PUBLIC SCHOOLS OF EDISON TOWNSHIP

OFFICE OF CURRICULUM AND INSTRUCTION

Physics 1-1

Length of Course:	Term
Elective/Required:	Elective
Schools:	High Schools
Eligibility:	Grades 11, 12
Credit Value:	6 Credits
Date Approved:	September 24, 2018

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STATEMENT OF PURPOSE

The Physics 1-1 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 and is an elective course for Grade 12 science. All students will understand that physical science principles, including fundamental ideas about matter, energy, and motion, are powerful conceptual tools for making sense of phenomena in physical, living, and Earth systems science. An overarching goal for learning in physics is to help students see that there are mechanisms of cause and effect in all systems and processes that can be understood through a common set of physical quantities and principles. 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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Laurie Maier - Supervisor of Science, Edison and JP Stevens High Schools

COURSE OBJECTIVES

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

Motion and Stability: Forces and Interactions

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

- **(NJSLS/HS-PS2-2)** Use mathematical representations to support the claim that the total momentum of a system of objects is conserved when there is no net force on the system.

- **(NJSLS/HS-PS2-3)** Apply scientific and engineering ideas to design, evaluate, and refine a device that minimizes the force on a macroscopic object during a collision.

- **(NJSLS/HS-PS2-4)** Use mathematical representations of Newton's Law of Gravitation and Coulomb's Law to describe and predict the gravitational and electrostatic forces between objects.

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

Energy

- **(NJSLS/HS-PS3-1)** Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.

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

- **(NJSLS/HS-PS3-3)** Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.

- **(NJSLS/HS-PS3-5)** Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the forces between objects and the changes in energy of the objects due to the interaction.

Waves And Their Applications In Technologies For Information Transfer

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

- **(NJSLS/HS-PS4-3)** Evaluate the claims, evidence, and reasoning behind the idea that electromagnetic radiation can be described either by a wave model or a particle model, and that for some situations one model is more useful than the other.

- **(NJSLS/HS-PS4-4)** Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter.

Engineering Design

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

Earth's Place In The Universe

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

TIMELINE AND PACING GUIDE

Marking Period 1:
Kinematics
Dynamics
Quarterly Exam 1

Marking Period 2:
Circular Motion
Gravitation
Momentum
Quarterly Exam 2

Marking Period 3:
Work and Energy
Electrostatics
Electric Circuits (DC only)
Quarterly Exam 3

Marking Period 4:
Magnetism
Waves
Electromagnetic Radiation And Its Application in Technologies for Information Transfer
Quarterly Exam 4

Unit 1: Kinematics	

Essential Questions:
How do we define motion?
How do we describe and predict the motion of objects?
How do we describe objects in free fall?

NGSS Performance Expectations: (Students who demonstrate understanding can:)
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 one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.]

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

ELA/ Literacy
RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1)
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)
WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-1),(HS-PS2-5)

Mathematics
MP.2 Reason abstractly and quantitatively. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)
MP.4 Model with mathematics. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)
HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5)

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

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

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

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.

Student Learning Objectives: (SLO)			Instructional Actions	
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. (HS-PS2- 4),(HS-PS2-5)	**Planning and Carrying Out Investigations** Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS2-5) **Analyzing and Interpreting Data** Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-PS2-1) **Using Mathematics and Computational Thinking** Use	**Patterns** Empirical evidence is needed to identify patterns. (HE-ESS1-5) **Scale, Proportion, and Quantity** Algebraic thinking is used to examine scientific data and predict the effect of a change in one variable on another (e.g., linear growth vs. exponential growth). (HS-ESS1-4) **Cause and Effect** Systems can be designed to cause a desired effect (HS-PS2-3) **Systems and System Models** Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions— including energy, matter, and information flows— within and between systems at different scales. (HS-ETS1-4)	*Use appropriate online and textbook resources for presentation, demonstration, classroom and laboratory activities and formative assessments for:* Scientific method of problem solving Laws and theories Defining motion (i.e. reference frame activity) Vectors Constant speed and constant velocity (i.e. Scientific Argumentation: Toy Car Lab) Multiple representations of motion (i.e. dot diagrams, mathematical models, data tables, graphical) Constant acceleration Free fall (i.e. reaction time activity, Design a Testing Experiment: Free Fall)	**Formative Assessments**: Exit tickets Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

	mathematical representations of phenomena to describe explanations. (HS-PS2-2),(HS-PS2-4) **Constructing Explanations and Designing Solutions** Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3) **Obtaining, Evaluating, and Communicating Information** Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6) **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** Theories and laws provide explanations in science. (HS-PS2- 1),(HS-PS2-4) Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1),(HS-PS2-4)		Multiple representations problem solving (i.e. dot diagram, video analysis, data table, graphical and mathematical representations) and ranking tasks *Discovery Education Techbook: Physics* Unit: Motion ● Using Vectors and Scalars to Describe Motion ● Understanding and Describing Motion	

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
Discovery Education Techbook: Physics Physics Principles and Problems Glencoe 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/)	Modifications will be made to accommodate IEP mandates for classified students

Unit 2: Dynamics	
Essential Questions: *How can we change the motion of an object?* *How do we describe and predict changes in the motion of an object?* **NGSS Performance Expectations**: (Students who demonstrate understanding can:) 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 one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.] **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 **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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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.

