagrams are useful tools for visualizing forces being exerted on a single object and writing the equations that represent a physical situation

For uniform circular motion where the velocity is entirely perpendicular to the net centripetal force:

$$a_c = \frac{v^2}{r} \quad v = 2\pi r f \quad f = \frac{1}{T}$$

ESSENTIAL QUESTIONS:
What causes an object to move in uniform circular motion?
Why doesn't Earth "fall into" the Sun?

UNIT ASSESSMENT: (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)
Quarterly Exam
Tests and quizzes
Laboratory activities and reports

Concepts	Skills	Progress Indicators	Activities/Strategies Technology Implementation/ Interdisciplinary Connections	Assessment Check Points
PS2.A: Forces and Motion Newton's second law accurately predicts changes in the motion of macroscopic objects. (HS-PS2-1) **PS2.B: Types of Interactions** Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. (HS-PS2- 4),(HS-PS2-5)	**Planning and Carrying Out Investigations** Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS2-5) **Analyzing and Interpreting Data** 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	**Patterns** Empirical evidence is needed to identify patterns. (HE-ESS1-5) **Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2- 1),(HS-PS2-5)	*Use appropriate classroom materials, online and textbook resources (i.e. simulations, measurement tools/instruments/software) for presentation, demonstration, classroom and laboratory activities, and problem solving:* Create and use force diagrams to analyze physical situations to solve problems with motion qualitatively and quantitatively for horizontal circular motion. Express the motion of an object using narrative and mathematical representations. Design a plan to collect and analyze data for motion from force measurements, and carry out an analysis to	**Formative Assessments**: Exit tickets Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

	design solution. (HS-PS2-1) **Using Mathematics and Computational Thinking** Use mathematical representations of phenomena to describe explanations. (HS-PS2-2),(HS-PS2-4) **Constructing Explanations and Designing Solutions** Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3) **Obtaining, Evaluating, and Communicating Information** Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6)		determine the relationship between the net force and the vector sum of the individual forces.	

	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)			
Resources: Essential Materials, Supplementary Materials, Links to Best Practices Textbook: *Conceptual Physics Custom Edition* (Hewitt) Phet online simulations (https://phet.colorado.edu/en/simulations/category/physics) Gizmos (https://gizmos.explorelearning.com/) PAER Rutgers (http://www.islephysics.net/pt3/) The Physics Classroom (http://www.physicsclassroom.com/) Pivot Interactives (https://www.pivotinteractives.com/) Physics textbooks Experimental equipment pertinent to lab activities			**Instructional Adjustments:** Modifications will be made to accommodate IEP mandates for classified students	

Unit 5: Momentum

TARGETED STATE STANDARDS:

NGSS

NJSLS/HS-PS2-2. Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.
[Clarification Statement: Emphasis is on the quantitative conservation of momentum in interactions and the qualitative meaning of this principle.]
[Assessment Boundary: Assessment is limited to systems of two macroscopic bodies moving in one dimension.]

NJSLS/HS-PS2-3. Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.
[Clarification Statement: Examples of evaluation and refinement could include determining the success of the device at protecting an object from damage and modifying the design to improve it. Examples of a device could include a football helmet or a parachute.]
[Assessment Boundary: Assessment is limited to qualitative evaluations and/or algebraic manipulations.]

ELA/ Literacy

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)
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)
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)
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)

Technology
8.1.12.A.2 Produce and edit a multi-page digital document for a commercial or professional audience and present it to peers and/or professionals in that related area for review

Career Ready Practices
CRP4. Communicate clearly and effectively and with reason
CRP8. Utilize critical thinking to make sense of problems and persevere in solving them
CRP11. Use technology to enhance productivity.

UNIT OBJECTIVES/ENDURING UNDERSTANDINGS: (Students will be able to…)
Momentum is a conserved vector. A net force on a system yields a change in momentum (impulse) over time

$$\Sigma F = \frac{\Delta p}{\Delta t} = \frac{m\Delta V}{\Delta t} = ma \qquad p = mV \qquad \Sigma p_i + \Delta p = \Sigma p_f$$

The momentum of a closed, isolated system is constant.

