PUBLIC SCHOOLS OF EDISON TOWNSHIP

OFFICE OF CURRICULUM AND INSTRUCTION

Physics Honors

Length of Course:	Term
Elective/Required:	Required
Schools:	High School
Eligibility:	Grade 11
Credit Value:	6 Credits
Date Approved:	August 24, 2020

TABLE OF CONTENTS

STATEMENT OF PURPOSE

The Honors Physics curriculum is a college preparatory, laboratory based, 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. 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. A lab-based/inquiry physics course is structured so that students actively engage in scientific and engineering practices and experiences provided for students should engage them with fundamental questions about the world and with how scientists have investigated and found answers to those questions. Students should have the opportunity to carry out scientific investigations and engineering design projects related to the disciplinary core ideas in physics. Students will use scientific inquiry to understand science concepts and develop explanations of natural phenomena. The purpose of learning physics is both the understanding of basic concepts and the application of problem solving skills developed during that process.

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

Coordinated by:
Laurie Maier, Science Supervisor EHS/JPS

COURSE OBJECTIVES

By the end of the Honors Physics 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-PS4-2)** Evaluate questions about the advantages of using digital transmission and storage of information.

- **(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.

Weather and Climate

- **(NJSLS/HS-ESS2-4**) Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

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
9.2.12.CAP.4: Evaluate different careers and develop various plans (e.g., costs of public, private, training schools) and timetables for achieving them, including educational/training requirements, costs, loans, and debt repayment.
9.2.12.CAP.5: Assess and modify a personal plan to support current interests and postsecondary plans.
9.2.12.CAP.6: Identify transferable skills in career choices and design alternative career plans based on those skills.
9.2.12.CAP.7: Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest.
9.2.12.CAP.13: Analyze how the economic, social, and political conditions of a time period can affect the labor market.

TIMELINE AND PACING GUIDE

Marking Period 1:

Kinematics

- reference frames
- position, displacement
- average velocity
- constant acceleration
- free fall
- graphical analysis
- unit analysis

- vectors, scalars
- constant velocity 2D
- projectile motion
- relative velocity

Dynamics

- force, mass
- four fundamental forces
- Newton's Laws of Motion
- particular forces (weight, normal, tension, drag, friction)
- 1D and 2D
  - forces at an angle
  - inclined planes

Quarterly Exam 1

Marking Period 2:

Circular Motion
- kinematics
- dynamics
  - horizontal circular motion
  - vertical circular motion
- banked turns

Gravitation
- Kepler's Laws of Planetary Motion
- Universal Gravitation

Work and Energy
- work (constant force)
- work (variable force)
- mechanical energy
- energy conversions
- energy conservation
  - (includes discussion of internal energy)
- power

Momentum
- momentum
- impulse
- momentum conservation
  - 1D and 2D

Quarterly Exam 2

Marking Period 3:

Oscillations
- simple harmonic motion
  - spring oscillations
  - simple pendulum
- energy of simple harmonic motion

Mechanical Waves
- wave motion
- mechanical waves
- wave properties
  - reflection
  - refraction
  - diffraction
  - interference

Sound
- characteristics of sound
- string instruments
- wind instruments
- resonance
- beats

Geometric Optics
- Ray Model of Light
- reflection
- mirrors
- refraction
- lenses

Quarterly Exam 3

Marking Period 4:

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

Electric Field and Electric Potential
- electric field
- electric potential and electric potential difference
- electric potential energy

DC Circuits
- simple circuits
- series circuits
- parallel circuits
- combination circuits

Electromagnetism
- magnetism
  - magnetic force
  - magnetic field
- magnetic force on…
  - … charged particle
  - … current carrying wire

Quarterly Exam 4

(Optional) Special Relativity
- Postulates of Special Relativity
- simultaneity
- time dilation, length contraction
- space-time
- relativistic momentum
- mass-energy equivalence

Unit 1: Kinematics	4 weeks

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.]