Student Learning Objectives: (SLO)			Instructional Actions	
Disciplinary Core Ideas	**Science and Engineering Practices**	**Crosscutting Concepts**	**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) **Using Mathematics and Computational Thinking** Use mathematical	**Patterns** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS2-4) **Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2- 1),(HS-PS2-5) Systems can be designed to cause a desired effect. (HS-PS2-3) **Systems and System Models** When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2) **Systems and System Models**	*Use appropriate online and textbook resources for presentation, demonstration, classroom and laboratory activities and formative assessments for:* Drawing force diagrams Determining net force Newton's 1st Law of Motion Newton's 2nd Law of Motion (Mathematical: $a = F_{NET}/m$ and graphical analysis) Naming common forces: gravitational force/weight, normal force, tension force, drag force, spring force Friction force (i.e. Determining Coefficient of Friction Lab) Newton's 3rd Law of Motion (i.e. spring scale tug-of-war) Forces at an angle Multiple representations problem solving (i.e. dot diagram, force diagram, video analysis, data table, graphical and mathematical representations) and ranking tasks	**<u>Formative Assessments</u>**: Exit tickets Laboratory activities Classwork Homework **<u>Summative Assessments</u>:** Tests Quizzes Laboratory reports Project Quarterly exam

	representations of phenomena to describe explanations. (HS-PS2-2),(HS-PS2-4) **Constructing Explanations and Designing Solutions** Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3) **Obtaining, Evaluating, and Communicating Information** Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6) **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** Theories and laws provide explanations in science. (HS-PS2- 1),(HS-PS2-4) Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1),(HS-PS2-4)	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)	*Observable features of the student performance by the end of this unit:* Organizing Data Students organize data that represent the net force on a macroscopic object, its mass (which is held constant), and its acceleration (e.g., via tables, graphs, charts, vector drawings). Identifying Relationships Students use tools, technologies, and/or models to analyze the data and identify relationships within the datasets, including: • A more massive object experiencing the same net force as a less massive object has a smaller acceleration, and a larger net force on a given object produces a correspondingly larger acceleration; and • The result of gravitation is a constant acceleration on macroscopic objects as evidenced by the fact that the ratio of net force to mass remains constant. Interpreting Data Students use the analyzed data as evidence to describe that the relationship between the observed quantities is accurately modeled across the range of data by the formula $a = F_{net}/m$ (e.g., double force yields double acceleration, etc.).	

			Students use the data as empirical evidence to distinguish between causal and correlational relationships linking force, mass, and acceleration. Students express the relationship a = Fnet/m in terms of causality, namely that a net force on an object causes the object to accelerate. *Discovery Education Techbook: Physics* Unit: Motion ● Newton's 1st Law of Motion ● Newton's 2nd Law of Motion ● Newton's 3rd Law of Motion ● Applying Newton's Laws of Motion ● Free Body Diagrams Unit: Forces ● Fundamental Forces	

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
Discovery Education Techbook: Physics Physics Principles and Problems Glencoe 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/)	Modifications will be made to accommodate IEP mandates for classified students

Unit 3: Circular Motion	
Essential Questions: *What causes an object to move in uniform circular motion?* *Why doesn't Earth "fall into" the Sun?* **NGSS Performance Expectations**: (Students who demonstrate understanding can:) 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 one-dimensional motion and to macroscopic objects moving at non-relativistic speeds.] **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 **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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Career Ready Practices
CRP4. Communicate clearly and effectively and with reason
CRP8. Utilize critical thinking to make sense of problems and persevere in solving them
CRP11. Use technology to enhance productivity.

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.

Physics 1-1

Student Learning Objectives: (SLO)			Instructional Actions	
Disciplinary Core Ideas	**Science and Engineering Practices**	**Crosscutting Concepts**	**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) **Using Mathematics and Computational Thinking** Use mathematical representations of phenomena to describe	**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 online and textbook resources for presentation, demonstration, classroom and laboratory activities and formative assessments for:* Drawing force diagrams Drawing acceleration and velocity vectors for object moving in circular motion Kinematics and dynamics of circular motion (i.e. PAER videos, Circular Motion Lab, Flying Pigs Lab) Multiple representations problem solving (i.e. dot diagram, force diagram, video analysis, data table, graphical and mathematical representations) and ranking tasks *Discovery Education Techbook: Physics* Unit: Forces • Centripetal force and circular motion	**Formative Assessments**: Exit tickets Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

	explanations. (HS-PS2-2),(HS-PS2-4) **Constructing Explanations and Designing Solutions** Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3) **Obtaining, Evaluating, and Communicating Information** Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6) **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** Theories and laws provide explanations in science. (HS-PS2- 1),(HS-PS2-4) Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1),(HS-PS2-4)			

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
Discovery Education Techbook: Physics Physics Principles and Problems Glencoe 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/)	Modifications will be made to accommodate IEP mandates for classified students

Unit 4: Gravitation	

Essential Questions:
How do we describe the motion of planets around the Sun?
Why doesn't Earth "fall into" the Sun?
What is a" field force"?
What is "weightlessness"?

NGSS Performance Expectations: (Students who demonstrate understanding can:)
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.]