ESSENTIAL QUESTIONS:
How do we quantify motion?
How do airbags help save lives?

UNIT ASSESSMENT: (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)
Quarterly Exam
Tests and quizzes
Laboratory activities and reports

Concepts	Skills	Progress Indicators	Activities/Strategies Technology Implementation/ Interdisciplinary Connections	Assessment Check Points
PS2.A: Forces and Motion Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2) If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2),(HS-PS2-3) **ETS1.A: Defining and Delimiting Engineering Problems** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary to HS-PS2-3) **ETS1.C: Optimizing the Design Solution** Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the	**Planning and Carrying Out Investigations** Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS2-5) **Analyzing and Interpreting Data** 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)	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-1),(HS-PS2-5) Systems can be designed to cause a desired effect. (HS-PS2-3) **Systems and System Models** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2)	*Use appropriate classroom materials, online and textbook resources (i.e. simulations, measurement tools/instruments/software) for presentation, demonstration, classroom and laboratory activities, and problem solving:* Predict the change in momentum of an object from the average force exerted on the object and the interval of time during which the force is exerted. Define open and closed systems for everyday situations and apply conservation concepts for linear momentum. Apply mathematical routines appropriately to problems involving elastic collisions in one dimension and justify the selection of	**Formative Assessments**: Exit tickets Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

priority of certain criteria over others (trade-offs) may be needed. (secondary to HS-PS2-3)	**Using Mathematics and Computational Thinking** Use mathematical representations of phenomena to describe explanations. (HS-PS2-2),(HS-PS2-4) **Constructing Explanations and Designing Solutions** Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3) **Obtaining, Evaluating, and Communicating Information** Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6)		those mathematical routines based on conservation of momentum and restoration of kinetic energy. Apply the conservation of linear momentum to a closed system of objects involved in an inelastic collision to predict the change in kinetic energy. Design an experimental test of an application of the principle of the conservation of linear momentum, predict an outcome of the experiment using the principle, analyze data generated by that experiment whose uncertainties are expressed numerically, and evaluate the match between the prediction and the outcome.	

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
Textbook: *Conceptual Physics Custom Edition* (Hewitt) Phet online simulations (https://phet.colorado.edu/en/simulations/category/physics) Gizmos (https://gizmos.explorelearning.com/) PAER Rutgers (http://www.islephysics.net/pt3/) The Physics Classroom (http://www.physicsclassroom.com/) Pivot Interactives (https://www.pivotinteractives.com/) Physics textbooks Experimental equipment pertinent to lab activities	Modifications will be made to accommodate IEP mandates for classified students

Unit 6: Energy

TARGETED STATE STANDARDS:

NGSS

NJSLS/HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
[Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.]
[Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]

NJSLS/HS-PS3-2. Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).
[Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]

NJSLS/HS-PS3-3. Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.
[Clarification Statement: Emphasis is on both qualitative and quantitative evaluations of devices. Examples of devices could include Rube Goldberg devices, wind turbines, solar cells, solar ovens, and generators. Examples of constraints could include use of renewable energy forms and efficiency.]
[Assessment Boundary: Assessment for quantitative evaluations is limited to total output for a given input. Assessment is limited to devices constructed with materials provided to students.]

ELA/ Literacy

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)
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)
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)
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)

Technology
8.1.12.A.2 Produce and edit a multi-page digital document for a commercial or professional audience and present it to peers and/or professionals in that related area for review

Career Ready Practices
CRP4. Communicate clearly and effectively and with reason
CRP8. Utilize critical thinking to make sense of problems and persevere in solving them
CRP11. Use technology to enhance productivity.

UNIT OBJECTIVES/ENDURING UNDERSTANDINGS: (Students will be able to…)
A system is an object or a collection of objects. The objects are treated as having no internal structure.