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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 change in position.
Velocity is the rate of change of position with time.
Acceleration is the rate of change of velocity with time.
Changes in each property are expressed by subtracting initial values from final values

$$v = \frac{\Delta x}{\Delta t}$$

$$a = \frac{\Delta V}{\Delta t}$$

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

$$v = v_0 + a\Delta t \qquad x = x_o + v_0\Delta t + \frac{1}{2}a\Delta t \quad ^2 \quad v \quad ^2 = v_o^2 + 2a\Delta x$$

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?
How is motion in one dimension affected by motion in another dimension?

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	**Planning and Carrying Out Investigations** Plan and conduct an	**Patterns** Empirical evidence is needed to identify	*Use appropriate classroom materials, online and textbook resources (i.e.*	**<u>Formative Assessments</u>**: Exit tickets

(gravitational, electric, and magnetic) permeating space that can transfer energy through space. (HS-PS2- 4),(HS-PS2-5)	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 mathematical representations of phenomena to describe explanations. (HS-PS2-2),(HS-PS2-4) **Constructing Explanations and Designing Solutions**	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 interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-ETS1-4)	*simulations, measurement tools/instruments/software) for presentation, demonstration, classroom and laboratory activities, and problem solving:* Express the motion of an object in one and two dimensions using multiple representations (i.e. narrative, dot diagram, video analysis, data table, graphical and mathematical representations) and ranking tasks 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 change in velocity per unit time, and velocity is equal to the change in position per unit time.	Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

	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)			

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
Textbook: *Physics Principles with Applications 7th Edition* (Giancoli) Gizmos: https://www.explorelearning.com/ Phet online simulations (https://phet.colorado.edu/en/simulations/category/physics) PAER Rutgers (http://www.islephysics.net/pt3/) The Physics Classroom (http://www.physicsclassroom.com/) Twu Physics (https://sites.google.com/site/twuphysicslessons/) Physics textbooks Experimental equipment pertinent to lab activities	Modifications will be made to accommodate IEP mandates for classified students

Unit 2: Dynamics	3 weeks

TARGETED STATE STANDARDS:

NGSS

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9.2.12.CAP.13: Analyze how the economic, social, and political conditions of a time period can affect the labor market.

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 design solution. (HS-PS2-1)	**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

	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) **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena**	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. Design an experiment for collecting data to determine the relationship between the net force exerted on an object, its inertial mass, and its acceleration. Design a plan for collecting data to measure gravitational mass and inertial mass and to distinguish between the two experiments. 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. Analyze a scenario and make claims (develop arguments, justify assertions) about the forces exerted on an object by other objects for different types of forces or components of forces.	

	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)		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 and two dimensions using multiple representations (i.e. narrative, dot diagram, video analysis, data table, graphical and mathematical representations) and ranking tasks	

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
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Unit 3: Circular Motion	1.5 weeks

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
9.2.12.CAP.4: Evaluate different careers and develop various plans (e.g., costs of public, private, training schools) and timetables for achieving them, including educational/training requirements, costs, loans, and debt repayment.
9.2.12.CAP.5: Assess and modify a personal plan to support current interests and postsecondary plans.
9.2.12.CAP.6: Identify transferable skills in career choices and design alternative career plans based on those skills.
9.2.12.CAP.7: Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest.
9.2.12.CAP.13: Analyze how the economic, social, and political conditions of a time period can affect the labor market.

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:

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

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,	**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, vertical circular motion and banked turns. Express the motion of an object using narrative and	**Formative Assessments**: Exit tickets Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

	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) **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		mathematical representations. Design a plan to collect and analyze data for motion from force measurements, and carry out an analysis to determine the relationship between the net force and the vector sum of the individual forces.	

