Passaic County Technical Institute

Wayne, NJ

Physics Curriculum

Course #0074

5 Credits

August 2016

Physics Curriculum

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I. Course Description

Physics deals with the principles upon which the advances in modern technology are based. The major fields of mechanics, sound, and light are covered. As the year progresses, students will discover how unrelated phenomena can be explained with the help of a few fundamental unifying laws, and how a huge body of unrelated information can become unified. For example, out of the many motions of various bodies from the smallest nuclear particle to the giant planets the student will discover a few simple laws that describe all motion. Students will also gain an understanding of Newton's Universal Law of gravitation and Einstein's theory of gravity. An emphasis will be given to physics applications and related careers.

II. Course Objectives/Outline

Content Area:	Physics		Grade(s)	10, 11, 12
Unit Plan Title:	Forces and Motion	Time Frame	11 Weeks	

NJ Student Learning Standards

- Given a graph of position or velocity as a function of time, recognize in what time intervals the position, velocity and acceleration of an object are positive, negative, or zero and sketch a graph of each quantity as a function of time. *[Clarification Statement: Students should be able to accurately move from one representation of motion to another.]* PS2.A

- **Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.** *[Clarification Statement: Examples of data could include tables or graphs of position or velocity as a function of time for objects subject to a net unbalanced force, such as a falling object, an object rolling down a ramp, or a moving object being pulled by a constant force.] [Assessment Boundary: Assessment is limited to one-dimensional motion and to macroscopic object is moving at non-relativistic speeds.]* HS-PS2-1

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

- **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.]* HS-PS2-3

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying out Investigations (pp. 59- 61, NRC, 2012) Planning and carrying out investigations in 9-12 builds on K-8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and	**PS2.A: Forces and Motion** (pp. 114-116, NRC, 2012) • Newton's second law accurately predicts changes in the motion of macroscopic objects. (SLO 1, 2 & 3),(HS-PS2-1) • Momentum is defined for a particular frame of reference; it is the mass times the velocity of the object. (SLO 5),(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),(SLO 5)	**Cause and Effect** (pp. 87-89, NRC, 2012) • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HS-PS2-1) • Systems can be designed to cause a desired effect. (HS-PS2-3) **Systems and System Models** (pp. 91-94, NRC, 2012) • When investigating or describing a system, the boundaries and initial conditions of the system need to be defined. (HS-PS2-2) - **Connections to Nature of Science** **Science Models, Laws, Mechanisms, and Theories Explain**

refine the design accordingly. (HS-PS2-1),(HSPS2-3) **Analyzing and Interpreting Data** (pp. 61-63, NRC, 2012) Analyzing data in 9–12 builds on K–8 and progresses to introducing more detailed statistical analysis, the comparison of data sets for consistency, and the use of models to generate and analyze data. • Analyze data using tools, technologies, and/or models (e.g., computational, mathematical) in order to make valid and reliable scientific claims or determine an optimal design solution. (SLO 1, 2 & 3), (HS-PS2-1) **Using Mathematics and Computational Thinking** (pp. 64-67, NRC, 2012) Mathematical and computational thinking at the 9– 12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical representations of phenomena to describe explanations. (SLO 1, 2 & 4), (HS-PS2-2) **Constructing Explanations and Designing Solutions** (pp. 67-71, NRC, 2012) Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories.	**ETS1.A: Defining and Delimiting an Engineering Problem** (pp. 204-206, NRC, 2012) • Criteria and constraints also include satisfying any requirements set by society, such as taking issues of risk mitigation into account, and they should be quantified to the extent possible and stated in such a way that one can tell if a given design meets them. (secondary to HS-PS2-3) **ETS1.C: Optimizing the Design Solution** (pp. 208- 210, NRC, 2012) • Criteria may need to be broken down into simpler ones that can be approached systematically, and decisions about the priority of certain criteria over others (trade-offs) may be needed. (HS-PS2-3)	**Natural Phenomena** (pp. 96-101, Appendix H: NRC, 2013) • Theories and laws provide explanations in science. (HS-PS2-1) • Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-1)

• Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3		

NJSLS
WHST.11-12.7 WHST.11-12.9 RST.11-12.1, RST.11-12.7 See Appendix I

Content Area:	Physics		Grade(s)	10, 11, 12
Unit Plan Title:	Types of Interactions	Time Frame	14 Weeks	

NJ Student Learning Standards

- **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.]* HS-PS2-4
- **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. Include the use of mathematical or computational representations that depict that the square of a revolving body's period of revolution is proportional to the cube of its distance to a gravitational center (where T is the orbital period and R is the semi-major axis of the orbit, Kepler's Third Law of Planetary Motion)] [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.]* HS-ESS1-4
- **Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.*** *[Clarification Statement: Emphasis is on the contact forces that determine the functioning of the material. Examples could include why flexible but durable materials are made up of long chained molecules, and pharmaceuticals are designed to interact with specific receptors.] [Assessment Boundary: Assessment is limited to provide molecular structures of specific designed materials.]* HS-PS2-6
- **Construct an explanation of the Big Bang theory based on astronomical evidence of light spectra, motion of distant galaxies, and composition of matter in the universe. HS-ESS1-2**
- **Communicate scientific ideas about the way stars, over their life cycle, produce elements. HS-ESS1-3**

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9– 12 level builds on K–8 and progresses to	**PS2.A: Forces and Motion** • Newton's second law accurately predicts changes in the motion of macroscopic objects. (SLO 1, 2 & 3)	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide evidence for causality in explanations of phenomena.

using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical representations of phenomena to describe explanations. (HS-PS2- 4) (HS-ESS1-4), (SLO 1, 2, 5 & 6) **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs. • 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) **Constructing Explanations and Designing Solutions** (pp. 67-71) Students construct explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS1-2)	**PS1.A: Structure and Properties** of **Matter** • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. • The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. **PS2.B: Types of Interactions** • Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4) • Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (HS-PS2-4) • 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) **ESS1.B: Earth and the Solar System** • Kepler's laws describe common features of the motions of orbiting objects, including their elliptical paths around the sun. Orbits may change due to the gravitational effects from, or collisions with, other objects in the solar system. (HS-ESS1-4), (SLO 6) **ESS1.A: The Universe and Its Stars** (pp. 173-174) • The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2),(HS-ESS1-3)	(HS-PS2-4) **Cause and Effect** • Empirical evidence is required to differentiate between cause and correlation and make claims about specific causes and effects. (HSPS2-1),(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) **Structure and Function** • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (HS-PS2-6) **Scale, Proportion, and Quantity** • Algebraic thinking is used to examine exponential growth). (HS-ESS1-4) **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. **Scale, Proportion, and Quantity** (pp. 89-91) • 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)

Obtaining, Evaluating, and Communicating Information (pp. 74-77) Students evaluate the validity and reliability of the claims, methods, and designs. • Communicate scientific ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-ESS1-3) - ***Connections to Nature of Science*** **Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-ESS1-2)	• The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (HS-ESS1-2) • Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (HS-ESS1-2),(HS-ESS1-3) **PS4.B: Electromagnetic Radiation** (pp. 133-136) Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. *(secondary to HS-ESS1-2)*	**Energy and Matter** (pp. 94-96) • Energy cannot be created or destroyed–only moved between one place and another place, between objects and/or fields, or between systems. (HS-ESS1-2) • In nuclear processes, atoms are not conserved, but the total number of protons plus neutrons is conserved. (HS-ESS1-3) - ***Connections to Nature of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. (HS-ESS1-2) Science assumes the universe is a vast single system in which basic laws are consistent. (HS-ESS1-2)
NJSLS		
WHST.11-12.2 WHST.11-12.7 WHST.11-12.8 WHST.11-12.9 RST.11-12.1, RST.11-12.7 See Appendix I		