An interaction can be either a force exerted by objects outside the system or the transfer of some quantity with objects outside the system.

The placement of a boundary between a system and its environment is a decision made by the person considering the situation in order to simplify or otherwise assist in analysis.

Work changes the energy of a system, and both are conserved scalar quantities.

The change in kinetic energy of an object depends on the force exerted on the object and on the displacement of the object during the interval that the force is exerted.

Only the component of the net force exerted on an object parallel or antiparallel to the displacement of the object will increase or decrease the

kinetic energy of the object

* A single object can only have kinetic energy

For work done by a constant force: the magnitude of the change in the kinetic energy is the product of the magnitude of the displacement and of the magnitude of the component of force parallel or antiparallel to the displacement

$$Work = F_{\parallel} \cdot \Delta x = F\Delta x \cos\theta = \Delta E$$

The component of the net force exerted on an object perpendicular to the direction of the displacement of the object can change the direction of the motion of the object without changing the kinetic energy of the object. This should include uniform circular motion and projectile motion.

Mechanical Power is the time rate at which work is done or energy is transferred.

$$Power = \frac{\Delta E}{\Delta t} = \frac{work}{\Delta tt} = \Sigma F \cdot v$$

Mechanical energy of a rigid system consists of the sum of kinetic energy and potential energies (gravitational, elastic).
Energy of a rigid system consists of the sum of kinetic energy, potential energies and microscopic internal energy.
For a rigid system:

Translational kinetic energy:

$$KE = \tfrac{1}{2}mv^2$$

Gravitational potential energy:

$$GPE = mgh$$

For all systems under all circumstances, energy is conserved. For an isolated or closed system, conserved quantities are constant. An open system is one that exchanges any conserved quantity with its surroundings.

ESSENTIAL QUESTIONS:

How can we change the energy of a system?
How can we analyze motion in terms of energy?
Why is the first hill of a roller coaster always the tallest?

UNIT ASSESSMENT: (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)
Quarterly Exam
Tests and quizzes
Laboratory activities and reports

Concepts	Skills	Progress Indicators	Activities/Strategies Technology Implementation/ Interdisciplinary Connections	Assessment Check Points
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. (HSPS3-1),(HS-PS3-2) At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HSPS3-2) (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	**Planning and Carrying Out Investigations** Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS2-5) **Developing and Using Models** Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-2),(HSPS3-5)	**Systems and System Models** Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HSPS3-1) **Energy and Matter** Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system. (HSPS3-3) 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)	*Use appropriate classroom materials, online and textbook resources (i.e. simulations, measurement tools/instruments/software) for presentation, demonstration, classroom and laboratory activities, and problem solving:* Define open and closed systems for everyday situations and apply conservation concepts for energy. Make predictions about the changes in kinetic energy of an object in a system based on considerations of the direction of the net force on the object as the object moves. Use net force and velocity vectors to determine qualitatively whether the kinetic energy of an object	**Formative Assessments**: Exit tickets Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

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 (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	**Using Mathematics and Computational Thinking** Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-PS3-1) **Constructing Explanations and Designing Solutions** Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HSPS3-3) **Obtaining, Evaluating, and Communicating Information** Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6)	**Connections to Engineering, Technology, and Applications of Science** **Influence of Science, Engineering, and Technology on Society and the Natural World** Modern civilization depends on major technological systems. Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS3-3) **Connections to Nature of Science Scientific Knowledge Assumes an Order and Consistency in Natural Systems** Science assumes the universe is a vast single system in which basic	would increase, decrease, or remain unchanged. Apply mathematical routines to determine the change in kinetic energy of an object given the forces exerted on the object and the displacement of the object. Calculate the total energy of a system and justify the mathematical routines used in the calculation of component types of energy within the system whose sum is the total energy. Predict changes in the total energy of a system due to changes in position and speed of objects or frictional interactions within the system. Make predictions about the changes in the mechanical energy of a system when a component of an external force acts parallel or antiparallel to the direction of the displacement of the center of mass.	

describe system behavior. (HS-PS3-1) The availability of energy limits what can occur in any system. (HS-PS3-1) **PS3.D: Energy in Chemical Processes** Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3),(HS-PS3-4) **ETS1.A: Defining and Delimiting Engineering Problems** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary to HS-PS3-3)		laws are consistent. (HSPS3-1)	Design an experiment to test conservation concepts.	