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

ELA/ Literacy
RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1)
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)
WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-1),(HS-PS2-5)

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

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

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

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

NJSLS/HS-PS2-4: Use mathematical representations of Newton’s Law of Gravitation to describe and predict the gravitational force between objects.

Student Learning Objectives: (SLO)			Instructional Actions	
Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	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 Communicating Information** Communicate scientific and technical information (e.g.	**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 online and textbook resources for presentation, demonstration, classroom and laboratory activities and formative assessments for:* Kepler's Laws Newton's Law of Universal Gravitation (i.e. Phet Gravity Force Lab, Gravity and Orbits) Orbits of planets and satellites: determining speed of a satellite orbiting Earth; determining period of a satellite orbiting Earth Acceleration due to gravity and "weightlessness" Gravitational Field (g) Inertial mass vs. gravitational mass Multiple representations problem solving (i.e. dot diagram, force diagram, video analysis, data table, graphical and mathematical	**Formative Assessments**: Exit tickets Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

	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)		representations) and ranking tasks *Observable features of the student performance by the end of this unit:* Representation ● Students identify and 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). ● Students clearly define the system of the interacting objects that is mathematically represented. ● Using the given mathematical representations, students identify and describe the	

			gravitational attraction between two objects as the product of their masses divided by the separation distance squared ($F_g = G\ m_1 m_2/d_2$) Mathematical modeling ● Students use the 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). ● Students correctly use the given mathematical formulas to predict the gravitational force between objects Analysis ● Students use the given mathematical or computational representation of Kepler's second law of planetary motion (an orbiting body	

			sweeps out equal areas in equal time) to predict the relationship between the distance between an orbiting body and its star, and the object's orbital velocity (i.e., that the closer an orbiting body is to a star, the larger its orbital velocity will be). ● Students use the given mathematical or computational representation of Kepler's third law of planetary motion (T 2 ∝ R 3 , where T is the orbital period and R is the semi-major axis of the orbit) to predict how either the orbital distance or orbital period changes given a change in the other variable. ● Students use Newton's law of gravitation plus his third law of motion to predict how the acceleration of a planet towards the sun varies with its distance from the sun, and to argue qualitatively about	

			how this relates to the observed orbits. ● Based on the given mathematical models, students describe that the ratio between gravitational force between objects with a given mass is a pattern that is independent of distance ● Students describe that the mathematical representation of the gravitational field (Fg = G m_1m_2/d_2) only predicts an attractive force because mass is always positive. ● Students use the given formulas for the forces as evidence to describe that the change in the energy of objects interacting through gravitational forces depends on the distance between the objects. *Discovery Education Techbook: Physics* Unit: Forces ● Gravity	

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	Instructional Adjustments:
Discovery Education Techbook: Physics Physics Principles and Problems Glencoe 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/)	Modifications will be made to accommodate IEP mandates for classified students

Unit 5: Momentum	

Essential Questions:
How do we quantify motion?
How do airbags help save lives?
How can we predict the final momenta of objects in a system after a collision?

NGSS Performance Expectations: (Students who demonstrate understanding can:)
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.]

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

ELA/ Literacy
RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1)
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)
WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-1),(HS-PS2-5)

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

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

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

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.

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
Discovery Education Techbook: Physics Physics Principles and Problems Glencoe 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/)	Modifications will be made to accommodate IEP mandates for classified students

Physics 1-1

Student Learning Objectives: (SLO)			**Instructional Actions**	
Disciplinary Core Ideas	**Science and Engineering Practices**	**Crosscutting Concepts**	**Activities/Strategies** **Technology Implementation/ Interdisciplinary Connections**	**Assessment Check Points**
PS2.A: Forces and Motion Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (HS-PS2-2) If a system interacts with objects outside itself, the total momentum of the system can change; however, any such change is balanced by changes in the momentum of objects outside the system. (HS-PS2-2),(HS-PS2-3) **ETS1.A: Defining and Delimiting Engineering Problems** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary to HS-PS2-3)	**Planning and Carrying Out Investigations** Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS2-5) **Analyzing and Interpreting Data** Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-PS2-1) **Using Mathematics and Computational Thinking**	**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 online and textbook resources for presentation, demonstration, classroom and laboratory activities and formative assessments for:* Momentum Impulse Impulse-momentum theorem (i.e. Lab: Egg Drop) Conservation of momentum (i.e. Lab: Conservation of Momentum) *Observable features of the student performance by the end of this unit:* <u>Representation</u> Students clearly define the system of the two interacting objects that is represented mathematically, including boundaries and initial conditions. Students identify and describe the momentum of each object in the system as the product of its mass and its velocity, $p = mv$ (p and v are restricted to one-dimensional vectors), using the mathematical representations.	**<u>Formative Assessments</u>**: Exit tickets Laboratory activities Classwork Homework **<u>Summative Assessments</u>:** Tests Quizzes Laboratory reports Project Quarterly exam