Content Area:	Physics		Grade(s)	10, 11, 12
Unit Plan Title:	Energy	Time Frame	3 Weeks	
NJ Student Learning Standards				
• **Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions**				

of particles (objects) and energy associated with the relative positions of particles (objects). *[Clarification Statement: Examples of phenomena at the macroscopic scale could include the conversion of kinetic energy to thermal energy, the energy stored due to position of an object above the earth, and the energy stored between two electrically-charged plates. Examples of models could include diagrams, drawings, descriptions, and computer simulations.]* HS-PS3-2

- **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 fields.]* HS-PS3-1

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (SLO 1), (HSPS3-2) **Planning and Carrying Out Investigations** Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical, and empirical models. • Plan and conduct an investigation individually and collaboratively to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable measurements and consider limitations on the precision of the data (e.g., number of trials, cost, risk, time), and refine the design accordingly. (HS-PS3-3) **Using Mathematics and Computational**	**PS2.B: Types of Interactions** • Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4) • Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (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) **PS3.A: Definitions of Energy** • "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (secondary to HS-PS2-5) PS3.C: Relationship Between Energy and Forces • When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5) **PS3.B: Conservation of Energy and Energy**	**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. (HSPS2-5) • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS3-5) **Structure and Function** • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of components to reveal its function and/or solve a problem. (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-PS2-4) • Laws are statements or descriptions of the relationships among observable phenomena. (HS-PS2-4)

Thinking Mathematical and computational thinking at the 9– 12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Create a computational model or simulation of a phenomenon, designed device, process, or system. (SLO 1 & 2) (HS-PS3-1), (HS-PS3-2) **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and/or refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritized criteria, and tradeoff considerations. (HS-PS3-3)	**Transfer** • Conservation of energy means that the total change of energy in any system is always equal to the total energy transferred into or out of the system (HS-PS3-1) • Energy cannot be created or destroyed, but it can be transported from one place to another and transferred between systems. (HS-PS3-1), • Mathematical expressions, which quantify how the stored energy in a system depends on its configuration (e.g., relative positions of charged particles, compression of a spring) and how kinetic energy depends on mass and speed, allow the concept of conservation of energy to be used to predict and describe system behavior. (HS-PS3-1)	
NJSLS		
WHST.11-12.7, WHST.9-12.9 RST.11-12.1, RST.11-12.7 See Appendix I		

Content Area:	Physics		Grade(s)	10, 11, 12
Unit Plan Title:	Electricity and Magnetism	Time Frame	6 Weeks	
NJ Student Learning Standards				

- **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.]* HS-PS3-5
- **Use mathematical representations of 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.]* HS-PS2-4
- **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 provides materials and tools.]* HS-PS2-5
- **Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials.** [Clarification Statement: Emphasis is on the attractive and repulsive forces that determine the functioning of the material. Examples could include why electrically conductive materials are often made of metal] [Assessment Boundary: Assessment is limited to provide molecular structures of specific designed materials.] [Teacher Note: The emphasis in this unit is on the electrical properties of materials.] HS-PS2-5
- **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 is limited to devices constructed with materials provided to students.] HS-PS2-6

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Planning and Carrying Out Investigations Planning and carrying out investigations to answer questions or test solutions to problems in 9–12 builds on K–8 experiences and progresses to include investigations that provide evidence for and test conceptual, mathematical, physical and empirical models. • Plan and conduct an investigation individually and 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)	**PS2.B: Types of Interactions** • Newton's law of universal gravitation and Coulomb's law provide the mathematical models to describe and predict the effects of gravitational and electrostatic forces between distant objects. (HS-PS2-4) • Forces at a distance are explained by fields (gravitational, electric, and magnetic) permeating space that can transfer energy through space. Magnets or electric currents cause magnetic fields; electric charges or changing magnetic fields cause electric fields. (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)	**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. (HSPS2-5) • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS3-5) **Structure and Function** • Investigating or designing new systems or structures requires a detailed examination of the properties of different materials, the structures of different components, and connections of