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
Textbook: *Conceptual Physics Custom Edition* (Hewitt) Phet online simulations (https://phet.colorado.edu/en/simulations/category/physics) Gizmos (https://gizmos.explorelearning.com/) PAER Rutgers (http://www.islephysics.net/pt3/) The Physics Classroom (http://www.physicsclassroom.com/) Pivot Interactives (https://www.pivotinteractives.com/) Physics textbooks Experimental equipment pertinent to lab activities	Modifications will be made to accommodate IEP mandates for classified students

Unit 7: Waves

TARGETED STATE STANDARDS:

NGSS

NJSLS/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.]

NJSLS/HS-PS3-2: Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects). [Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]

ELA/ Literacy

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)
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)
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) P.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)
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)

Technology
8.1.12.A.2 Produce and edit a multi-page digital document for a commercial or professional audience and present it to peers and/or professionals in that related area for review

Career Ready Practices
CRP4. Communicate clearly and effectively and with reason
CRP8. Utilize critical thinking to make sense of problems and persevere in solving them
CRP11. Use technology to enhance productivity.

UNIT OBJECTIVES/ENDURING UNDERSTANDINGS: (Students will be able to…)
Waves are a repetitive disturbance which translate energy without translating matter. Transverse waves oscillate perpendicular to the direction of motion and longitudinal waves oscillate parallel to the direction of motion. Waves have an amplitude, period, frequency, wavelength, and wave velocity. The wave source determines the frequency and amplitude. The medium determines the wave speed. Wavelength depends on frequency and velocity.

$$\lambda = \frac{v}{f}$$

Mechanical Waves
- wave motion
- mechanical waves
- wave characteristics
  - amplitude
  - wavelength
  - frequency
  - period
  - wave speed

Sound vs. Light Waves
- sound is a longitudinal wave
- light is an electromagnetic wave
- amplitude is loudness for sound

amplitude is brightness/intensity for light
frequency is pitch for sound
frequency is color for light

ESSENTIAL QUESTIONS:
How can you hear someone on a "can phone"?
How do noise canceling headphones work?
How are sound waves and light waves different?

UNIT ASSESSMENT: (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)
Quarterly Exam
Tests and quizzes
Laboratory activities and reports

Concepts	Skills	Progress Indicators	Activities/Strategies Technology Implementation/ Interdisciplinary Connections	Assessment Check Points
NJSLS/HS-PS4-1: Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. **PS3.B: Conservation of Energy and Energy Transfer** 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)	**Analyzing and Interpreting 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** Use mathematical representations of phenomena to describe explanations. (HS-PS2-2),(HS-PS2-4) **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)	**Patterns** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS2-4) **Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2- 1),(HS-PS2-5) **Energy and Matter** 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)	*Use appropriate classroom materials, online and textbook resources (i.e. simulations, measurement tools/instruments/software) for presentation, demonstration, classroom and laboratory activities, and problem solving:* Use a visual representation to construct an explanation of the distinction between transverse and longitudinal waves by focusing on the vibration that generates the wave. Describe representations of transverse and longitudinal waves. Describe sound in terms of transfer of energy and momentum in a medium and relate the concepts to everyday examples.	**Formative Assessments**: Exit tickets Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

	Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1),(HS-PS2-4) **Developing and Using Models** Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-2),(HSPS3-5)	**Systems and System Models** Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HSPS3-1)	Use graphical representation of a periodic mechanical wave to determine the amplitude of the wave. Use a graphical representation of a periodic mechanical wave (position versus time) to determine the period and frequency of the wave and describe how a change in the frequency would modify features of the representation. Use a visual representation of a periodic mechanical wave to determine the wavelength of the wave Explain and/or predict qualitatively how the energy carried by a sound wave relates to the amplitude of the wave and/or apply this concept to a real-world example.	