	(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)			

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
Textbook: *Physics Principles with Applications 7th Edition* (Giancoli) Gizmos: https://www.explorelearning.com/ Phet online simulations (https://phet.colorado.edu/en/simulations/category/physics) PAER Rutgers (http://www.islephysics.net/pt3/) The Physics Classroom (http://www.physicsclassroom.com/) Twu Physics (https://sites.google.com/site/twuphysicslessons/) Physics textbooks Experimental equipment pertinent to lab activities	Modifications will be made to accommodate IEP mandates for classified students

Unit 4: Gravitation	1 week

TARGETED STATE STANDARDS:

NGSS

NJSLS/HS-ESS1-4: Use mathematical or computational representations to predict the motion of orbiting objects in the solar system.
[Clarification Statement: Emphasis is on Newtonian gravitational laws governing orbital motions, which apply to human-made satellites as well as planets and moons.]
[Assessment Boundary: Mathematical representations for the gravitational attraction of bodies and Kepler's Laws of orbital motions should not deal with more than two bodies, nor involve calculus.]

NJSLS/HS-PS2-4: Use mathematical representations of Newton's Law of Gravitation to describe and predict the gravitational forces between objects.
[Clarification Statement: Emphasis is on both quantitative and conceptual descriptions of gravitational fields.]
[Assessment Boundary: Assessment is limited to systems with 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
9.2.12.CAP.4: Evaluate different careers and develop various plans (e.g., costs of public, private, training schools) and timetables for achieving them, including educational/training requirements, costs, loans, and debt repayment.
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9.2.12.CAP.7: Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest.
9.2.12.CAP.13: Analyze how the economic, social, and political conditions of a time period can affect the labor market.

UNIT OBJECTIVES/ENDURING UNDERSTANDINGS: (Students will be able to…)
A vector field gives, as a function of position (and perhaps time), the value of a physical quantity that is described by a vector.
Vector fields are represented by field vectors indicating direction and magnitude

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

Gravitational force describes the interaction of one object with mass with another object with mass
The gravitational force is always attractive
The magnitude of force between two spherically symmetric objects of mass m_1 and m_2 is $G(m_1m_2)/r^2$, where r is the center-to-center distance between the objects.
G is the fundamental constant of the gravitational interaction in our universe.

$$F_g = G\frac{M_{source}m_{system}}{r^2} = m_{system}g \qquad G = 6.67x10^{-11}\frac{m^3}{kg\ s^2}$$

In a narrow range of heights above Earth's surface, the local gravitational field, g, is approximately constant.

$$g = \frac{F_g}{m_{system}} = 9.8\frac{N}{kg}\ on\ Earth's\ surface \qquad a = g\ if\ \Sigma F = F_g$$

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

The gravitational field at a point in space is measured by dividing the gravitational force exerted by the field on a test object at that point by the mass of the test object and has the same direction as the force.

The gravitational field caused by a spherically symmetric object with mass is radial and, outside the object, varies as the inverse square of the radial distance from the center of that object.

$$g = G\frac{M_{source}}{r^2}$$

Projectiles and orbitals only have the gravitational force changing their motion, with a component of velocity perpendicular to the gravitational force

Describe the following relevant components in the given mathematical or computational representations of orbital motion: the trajectories of orbiting bodies, including planets, moons, or human-made spacecraft; each of which depicts a revolving body's eccentricity *e* = *f*/*d*, where *f* is the distance between foci of an ellipse, and *d* is the ellipse's major axis length (Kepler's first law of planetary motion).

Given mathematical or computational representations of orbital motion to depict that the square of a revolving body's period of revolution is proportional to the cube of its distance to a gravitational center (T 2 ∝ R 3 , where T is the orbital period and R is the semimajor axis of the orbit — Kepler's third law of planetary motion).

$\frac{r^2}{T^3} = \frac{r\prime^2}{T\prime^3}$around the same mass

ESSENTIAL QUESTIONS:

How do we keep track of time?
Why do objects orbit around each other in space?
Why doesn't Earth "fall into" the Sun?
What is "weightlessness"?

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 Newton's law of universal gravitation provides the mathematical model to describe and predict the effects of gravitational 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) **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)	**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) **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**	**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 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:* Use Newton's Law of Gravitation to calculate the gravitational force that two objects exert on each other and use that force in contexts other than orbital motion. 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. Calculate the gravitational field due to an object with mass *m*, where the field is	**Formative Assessments**: Exit tickets Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

	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)		a vector directed toward the center of the object of mass *m*. Approximate a numerical value of the gravitational field (*g*) near the surface of an object from its radius and mass relative to those of Earth or other reference objects.	