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)	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)		Students identify the claim, indicating that the total momentum of a system of two interacting objects is constant if there is no net force on the system. Mathematical modeling Students use the mathematical representations to model and describe the physical interaction of the two objects in terms of the change in the momentum of each object as a result of the interaction. Students use the mathematical representations to model and describe the total momentum of the system by calculating the vector sum of momenta of the two objects in the system. Analysis Students use the analysis of the motion of the objects before the interaction to identify a system with essentially no net force on it. Based on the analysis of the total momentum of the system, students support the claim that the momentum of the system is the same before and after the interaction between the objects in the system, so that momentum of the system is constant. Students identify that the analysis of the momentum of each object in the system indicates that any	

			change in momentum of one object is balanced by a change in the momentum of the other object, so that the total momentum is constant. Using scientific knowledge to generate the design solution Students design a device that minimizes the force on a macroscopic object during a collision. In the design, students: ● Incorporate the concept that for a given change in momentum, force in the direction of the change in momentum is decreased by increasing the time interval of the collision ($F\Delta t = m\Delta v$); and ● Explicitly make use of the principle above so that the device has the desired effect of reducing the net force applied to the object by extending the time the force is applied to the object during the collision. In the design plan, students describe the scientific rationale for their choice of materials and for the structure of the device. Describing criteria and constraints, including quantification when appropriate Students describe and quantify (when appropriate) the criteria and constraints, along with the tradeoffs implicit in these design solutions.	

			Examples of constraints to be considered are cost, mass, the maximum force applied to the object, and	

Unit 6: Work and Energy	

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?

NGSS Performance Expectations: (Students who demonstrate understanding can:)
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.]

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

ELA/ Literacy
RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1)
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)
WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-1),(HS-PS2-5)

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

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

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

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.

Student Learning Objectives: (SLO)			**Instructional Actions**	
Disciplinary Core Ideas	**Science and Engineering Practices**	**Crosscutting Concepts**	**Activities/Strategies Technology Implementation/ Interdisciplinary Connections**	**Assessment Check Points**
PS3.A: Definitions of Energy Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HSPS3-1),(HS-PS3-2) At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HSPS3-2) (HS-PS3-3) These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a 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	**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) **Using Mathematics and Computational Thinking** Create a computational model or simulation of a phenomenon, designed	**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) **Connections to Engineering, Technology, and Applications of Science**	*Use appropriate online and textbook resources for presentation, demonstration, classroom and laboratory activities and formative assessments for:* Work Energy, Mechanical Energy (Kinetic Energy and Gravitational Potential Energy), Thermal Energy Power Conservation of Mechanical Energy (Student-designed experiment) *Observable features of the student performance by the end of this unit:* <u>Representation</u> Students identify and describe the components to be computationally modeled, including: ● The boundaries of the system and that the reference level for potential energy = 0 (the potential energy	<u>**Formative Assessments**</u>: Exit tickets Laboratory activities Classwork Homework <u>**Summative Assessments**</u>**:** Tests Quizzes Laboratory reports Project Quarterly exam

of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2) **PS3.B: Conservation of Energy and Energy Transfer** Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1) Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4) Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1) The availability of energy limits what can occur in any system. (HS-PS3-1)	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)	**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. (HSPS3-1)	of the initial or final state does not have to be zero); ● The initial energies of the system's components (e.g., energy in fields, thermal energy, kinetic energy, energy stored in springs — all expressed as a total amount of Joules in each component), including a quantification in an algebraic description to calculate the total initial energy of the system; ● The energy flows in or out of the system, including a quantification in an algebraic description with flow into the system defined as positive; and ● The final energies of the system components, including a quantification in an algebraic description to calculate the total final energy of the system Computational Modeling Students use the algebraic descriptions of the initial and	

PS3.D: Energy in Chemical Processes Although energy cannot be destroyed, it can be converted to less useful forms—for example, to thermal energy in the surrounding environment. (HS-PS3-3),(HS-PS3-4) **ETS1.A: Defining and Delimiting Engineering Problems** Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary to HS-PS3-3)			final energy state of the system, along with the energy flows to create a computational model (e.g., simple computer program, spreadsheet, simulation software package application) that is based on the principle of the conservation of energy. Students use the computational model to calculate changes in the energy of one component of the system when changes in the energy of the other components and the energy flows are known. <u>Analysis</u> Students use the computational model to predict the maximum possible change in the energy of one component of the system for a given set of energy flows. Students identify and describe the limitations of the computational model, based on the assumptions that were made in creating the algebraic descriptions of energy changes and flows in the system. <u>Components of the model</u> Students develop models in which they identify and	

			describe the relevant components, including: ● All the components of the system and the surroundings, as well as energy flows between the system and the surroundings; ● Clearly depicting both a macroscopic and a molecular/atomic-level representation of the system; and ● Depicting the forms in which energy is manifested at two different scales: ○ Macroscopic, such as motion, sound, light, thermal energy, potential energy or energy in fields; and ○ Molecular/atomic, such as motions (kinetic energy) of particles (e.g., nuclei and electrons), the relative positions of particles in fields	

			(potential energy), and energy in fields. <u>Relationships</u> Students describe the relationships between components in their models, including: ● Changes in the relative position of objects in gravitational, fields can affect the energy of the fields ● Thermal energy includes both the kinetic and potential energy of particle vibrations in solids or molecules and the kinetic energy of freely moving particles (e.g., inert gas atoms, molecules) in liquids and gases. ● The total energy of the system and surroundings is conserved at a macroscopic and molecular/atomic level ● Chemical energy can be considered in terms of systems of nuclei and electrons	

			in electrostatic fields (bonds). • As one form of energy increases, others must decrease by the same amount as energy is transferred among and between objects and fields. <u>Connections</u> Students use their models to show that in closed systems the energy is conserved on both the macroscopic and molecular/atomic scales so that as one form of energy changes, the total system energy remains constant, as evidenced by the other forms of energy changing by the same amount or changes only by the amount of energy that is transferred into or out of the system. Students use their models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles/objects and energy associated with the relative positions of particles/objects on both the macroscopic and microscopic scales.	