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
Textbook: *Conceptual Physics Custom Edition* (Hewitt) Phet online simulations (https://phet.colorado.edu/en/simulations/category/physics) Gizmos (https://gizmos.explorelearning.com/) PAER Rutgers (http://www.islephysics.net/pt3/) The Physics Classroom (http://www.physicsclassroom.com/) Pivot Interactives (https://www.pivotinteractives.com/) Physics textbooks Experimental equipment pertinent to lab activities	Modifications will be made to accommodate IEP mandates for classified students

Unit 8: Electrostatics

TARGETED STATE STANDARDS:

NGSS

NJSLS/HS-PS2-4. Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the electrostatic forces between objects.
[Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of electric fields.]
[Assessment Boundary: Assessment is limited to systems with two objects.]

NJSLS/HS-PS3-5. Develop and use a model of two objects interacting through electric fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.
[Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.]
[Assessment Boundary: Assessment is limited to systems containing two objects.]

ELA/ Literacy

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)
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)
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)

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)

Technology
8.1.12.A.2 Produce and edit a multi-page digital document for a commercial or professional audience and present it to peers and/or professionals in that related area for review

Career Ready Practices
CRP4. Communicate clearly and effectively and with reason
CRP8. Utilize critical thinking to make sense of problems and persevere in solving them
CRP11. Use technology to enhance productivity.

UNIT OBJECTIVES/ENDURING UNDERSTANDINGS: (Students will be able to…)
Two different electric charges, which are conventionally referred to as positive charge and negative charge, determine how charged objects interact. Charge is conserved. Electric forces are exerted by electric fields created by changes

$$F_e = k\frac{Q_{source}q_{system}}{\triangle r^2} \qquad k = 9x10^9 Nm^2/C^2$$

The particles which make up atoms are neutrons with no charge and positive protons in the nucleus, and negative electrons outside the central nucleus.

$|q_e| = 1.6x10^{-19}$ C $\qquad m_p = 1.673x10^{-27}$ kg $\qquad m_n = 1.675x10^{-27}$ kg

$m_e = 9.11 \times 10^{-31}$ kg $\qquad 1\ u = 1.66 \times 10^{-27}$ kg

An object can either allow the flow of electrons (conductor), not allow the flow of electrons (insulator), or somewhat allow the flow of electrons (semiconductor).

ESSENTIAL QUESTIONS:
What is the fundamental force responsible for most everyday interactions?
What are the parallels between gravitational force and electrostatic force?

UNIT ASSESSMENTt: (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)
Quarterly Exam
Tests and quizzes
Laboratory activities and reports

Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Activities/Strategies Technology Implementation/ Interdisciplinary Connections	Assessment Check Points
PS1.A: Structure and Properties of Matter The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (secondary to HS-PS2-6) **PS2.B: Types of Interactions** Coulomb's law provides the mathematical model to describe and predict the effects of electrostatic force 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. (HS-PS2-4),(HS-PS2-5) Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects.	**Analyzing and Interpreting 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** Use mathematical representations of phenomena to describe explanations. (HS-PS2-2),(HS-PS2-4) **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** Theories and laws provide explanations in science.	**Patterns** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS2-4) **Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2- 1),(HS-PS2-5) **Energy and Matter** Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or	*Use appropriate classroom materials, online and textbook resources (i.e. simulations, measurement tools/instruments/software) for presentation, demonstration, classroom and laboratory activities, and problem solving.* Make predictions, using the conservation of electric charge, about the sign and relative quantity of net charge of objects or systems after various charging processes, including conservation of charge in simple circuits. Use Coulomb's law qualitatively and quantitatively to make predictions about the interaction between two electric point charges.	**Formative Assessments**: Exit tickets Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