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
Textbook: *Physics Principles with Applications 7th Edition* (Giancoli) Gizmos: https://www.explorelearning.com/ Phet online simulations (https://phet.colorado.edu/en/simulations/category/physics) PAER Rutgers (http://www.islephysics.net/pt3/) The Physics Classroom (http://www.physicsclassroom.com/) Twu Physics (https://sites.google.com/site/twuphysicslessons/) Physics textbooks Experimental equipment pertinent to lab activities	Modifications will be made to accommodate IEP mandates for classified students

Unit 5: Work and Energy	2 weeks

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.]

NJSLS/HS-ESS2-4. Use a model to describe how variations in the flow of energy into and out of Earth's systems result in changes in climate.

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

9.2.12.CAP.4: Evaluate different careers and develop various plans (e.g., costs of public, private, training schools) and timetables for achieving them, including educational/training requirements, costs, loans, and debt repayment.
9.2.12.CAP.5: Assess and modify a personal plan to support current interests and postsecondary plans.
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9.2.12.CAP.7: Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest.
9.2.12.CAP.13: Analyze how the economic, social, and political conditions of a time period can affect the labor market.

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.

For work done <u>by</u> a variable spring force:

$$Work = \tfrac{1}{2}kx_I^2 - \tfrac{1}{2}kx_F^2$$

$$F_{restoring} = -k\,\Delta x$$

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:

$$\Delta U_G = mg\Delta h$$

Elastic potential energy:

$$U_S = \tfrac{1}{2}kx_F^2$$

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?
Why haven't humans created a perpetual motion machine?

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

Unit 6: Momentum	1 week

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
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9.2.12.CAP.5: Assess and modify a personal plan to support current interests and postsecondary plans.
9.2.12.CAP.6: Identify transferable skills in career choices and design alternative career plans based on those skills.
9.2.12.CAP.7: Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest.
9.2.12.CAP.13: Analyze how the economic, social, and political conditions of a time period can affect the labor market.

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

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

ESSENTIAL QUESTIONS:
How do we quantify motion?
How do airbags help save lives?
What happens when objects collide and how can this be mitigated?

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	**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. Perform an analysis on data presented as a force-time graph and predict the change in momentum of a system. Define open and closed systems for everyday situations and apply conservation concepts for linear momentum.	**Formative Assessments**: Exit tickets Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

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 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)		Apply mathematical routines appropriately to problems involving elastic collisions in one dimension and justify the selection of 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. Classify a given collision situation as elastic or inelastic, justify the selection of conservation of linear momentum and restoration	

			of kinetic energy as the appropriate principles for analyzing an elastic collision, solve for missing variables, and calculate their values.	

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	**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

energy can be modeled as a combination of energy associated with the motion of particles and energy associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2) **PS3.B: Conservation of Energy and Energy Transfer** Conservation of energy means that the total change of energy in any system is always equal to the total 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,	**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 laws are consistent.	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.	

which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1) The availability of energy limits what can occur in any system. (HS-PS3-1) **PS3.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		(HSPS3-1)	Create a representation or model showing that a single object can only have kinetic energy and use information about that object to calculate its kinetic energy. Translate between a representation of a single object, which can only have kinetic energy, and a system that includes the object, which may have both kinetic and potential energies. Describe and make predictions about the internal energy of systems. Design an experiment and analyze graphical data in which interpretations of the area under a force-distance curve are needed to determine the work done on or by the object or system. Predict and calculate from graphical data the energy transfer to or work done on an object or system from information about a force exerted on the object or system through a distance.	

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)			Design an experiment to test conservation concepts.	

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
Textbook: *Physics Principles with Applications 7th Edition* (Giancoli) Gizmos: https://www.explorelearning.com/ Phet online simulations (https://phet.colorado.edu/en/simulations/category/physics) PAER Rutgers (http://www.islephysics.net/pt3/) The Physics Classroom (http://www.physicsclassroom.com/) Twu Physics (https://sites.google.com/site/twuphysicslessons/) Physics textbooks Experimental equipment pertinent to lab activities	Modifications will be made to accommodate IEP mandates for classified students

Unit 7: Oscillations	1 week

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.]