			<u>Using scientific knowledge to generate the design solution</u> Students design a device that converts one form of energy into another form of energy. Students develop a plan for the device in which they: ● Identify what scientific principles provide the basis for the energy conversion design; ● Identify the forms of energy that will be converted from one form to another in the designed system; ● Identify losses of energy by the design system to the surrounding environment; ● Describe the scientific rationale for choices of materials and structure of the device, including how student-generated evidence influenced the design; and ● Describe that this device is an example of how the application of scientific knowledge and engineering design can increase benefits for modern civilization while decreasing costs and risk.	

			Describing criteria and constraints, including quantification when appropriate Students describe and quantify (when appropriate) prioritized criteria and constraints for the design of the device, along with the tradeoffs implicit in these design solutions. Examples of constraints to be considered are cost and efficiency of energy conversion. Evaluating potential solutions Students build and test the device according to the plan. Students systematically and quantitatively evaluate the performance of the device against the criteria and constraints. Refining and/or optimizing the design solution Students use the results of the tests to improve the device performance by increasing the efficiency of energy conversion, keeping in mind the criteria and constraints, and noting any modifications in tradeoffs. *Discovery Education Techbook: Physics*	

			Unit: Forces • Work and Power Unit: Conservation of Energy and Momentum • Types of Energy • Conservation of Energy • Work, Power, and Impulse	

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
Discovery Education Techbook: Physics Physics Principles and Problems Glencoe 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/)	Modifications will be made to accommodate IEP mandates for classified students

Unit 7: Electrostatics	

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?

NGSS Performance Expectations: (Students who demonstrate understanding can:)
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.]

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

ELA/ Literacy
RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1)
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)
WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-1),(HS-PS2-5)

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

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

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

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.

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.

Physics 1-1

Student Learning Objectives: (SLO)			Instructional Actions	
Disciplinary Core Ideas	**Science and Engineering Practices**	**Crosscutting Concepts**	**Activities/Strategies Technology Implementation/ Interdisciplinary Connections**	**Assessment Check Points**
PS1.A: Structure and Properties of Matter The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (secondary to HS-PS2-6) **PS2.B: Types of Interactions** Coulomb's law provides the mathematical model to describe and predict the effects of electrostatic force between distant objects. (HS-PS2-4) Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. (HS-PS2-4),(HS-PS2-5) Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter, as well as the contact forces between material objects. (HS-PS2-6),(secondary to HS-PS1-1),(secondary to HS-PS1-3) **PS3.A: Definitions of Energy**	**Analyzing and Interpreting Data** Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (HS-PS2-1) **Using Mathematics and Computational Thinking** Use mathematical representations of phenomena to describe explanations. (HS-PS2-2),(HS-PS2-4) **Connections to Nature of Science Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** Theories and laws provide explanations in science. (HS-PS2- 1),(HS-PS2-4) Laws are statements or descriptions of the relationships among observable phenomena. (HS-	**Patterns** Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena. (HS-PS2-4) **Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2- 1),(HS-PS2-5) **Energy and Matter** Energy cannot be created or destroyed—only moves between one place and another place, between objects and/or fields, or between systems. (HS-PS3-2)	*Use appropriate online and textbook resources for presentation, demonstration, classroom and laboratory activities and formative assessments for:* Structure of matter (conductors, insulators) Electric charge Methods of charging Coulomb's Law Electric field Electric potential, electric potential difference Electric potential energy Capacitor (definition, stores energy) *Observable features of the student performance by the end of this unit:* <u>Representation</u> Students clearly define the system of the interacting	**<u>Formative Assessments</u>**: Exit tickets Laboratory activities Classwork Homework **<u>Summative Assessments</u>:** Tests Quizzes Laboratory reports Project Quarterly exam

"Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (secondary to HS-PS2-5) **PS3.C: Relationship Between Energy and Forces** When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5) **PS3.B: Conservation of Energy and Energy Transfer** Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1) **PS3.C: Relationship Between Energy and Forces** When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5)	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)		objects that is mathematically represented Using the given mathematical representations, students identify and describe the electrostatic force between two objects as the product of their individual charges divided by the separation distance squared ($F_e = k\ q_1q_2 / d_2$) Mathematical modeling Students correctly use the given mathematical formulas to predict the electrostatic force between charged objects. Analysis Based on the given mathematical models, students describe that the ratio between electric force between objects with a given charge is a pattern that is independent of distance. Students describe that the mathematical representation of the electric field ($F_e = k\ q_1q_2 / d_2$) predicts both attraction and repulsion because electric charge can be either positive or negative. Students use the given formulas for the force as evidence to describe that the	