(HS-PS2-6),(secondary to HS-PS1-1),(secondary to HS-PS1-3) **PS3.A: Definitions of Energy** "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (secondary to HS-PS2-5) **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.B: Conservation of Energy and Energy Transfer** 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) **PS3.C: Relationship Between Energy and Forces** When two objects interacting	(HS-PS2- 1),(HS-PS2-4) Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1),(HS-PS2-4) **Developing and Using Models** Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-2),(HSPS3-5)	between systems. (HS-PS3-2)	Connect the concepts of gravitational force and electric force to compare similarities and differences between the forces.	

through a field change relative position, the energy stored in the field is changed. (HS-PS3-5)				
Resources: Essential Materials, Supplementary Materials, Links to Best Practices Textbook: *Conceptual Physics Custom Edition* (Hewitt) Phet online simulations (https://phet.colorado.edu/en/simulations/category/physics) Gizmos (https://gizmos.explorelearning.com/) PAER Rutgers (http://www.islephysics.net/pt3/) The Physics Classroom (http://www.physicsclassroom.com/) Pivot Interactives (https://www.pivotinteractives.com/) Physics textbooks Experimental equipment pertinent to lab activities			**Instructional Adjustments:** Modifications will be made to accommodate IEP mandates for classified students	

Unit 9: DC Circuits

TARGETED STANDARDS:

NGSS

NJSLS/HS-PS3-1. Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.
[Clarification Statement: Emphasis is on explaining the meaning of mathematical expressions used in the model.]
[Assessment Boundary: Assessment is limited to basic algebraic expressions or computations; to systems of two or three components; and to thermal energy, kinetic energy, and/or the energies in gravitational, magnetic, or electric fields.]

ELA/ Literacy

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)
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)
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)
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)

Technology

8.1.12.A.2 Produce and edit a multi-page digital document for a commercial or professional audience and present it to peers and/or professionals in that related area for review

Career Ready Practices
CRP4. Communicate clearly and effectively and with reason
CRP8. Utilize critical thinking to make sense of problems and persevere in solving them
CRP11. Use technology to enhance productivity.

UNIT OBJECTIVES/ENDURING UNDERSTANDINGS: (Students will be able to…)
Electric circuits are conductors connecting a voltage source (like a battery or generator) to a resistor which uses that voltage to convert electric energy to another form.

The amount of charge which flows over time is called electric current

$$I = \frac{\Delta Q}{\Delta t} = \frac{dQ}{dt}.$$

Current in a circuit is dependent on the voltage provided to the circuit's resistors

$$I = \frac{\Delta V}{R}.$$

Voltage used by resistors is dependent on the current and resistance

$$I = \Delta V/R.$$

Resistance of an object is dependent on the shape and size of the object, along with the resistivity the material it is made from.

Multiple resistors can be simplified to a single equivalent resistance.

$$R_{series} = \sum \quad R \qquad \frac{1}{R_{parallel}} = \sum \quad \frac{1}{R}$$

Due to conservation of charge, all currents going into a junction must be the same as all currents leaving a junction.

Due to conservation of energy, the sum of all voltages in any loop is zero.

ESSENTIAL QUESTIONS:
Why does a smartphone charge faster when it isn't being used, but slow when it is?
How do the outlets in a house work?
How can we use electrical energy?

UNIT ASSESSMENT: (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)
Quarterly Exam
Tests and quizzes
Laboratory activities and reports

Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Activities/Strategies Technology Implementation/ Interdisciplinary Connections	Assessment Check Points
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. (HSPS3-1),(HS-PS3-2) At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HSPS3-2) (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	**Using Mathematics and Computational Thinking** Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-PS3-1) **Obtaining, Evaluating, and Communicating Information** Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6) **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural**	**Systems and System Models** Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HSPS3-1)	*Use appropriate classroom materials, online and textbook resources (i.e. simulations, measurement tools/instruments/software) for presentation, demonstration, classroom and laboratory activities, and problem solving.* Create a simple circuit and determine quantities of voltage, resistance, current and electrical power. Conduct and experiment to devise Ohm's Law. Create a series circuit and a parallel circuit and determine quantities of voltage, resistance, current and electrical power.	**Formative Assessments**: Exit tickets Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2) **PS3.B: Conservation of Energy and Energy Transfer** Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1) Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4) Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative	**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)			