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)
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
9.2.12.CAP.4: Evaluate different careers and develop various plans (e.g., costs of public, private, training schools) and timetables for achieving them, including educational/training requirements, costs, loans, and debt repayment.
9.2.12.CAP.5: Assess and modify a personal plan to support current interests and postsecondary plans.
9.2.12.CAP.6: Identify transferable skills in career choices and design alternative career plans based on those skills.
9.2.12.CAP.7: Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest.
9.2.12.CAP.13: Analyze how the economic, social, and political conditions of a time period can affect the labor market.

UNIT OBJECTIVES/ENDURING UNDERSTANDINGS: (Students will be able to…)
Simple harmonic motion is the result of a restoring force that is proportional to the displacement from equilibrium

For simple harmonic motion, mechanical energy is constant

$$E = KE + U_{spring}$$

$$E = \frac{1}{2} mv^2 + \frac{1}{2} kx^2$$

$$E = \frac{1}{2} mv_{max}^2 = \frac{1}{2} kx_{max}^2$$

Angular frequency of spring oscillation is:

$$\omega_s = \sqrt{\frac{k}{m}}$$

Period of spring oscillation is:

$$T_s = 2\pi\sqrt{\frac{m}{k}}$$

Period of pendulum oscillation is:

$$T_p = 2\pi\sqrt{\frac{L}{g}}$$

ESSENTIAL QUESTIONS:
At what point during a bungee jump will you reach your greatest speed?

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) **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) The availability of energy limits what can occur in any	**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**	**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)	Predict which properties determine the motion of a simple harmonic oscillator and what the dependence of the motion is on those properties. Design a plan and collect data in order to ascertain the characteristics of the motion of a system undergoing oscillatory motion caused by a restoring force. Analyze data to identify qualitative and quantitative relationships between given values and variables (i.e. force, displacement, acceleration, velocity, period of motion, frequency, spring constant, string length, mass) associated with objects in oscillatory motion and use	**Formative Assessments**: Exit tickets Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

system. (HS-PS3-1)	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) **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)	those data to determine the value of an unknown. Calculate the expected behavior of a system using the object model (i.e. by ignoring changes in internal structure) to analyze a situation. Then, when the model fails, the student can justify the use of conservation of energy principles to calculate the change in internal energy due to changes in internal structure because the object is actually a system. Calculate changes in kinetic energy and potential energy of a system using information from representations of that system.	

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
Textbook: *Physics Principles with Applications 7th Edition* (Giancoli) Gizmos: https://www.explorelearning.com/ Phet online simulations (https://phet.colorado.edu/en/simulations/category/physics) PAER Rutgers (http://www.islephysics.net/pt3/) The Physics Classroom (http://www.physicsclassroom.com/) Twu Physics (https://sites.google.com/site/twuphysicslessons/) Physics textbooks Experimental equipment pertinent to lab activities	Modifications will be made to accommodate IEP mandates for classified students

Unit 8: Mechanical Waves and Sounds	2 weeks

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)
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
9.2.12.CAP.4: Evaluate different careers and develop various plans (e.g., costs of public, private, training schools) and timetables for achieving them, including educational/training requirements, costs, loans, and debt repayment.
9.2.12.CAP.5: Assess and modify a personal plan to support current interests and postsecondary plans.
9.2.12.CAP.6: Identify transferable skills in career choices and design alternative career plans based on those skills.
9.2.12.CAP.7: Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest.
9.2.12.CAP.13: Analyze how the economic, social, and political conditions of a time period can affect the labor market.

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.

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

Amplitudes add as described by the principle of superposition.

Possible standing waves are called harmonics.

Sound in terms of transfer of energy and momentum in a medium and relate the concepts to everyday examples. Predict the properties of standing sound waves in open and closed pipes or on strings with fixed or unfixed ends.

Beats arise from combining two sound waves of slightly different frequencies.