			change in the energy of objects interacting through electric force depends on the distance between the objects. <u>Components of the model</u> Students develop a model in which they identify and describe the relevant components to illustrate the forces and changes in energy involved when two objects interact, including: ● The two objects in the system, including their initial positions and velocities (limited to one dimension). ● The nature of the interaction (electric or magnetic) between the two objects. ● The relative magnitude and the direction of the net force on each of the objects. ● Representation of a field as a quantity that has a magnitude and direction at all points in space and which contains energy. <u>Relationships</u> In the model, students describe the relationships between components, including the change in the energy of the objects, given	

			the initial and final positions and velocities of the objects. Connections Students use the model to determine whether the energy stored in the field increased, decreased, or remained the same when the objects interacted. Students use the model to support the claim that the change in the energy stored in the field (which is qualitatively determined to be either positive, negative, or zero) is consistent with the change in energy of the objects. Using the model, students describe the cause and effect relationships on a qualitative level between forces produced by electric or magnetic fields and the change of energy of the objects in the system. *Discovery Education Techbook: Physics* Unit: Forces • Electric Forces Unit: Electromagnetism • Electric and Magnetic Fields	

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	Instructional Adjustments:
Discovery Education Techbook: Physics Physics Principles and Problems Glencoe 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/)	Modifications will be made to accommodate IEP mandates for classified students

Unit 8: DC Circuits	

Essential Questions:
How can we use electrical energy?
How is electric potential energy distributed throughout a circuit?

NGSS Performance Expectations: (Students who demonstrate understanding can:)
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.]

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

ELA/ Literacy
RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1)
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)
WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-1),(HS-PS2-5)

Mathematics
MP.2 Reason abstractly and quantitatively. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)
MP.4 Model with mathematics. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)
HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5)

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

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

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

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.

Student Learning Objectives: (SLO)			Instructional Actions	
Disciplinary Core Ideas	**Science and Engineering Practices**	**Crosscutting Concepts**	**Activities/Strategies Technology Implementation/ Interdisciplinary Connections**	**Assessment Check Points**
PS3.A: Definitions of Energy Energy is a quantitative property of a system that depends on the motion and interactions of matter and radiation within that system. That there is a single quantity called energy is due to the fact that a system's total energy is conserved, even as, within the system, energy is continually transferred from one object to another and between its various possible forms. (HSPS3-1),(HS-PS3-2) At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy. (HSPS3-2) (HS-PS3-3) These relationships are better understood at the microscopic scale, at which all of the different manifestations of energy can be modeled as a 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	**Using Mathematics and Computational Thinking** Create a computational model or simulation of a phenomenon, designed device, process, or system. (HS-PS3-1) **Obtaining, Evaluating, and Communicating Information** Communicate scientific and technical information (e.g. about the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS2-6) **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** Theories and laws provide explanations in science. (HS-PS2- 1),(HS-PS2-4)	**Systems and System Models** Models can be used to predict the behavior of a system, but these predictions have limited precision and reliability due to the assumptions and approximations inherent in models. (HSPS3-1)	*Use appropriate online and textbook resources for presentation, demonstration, classroom and laboratory activities and formative assessments for:* Electric current Electric power Resistance Ohm's Law Circuit diagrams Energy transfer in electric circuits Paying for energy Electrical safety devices (i.e. fuse, circuit breaker, ground fault interrupter) Circuit tools (i.e. ammeter, voltmeter) Simple circuits: series circuits, parallel circuits	**Formative Assessments**: Exit tickets Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

position energy can be thought of as stored in fields (which mediate interactions between particles). This last concept includes radiation, a phenomenon in which energy stored in fields moves across space. (HS-PS3-2) **PS3.B: Conservation of Energy and Energy Transfer** Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system. (HS-PS3-1) Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1),(HS-PS3-4) Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g. relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1) The availability of energy limits what can occur in any system. (HS-PS3-1)	Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1),(HS-PS2-4)		*Discovery Education Techbook: Physics* Unit: Electromagnetism ● Electric Circuits ● Conductors and Insulators	

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:**
Discovery Education Techbook: Physics Physics Principles and Problems Glencoe 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/)	Modifications will be made to accommodate IEP mandates for classified students

Unit 9: Magnetism	

Essential Questions:
What is the relationship between electricity and magnetism?

NGSS Performance Expectations: (Students who demonstrate understanding can:)
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.]

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

ELA/ Literacy
RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1)
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)
WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-1),(HS-PS2-5)

Mathematics
MP.2 Reason abstractly and quantitatively. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)
MP.4 Model with mathematics. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)

HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5)
HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5) HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5)
HSA-SSE.A.1 Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1),(HS-PS2-4)
HSA-SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1),(HS-PS2- 4)
HSA-CED.A.1 Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1),(HS-PS2-2)
HSA-CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-PS2- 1),(HS-PS2-2)
HSA-CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1),(HS-PS2-2)
HSF-IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. (HS-PS2-1)

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

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

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.

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.