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)				
Resources: Essential Materials, Supplementary Materials, Links to Best Practices Textbook: *Conceptual Physics Custom Edition* (Hewitt) Phet online simulations (https://phet.colorado.edu/en/simulations/category/physics) Gizmos (https://gizmos.explorelearning.com/) PAER Rutgers (http://www.islephysics.net/pt3/) The Physics Classroom (http://www.physicsclassroom.com/) Pivot Interactives (https://www.pivotinteractives.com/) Physics textbooks Experimental equipment pertinent to lab activities			**Instructional Adjustments:** Modifications will be made to accommodate IEP mandates for classified students	

Unit 10: Electromagnetism

TARGETED STANDARDS:

NGSS

NJSLS/HS-PS2-5. Plan and conduct an investigation to provide evidence that an electric current can produce a magnetic field and that a changing magnetic field can produce an electric current.
[Assessment Boundary: Assessment is limited to designing and conducting investigations with provided materials and tools.]

NJSLS/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.
[Clarification Statement: Examples of models could include drawings, diagrams, and texts, such as drawings of what happens when two charges of opposite polarity are near each other.]
[Assessment Boundary: Assessment is limited to systems containing two objects.]

ELA/ Literacy

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)
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)
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)

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)

Technology
8.1.12.A.2 Produce and edit a multi-page digital document for a commercial or professional audience and present it to peers and/or professionals in that related area for review

Career Ready Practices
CRP4. Communicate clearly and effectively and with reason
CRP8. Utilize critical thinking to make sense of problems and persevere in solving them
CRP11. Use technology to enhance productivity.

UNIT OBJECTIVES/ENDURING UNDERSTANDINGS: (Students will be able to…)
Magnetic properties.

Magnetic fields are created by changing electric fields and exert magnetic force on changing electric fields.

Similarly, a changing magnetic flux over time creates a voltage.

ESSENTIAL QUESTIONS:
What is the relationship between electricity and magnetism?

UNIT ASSESSMENT: (What is the evidence (authentic) that students have achieved the targeted standards/unit objectives?)
Quarterly Exam
Tests and quizzes
Laboratory activities and reports

Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Activities/Strategies Technology Implementation/ Interdisciplinary Connections	Assessment Check Points
PS2.B: Types of Interactions Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4),(HS-PS2-5) **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)	**Planning and Carrying Out Investigations** Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS2-5) **Analyzing and Interpreting Data** 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)	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2- 1),(HS-PS2-5)	*Use appropriate classroom materials, online and textbook resources (i.e. simulations, measurement tools/instruments/software) for presentation, demonstration, classroom and laboratory activities, and problem solving.* Observe the effects of a force exerted on a moving charged object by a magnetic field. Observe the effects of a force exerted on a current-carrying wire by a magnetic field.	**Formative Assessments**: Exit tickets Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

	Using Mathematics and Computational Thinking Use mathematical representations of phenomena to describe explanations. (HS-PS2-2),(HS-PS2-4) **Obtaining, Evaluating, and Communicating Information** Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6) **Developing and Using Models** Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-2),(HSPS3-5)			

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
Textbook: *Conceptual Physics Custom Edition* (Hewitt) Phet online simulations (https://phet.colorado.edu/en/simulations/category/physics) Gizmos (https://gizmos.explorelearning.com/) PAER Rutgers (http://www.islephysics.net/pt3/) The Physics Classroom (http://www.physicsclassroom.com/) Pivot Interactives (https://www.pivotinteractives.com/) Physics textbooks Experimental equipment pertinent to lab activities	Modifications will be made to accommodate IEP mandates for classified students