ESSENTIAL QUESTIONS:
How can you hear someone on a "can phone"?

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	**Analyzing and Interpreting Data**	**Patterns** Different patterns may	Use a visual representation to construct an explanation	**Formative Assessments**: Exit tickets

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)	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) Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1),(HS-PS2-4)	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) **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	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. 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	Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

	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)	inherent in models. (HSPS3-1)	wave to determine the wavelength of the wave Use representations of individual pulses and construct representations to model the interaction of two wave pulses to analyze the superposition of two pulses. Predict properties of standing waves that result from the addition of incident and reflected waves that are confined to a region and have nodes and antinodes. 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. Calculate wavelengths and frequencies (if given wave speed) of standing waves based on boundary conditions and length of region within which the wave is confined and calculate numerical values	

			of wavelengths and frequencies. Examples include musical instruments.	

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
Textbook: *Physics Principles with Applications 7th Edition* (Giancoli) Gizmos: https://www.explorelearning.com/ Phet online simulations (https://phet.colorado.edu/en/simulations/category/physics) PAER Rutgers (http://www.islephysics.net/pt3/) The Physics Classroom (http://www.physicsclassroom.com/) Twu Physics (https://sites.google.com/site/twuphysicslessons/) Physics textbooks Experimental equipment pertinent to lab activities	Modifications will be made to accommodate IEP mandates for classified students

Unit 9: Geometric Optics	2 weeks

TARGETED STATE STANDARDS:

NGSS

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. [Clarification Statement: Emphasis is on how the experimental evidence supports the claim and how a theory is generally modified in light of new evidence. Examples of a phenomenon could include resonance, diffraction, and photoelectric effect.] [Assessment Boundary: Assessment does not include using quantum theory.]

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
9.2.12.CAP.4: Evaluate different careers and develop various plans (e.g., costs of public, private, training schools) and timetables for achieving them, including educational/training requirements, costs, loans, and debt repayment.
9.2.12.CAP.5: Assess and modify a personal plan to support current interests and postsecondary plans.
9.2.12.CAP.6: Identify transferable skills in career choices and design alternative career plans based on those skills.
9.2.12.CAP.7: Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest.
9.2.12.CAP.13: Analyze how the economic, social, and political conditions of a time period can affect the labor market.

UNIT OBJECTIVES/ENDURING UNDERSTANDINGS: (Students will be able to…)
Reflection and Law of Reflection
Image formation from plane mirror, concave mirror, convex mirror
Refraction and Snell's Law
Image formation from thin concave lens and thin convex lens

ESSENTIAL QUESTIONS:
How tall must a full length mirror be?

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-PS4-3: 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.	**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	**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)	Contrast mechanical and electromagnetic waves in terms of the need for a medium in wave propagation. Make claims using connections across concepts about the behavior of light as the wave travels from one medium into another, as some is transmitted, some is reflected, and some is absorbed. Make predictions about the locations of object and image relative to the location of a reflecting surface. The prediction should be based on the model of specular reflection with all angles measured relative to the normal to the surface.	**Formative Assessments**: Exit tickets Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

	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) **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)	Describe models of light traveling across a boundary from one transparent material to another when the speed of propagation changes, causing a change in the path of the light ray at the boundary of the two media. Plan data collection strategies as well as perform data analysis and evaluation of the evidence for finding the relationship between the angle of incidence and the angle of refraction for light crossing boundaries from one transparent material to another (Snell's law). Make claims and predictions about path changes for light traveling across a boundary from one transparent material to another at non-normal angles resulting from changes in the speed of propagation. Plan data collection strategies and perform data analysis and	

			evaluation of evidence about the formation of images due to reflection of light from curved spherical mirrors. Use quantitative and qualitative representations and models to analyze situations and solve problems about image formation occurring due to the reflection of light from surfaces. Use quantitative and qualitative representations and models to analyze situations and solve problems about image formation occurring due to the refraction of light through thin lenses Plan data collection strategies, perform data analysis and evaluation of evidence, and refine scientific questions about the formation of images due to refraction for thin lenses.	