Student Learning Objectives: (SLO)			**Instructional Actions**	
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) **Using Mathematics and Computational Thinking** Use mathematical representations of	**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 online and textbook resources for presentation, demonstration, classroom and laboratory activities and formative assessments for:* Magnetism Magnetic field Magnetic force on moving charged particle Magnetic force on current-carrying wire Electric current from changing magnetic field *Observable features of the student performance by the end of this unit:* Identifying the phenomenon to be investigated Students describe the phenomenon under investigation, which includes the following idea: that an electric current produces a magnetic field and that a changing magnetic field produces an electric current.	**Formative Assessments**: Exit tickets Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

	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)		<u>Identifying the evidence to answer this question</u> Students develop an investigation plan and describe the data that will be collected and the evidence to be derived from the data about 1) an observable effect of a magnetic field that is uniquely related to the presence of an electric current in the circuit, and 2) an electric current in the circuit that is uniquely related to the presence of a changing magnetic field near the circuit. Students describe why these effects seen must be causal and not correlational, citing specific cause-effect relationships. <u>Planning for the investigation</u> In the investigation plan, students include: ● The use of an electric circuit through which electric current can flow, a source of electrical energy that can be placed in the circuit, the shape and orientation of the wire, and the types and positions of detectors; ● A means to indicate or measure when electric current is	

			flowing through the circuit; ● A means to indicate or measure the presence of a local magnetic field near the circuit; and ● A design of a system to change the magnetic field in a nearby circuit and a means to indicate or measure when the magnetic field is changing. In the plan, students state whether the investigation will be conducted individually or collaboratively. <u>Collecting the data</u> Students measure and record electric currents and magnetic fields. <u>Refining the design</u> Students evaluate their investigation, including an evaluation of: ● The accuracy and precision of the data collected, as well as limitations of the investigation; and ● The ability of the data to provide the evidence required.	

			If necessary, students refine the investigation plan to produce more accurate, precise, and useful data such that the measurements or indicators of the presence of an electric current in the circuit and a magnetic field near the circuit can provide the required evidence. *Discovery Education Techbook: Physics* Unit: Electromagnetism ● Electric and Magnetic Fields ● Electricity and Magnetism	

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
Discovery Education Techbook: Physics Physics Principles and Problems Glencoe 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/)	Modifications will be made to accommodate IEP mandates for classified students

Unit 10: Waves	

Essential Questions:
What are defining properties of a wave?

NGSS Performance Expectations: (Students who demonstrate understanding can:)
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.]

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

ELA/ Literacy
RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1)
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)
WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-1),(HS-PS2-5)

Mathematics
MP.2 Reason abstractly and quantitatively. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)
MP.4 Model with mathematics. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4)
HSN-Q.A.1 Use units as a way to understand problems and to guide the solution of multi-step problems; choose and interpret units consistently in formulas; choose and interpret the scale and the origin in graphs and data displays. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5)
HSN-Q.A.2 Define appropriate quantities for the purpose of descriptive modeling. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5) HSN-Q.A.3 Choose a level of accuracy appropriate to limitations on measurement when reporting quantities. (HS-PS2-1),(HS-PS2-2),(HS-PS2-4),(HS-PS2-5)

HSA-SSE.A.1 Interpret expressions that represent a quantity in terms of its context. (HS-PS2-1),(HS-PS2-4)
HSA-SSE.B.3 Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression. (HS-PS2-1),(HS-PS2- 4)
HSA-CED.A.1 Create equations and inequalities in one variable and use them to solve problems. (HS-PS2-1),(HS-PS2-2)
HSA-CED.A.2 Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales. (HS-PS2- 1),(HS-PS2-2)
HSA-CED.A.4 Rearrange formulas to highlight a quantity of interest, using the same reasoning as in solving equations. (HS-PS2-1),(HS-PS2-2)
HSF-IF.C.7 Graph functions expressed symbolically and show key features of the graph, by hand in simple cases and using technology for more complicated cases. (HS-PS2-1)

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

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

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.

Student Learning Objectives: (SLO)			Instructional Actions	
Disciplinary Core Ideas	**Science and Engineering Practices**	**Crosscutting Concepts**	**Activities/Strategies Technology Implementation/ Interdisciplinary Connections**	**Assessment Check Points**
PS4.A: Wave Properties The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (HS-PS4-1) Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) (HS-PS4-3)	**Using Mathematics and Computational Thinking** Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-PS4-1) **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)	**Cause and Effect** Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS4-1)	*Use appropriate online and textbook resources for presentation, demonstration, classroom and laboratory activities and formative assessments for:* Wave properties (waves can reflect, refract, disperse, diffract, interfere and follow Principle of Superposition) Waves are described by the wave equation ($v = f\lambda$) *Observable features of the student performance by the end of this unit:* Representation Students identify and describe the relevant components in the mathematical representations: ● Mathematical values for frequency, wavelength, and speed of waves traveling in various specified media; and ● The relationships between frequency, wavelength, and speed of waves	**Formative Assessments**: Exit tickets Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

			traveling in various specified media. <u>Mathematical modeling</u> Students show that the product of the frequency and the wavelength of a particular type of wave in a given medium is constant, and identify this relationship as the wave speed according to the mathematical relationship $v = f\lambda$. Students use the data to show that the wave speed for a particular type of wave changes as the medium through which the wave travels changes. Students predict the relative change in the wavelength of a wave when it moves from one medium to another (thus different wave speeds using the mathematical relationship $v = f\lambda$). Students express the relative change in terms of cause (different media) and effect (different wavelengths but same frequency). <u>Analysis</u> Using the mathematical relationship $v = f\lambda$, students assess claims about any of the three quantities when the other two quantities are	

			known for waves travelling in various specified media. Students use the mathematical relationships to distinguish between cause and correlation with respect to the supported claims. *Discovery Education Techbook: Physics* Unit: Waves • Wave Characterisitcs	

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
Discovery Education Techbook: Physics Physics Principles and Problems Glencoe 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/)	Modifications will be made to accommodate IEP mandates for classified students

Unit 11: Applications of Electromagnetic Radiation	

Essential Questions:
What is electromagnetic radiation?
What evidence exists that supports photon model of electromagnetic radiation?
What are applications of electromagnetic radiation?