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
Textbook: *Physics Principles with Applications 7th Edition* (Giancoli) Gizmos: https://www.explorelearning.com/ Phet online simulations (https://phet.colorado.edu/en/simulations/category/physics) PAER Rutgers (http://www.islephysics.net/pt3/) The Physics Classroom (http://www.physicsclassroom.com/) Twu Physics (https://sites.google.com/site/twuphysicslessons/) Physics textbooks Experimental equipment pertinent to lab activities	Modifications will be made to accommodate IEP mandates for classified students

Unit 10: Electrostatics	2 weeks

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
9.2.12.CAP.4: Evaluate different careers and develop various plans (e.g., costs of public, private, training schools) and timetables for achieving them, including educational/training requirements, costs, loans, and debt repayment.
9.2.12.CAP.5: Assess and modify a personal plan to support current interests and postsecondary plans.
9.2.12.CAP.6: Identify transferable skills in career choices and design alternative career plans based on those skills.
9.2.12.CAP.7: Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest.
9.2.12.CAP.13: Analyze how the economic, social, and political conditions of a time period can affect the labor market.

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

$$F_e = k\frac{Q_{source}q_{system}}{\triangle r^2} = Eq_{system} \quad \varepsilon_o = 8.85\,x\,10^{-12}C^2/Nm^2 \quad k = 9x10^9 Nm^2/C^2 = \frac{1}{4\pi\varepsilon_o}$$

$$U_e = k\frac{Q_{source}q_{system}}{r} = qV \qquad E = \frac{F_e}{q_{system}} = \frac{dV}{dx} = k\frac{Q_{source}}{dr^2} \qquad V = \frac{U_e}{q_{system}}$$

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 $m_p = 1.673x10^{-27}$ kg = $938.3x10^8$ eV $m_n = 1.675x10^{-27}$ kg = $939.6x10^8$ eV

$m_e = 9.11 \times 10^{-31}$ kg = 5.11×10^5 eV 1 u = 1.66×10^{-27} kg = 931 MeV/c^2

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?
How does one charged particle "know" to attract/repel another?
Why do we get electrically shocked?

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	**Analyzing and Interpreting Data** Analyze data using tools,	**Patterns** Different patterns may be observed at each of	Make predictions, using the conservation of electric charge, about the sign and	**Formative Assessments**: Exit tickets Laboratory activities

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. (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-	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) Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1),(HS-PS2-4)	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)	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. Connect the concepts of gravitational force and electric force to compare similarities and differences between the forces. Describe the electric force that results from the interaction of several separated point charges (generally two to four point charges, though more are permitted in situations of high symmetry) using appropriate mathematics. Predict the direction and the magnitude of the force exerted on an object with an electric charge q placed in an electric field E using	Classwork Homework **<u>Summative Assessments</u>:** Tests Quizzes Laboratory reports Project Quarterly exam

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 through a field change relative position, the energy stored in the field is changed. (HS-PS3-5)	**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)		the mathematical model of the relation between an electric force and an electric field. Calculate any one of the variables—electric force, electric charge, and electric field—at a point given the values and sign or direction of the other two quantities.	

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
Textbook: *Physics Principles with Applications 7th Edition* (Giancoli) Gizmos: https://www.explorelearning.com/ Phet online simulations (https://phet.colorado.edu/en/simulations/category/physics) PAER Rutgers (http://www.islephysics.net/pt3/) The Physics Classroom (http://www.physicsclassroom.com/) Twu Physics (https://sites.google.com/site/twuphysicslessons/) Physics textbooks Experimental equipment pertinent to lab activities	Modifications will be made to accommodate IEP mandates for classified students

Unit 11: DC Circuits	2 weeks

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
9.2.12.CAP.4: Evaluate different careers and develop various plans (e.g., costs of public, private, training schools) and timetables for achieving them, including educational/training requirements, costs, loans, and debt repayment.
9.2.12.CAP.5: Assess and modify a personal plan to support current interests and postsecondary plans.
9.2.12.CAP.6: Identify transferable skills in career choices and design alternative career plans based on those skills.
9.2.12.CAP.7: Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest.
9.2.12.CAP.13: Analyze how the economic, social, and political conditions of a time period can affect the labor market.

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

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

The electromotive force abbreviated as EMF [ε] is the ideal potential difference provided by a battery if it had no internal resistance.

$$\Delta V_{terminal} = \varepsilon - Ir_{internal}$$

Resistance of an object is dependent on the shape and size of the object, along with the resistivity the material it is made from as $R = \rho\frac{l}{A}$.

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. This is called Kirchoff's junction rule.

$$\Sigma I_{in\ junction} = \Sigma I_{out\ junction}$$

Due to conservation of energy, the sum of all voltages in any loop is zero. This is called Kirchoff's loop rule.

$$\Delta V_{loop} = 0$$

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?
How is electric potential energy distributed throughout a circuit?

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	**Using Mathematics and Computational Thinking**	**Systems and System Models**	Apply conservation of energy concepts to the	**Formative Assessments**: Exit tickets

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 associated with the configuration (relative position of the particles). In some cases the relative position energy can be thought of as	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 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.	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)	design of an experiment that will demonstrate the validity of Kirchhoff's loop rule in a circuit with only a battery and resistors either in series or in, at most, one pair of parallel branches. Apply conservation of energy (Kirchhoff's loop rule) in calculations involving the total electric potential difference for complete circuit loops with only a single battery and resistors in series and/or in, at most, one parallel branch. Apply conservation of electric charge (Kirchhoff's junction rule) to the comparison of electric current in various segments of an electrical circuit with a single battery and resistors in series and in, at most, one parallel branch and predict how those values would change if configurations of the circuit are changed.	Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

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	(HS-PS2-1),(HS-PS2-4)			

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	**Instructional Adjustments:**
Textbook: *Physics Principles with Applications 7th Edition* (Giancoli) Gizmos: https://www.explorelearning.com/ Phet online simulations (https://phet.colorado.edu/en/simulations/category/physics) PAER Rutgers (http://www.islephysics.net/pt3/) The Physics Classroom (http://www.physicsclassroom.com/) Twu Physics (https://sites.google.com/site/twuphysicslessons/) Physics textbooks Experimental equipment pertinent to lab activities	Modifications will be made to accommodate IEP mandates for classified students

Unit 12: Electromagnetism	2 weeks

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
9.2.12.CAP.4: Evaluate different careers and develop various plans (e.g., costs of public, private, training schools) and timetables for achieving them, including educational/training requirements, costs, loans, and debt repayment.
9.2.12.CAP.5: Assess and modify a personal plan to support current interests and postsecondary plans.
9.2.12.CAP.6: Identify transferable skills in career choices and design alternative career plans based on those skills.
9.2.12.CAP.7: Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest.
9.2.12.CAP.13: Analyze how the economic, social, and political conditions of a time period can affect the labor market.

UNIT OBJECTIVES/ENDURING UNDERSTANDINGS: (Students will be able to…
Magnetism
Magnetic fields are created by changing electric fields and exert magnetic force on changing electric fields.

$$\mu_o = 4\pi \; x \; 10^{-7} Tm/A \qquad B = \frac{\mu_o I}{2\pi r} \qquad F_m = qv \; x \; B \qquad F_m = Il \; x \; B$$

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)	Apply mathematical routines to express the force exerted on a moving charged object, or current-carrying wire, by a magnetic field. Use right-hand rules to analyze a situation involving a uniform magnetic field and a moving electrically charged object to determine the direction of the magnetic force exerted on the charged object due to the 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: *Physics Principles with Applications 7th Edition* (Giancoli) Gizmos: https://www.explorelearning.com/ Phet online simulations (https://phet.colorado.edu/en/simulations/category/physics) PAER Rutgers (http://www.islephysics.net/pt3/) The Physics Classroom (http://www.physicsclassroom.com/) Twu Physics (https://sites.google.com/site/twuphysicslessons/) Physics textbooks Experimental equipment pertinent to lab activities	Modifications will be made to accommodate IEP mandates for classified students