NGSS Performance Expectations: (Students who demonstrate understanding can:)
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, interference, diffraction, and photoelectric effect.]
[Assessment Boundary: Assessment does not include using quantum theory.]

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.
[Clarification Statement: Emphasis is on the idea that photons associated with different frequencies of light have different energies, and the damage to living tissue from electromagnetic radiation depends on the energy of the radiation. Examples of published materials could include trade books, magazines, web resources, videos, and other passages that may reflect bias.]
[Assessment Boundary: Assessment is limited to qualitative descriptions.]

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

ELA/ Literacy
RST.11-12.7 Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem. (HS-PS2-1)
RST.11-12.8 Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information. (HS-ETS1-1),(HS-ETS1-3)
WHST.9-12.9 Draw evidence from informational texts to support analysis, reflection, and research. (HS-PS2-1),(HS-PS2-5)

Mathematics

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

Technology

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

Career Ready Practices

CRP4. Communicate clearly and effectively and with reason
CRP8. Utilize critical thinking to make sense of problems and persevere in solving them
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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.

Physics 1-1

Student Learning Objectives: (SLO)			Instructional Actions	
Disciplinary Core Ideas	**Science and Engineering Practices**	**Crosscutting Concepts**	**Activities/Strategies Technology Implementation/ Interdisciplinary Connections**	**Assessment Check Points**
PS4.B: Electromagnetic Radiation Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (HS-PS4-3) When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, gamma rays) can ionize atoms and cause damage to living cells. (HS-PS4-4) Photoelectric materials emit electrons when they absorb light of a high-enough frequency. (HS-PS4-5)	**Engaging in Argument from Evidence** Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the merits of arguments. (HS-PS4-3)	**Cause and Effect** Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS4-4)	*Use appropriate online and textbook resources for presentation, demonstration, classroom and laboratory activities and formative assessments for:* Wave model of light Photon model of light Photoelectric effect Effects of electromagnetic radiation on matter *Observable features of the student performance by the end of this unit:* Identifying the given explanation and associated claims, evidence, and reasoning Students identify the given explanation that is to be supported by the claims, evidence, and reasoning to be evaluated, and that includes the following idea: Electromagnetic radiation can be described either by a wave model or a particle model, and for some situations one	**Formative Assessments**: Exit tickets Laboratory activities Classwork Homework **Summative Assessments:** Tests Quizzes Laboratory reports Project Quarterly exam

PS4.C: Information Technologies and Instrumentation Multiple technologies based on the understanding of waves and their interactions with matter are part of everyday experiences in the modern world (e.g., medical imaging, communications, scanners) and in scientific research. They are essential tools for producing, transmitting, and capturing signals and for storing and interpreting the information contained in them. (HS-PS4-5)			model is more useful than the other. Students identify the given claims to be evaluated. Students identify the given evidence to be evaluated, including the following phenomena: ● Interference behavior by electromagnetic radiation; and ● The photoelectric effect. Students identify the given reasoning to be evaluated. <u>Evaluating given evidence and reasoning</u> Students evaluate the given evidence for interference behavior of electromagnetic radiation to determine how it supports the argument that electromagnetic radiation can be described by a wave model. Students evaluate the phenomenon of the photoelectric effect to determine how it supports the argument that electromagnetic radiation can be described by a particle model.	

			Students evaluate the given claims and reasoning for modeling electromagnetic radiation as both a wave and particle, considering the transfer of energy and information within and between systems, and why for some aspects the wave model is more useful and for other aspects the particle model is more useful to describe the transfer of energy and information <u>Obtaining information</u> Students obtain at least two claims proposed in published material (using at least two sources per claim) regarding the effect of electromagnetic radiation that is absorbed by matter. One of these claims deals with the effect of electromagnetic radiation on living tissue. <u>Evaluating information</u> Students use reasoning about the data presented, including the energies of the photons involved (i.e., relative wavelengths) and the probability of ionization, to analyze the validity and reliability of each claim. Students determine the validity and reliability of the sources of the claims.	

			Students describe the cause and effect reasoning in each claim, including the extrapolations to larger scales from cause and effect relationships of mechanisms at small scales (e.g., extrapolating from the effect of a particular wavelength of radiation on a single cell to the effect of that wavelength on the entire organism).	

Resources: Essential Materials, Supplementary Materials, Links to Best Practices	**Instructional Adjustments:**
Discovery Education Techbook: Physics Physics Principles and Problems Glencoe 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/)	Modifications will be made to accommodate IEP mandates for classified students