Using Mathematics and Computational Thinking Mathematical and computational thinking at the 9– 12 level builds on K–8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical representations of phenomena to describe explanations. (HS-PS2- 4) **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs. • 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** Modeling in 9–12 builds on K–8 and progresses to using, synthesizing, and developing models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop and use a model based on evidence to illustrate the relationships	**PS3.A: Definitions of Energy** • "Electrical energy" may mean energy stored in a battery or energy transmitted by electric currents. (secondary to HS-PS2-5) **PS3.C: Relationship Between Energy and Forces** • When two objects interacting through a field change relative position, the energy stored in the field is changed. (HS-PS3-5)	components to reveal its function and/or solve a problem. (HS-PS2-6)

between systems or between components of a system. (HS-PS3-5)		

NJSLS
WHST.9-12.9, WHST.11-12.2, WHST.11-12.7, WHST.11-12.8, WHST.9-10.10 RST.11-12.1 See Appendix I

Content Area:	Physics		Grade(s)	10, 11, 12
Unit Plan Title:	Waves and their Applications	Time Frame	3 Weeks	

NJ Student Learning Standards

- **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 escribing those relationships qualitatively.]* HS-PS4-1

- **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]* HS-PS4-4

- **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 calculations.]* HS-PS4-3

- **Communicate technical information about how some technological devices use the principles of wave behavior and wave interactions with matter to transmit and capture information and energy.*** *[Clarification Statement: Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copied and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.]* HS-PS4-5

- **Evaluate questions about the advantages of using a digital transmission and storage of information.** *[Clarification Statement: Examples of advantages could include that digital information is stable because it can be stored reliably in computer memory, transferred easily, and copies and shared rapidly. Disadvantages could include issues of easy deletion, security, and theft.]* HS-PS4-2

Science and Engineering Practices	**Disciplinary Core Ideas**	**Crosscutting Concepts**
Asking Questions and Defining Problems Asking questions and defining problems in	**PS3.D: Energy in Chemical Processes** • Solar cells are human-made devices that likewise	**Cause and Effect** • Empirical evidence is required to differentiate between

grades 9–12 builds from grades K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. (HSPS4-2**)** **Using Mathematics and Computational Thinking** Mathematical and computational thinking at the 9- 12 level builds on K-8 and progresses to using algebraic thinking and analysis, a range of linear and nonlinear functions including trigonometric functions, exponentials and logarithms, and computational tools for statistical analysis to analyze, represent, and model data. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical representations of phenomena or design solutions to describe and/or support claims and/or explanations. (HS-PS4-1) **Engaging in Argument from Evidence** Engaging in argument from evidence in 9–12 builds on K–8 experiences and progresses to using appropriate and sufficient evidence and scientific reasoning to defend and critique claims and explanations about natural and designed worlds. Arguments may also come from current scientific or historical episodes in science. • Evaluate the claims, evidence, and reasoning behind currently accepted explanations or solutions to determine the	capture the sun's energy and produce electrical energy. (secondary to HS-PS4-5) **PS4.A: Wave Properties** • The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (HS-PS4-1) • Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. (HS-PS4-2),(HS-PS4-5) • [From the 3–5 grade band endpoints] Waves can add or cancel one another as they cross, depending on their relative phase (i.e., relative position of peaks and troughs of the waves), but they emerge unaffected by each other. (Boundary: The discussion at this grade level is qualitative only; it can be based on the fact that two different sounds can pass a location in different directions without getting mixed up.) (HS-PS4-3) **PS4.B: Electromagnetic Radiation** • Electromagnetic radiation (e.g., radio, microwaves, light) can be modeled as a wave of changing electric and magnetic fields or as particles called photons. The wave model is useful for explaining many features of electromagnetic radiation, and the particle model explains other features. (HS-PS4-3) • When light or longer wavelength electromagnetic radiation is absorbed in matter, it is generally converted into thermal energy (heat). Shorter wavelength electromagnetic radiation (ultraviolet, X-rays, 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)	cause and correlation and make claims about specific causes and effects. (HSPS4-1) • Cause and effect relationships can be suggested and predicted for complex natural and human designed systems by examining what is known about smaller scale mechanisms within the system. (HS-PS4-4) • Systems can be designed to cause a desired effect. (HS-PS4-5) Systems and System Models • Models (e.g., physical, mathematical, computer models) can be used to simulate systems and interactions—including energy, matter, and information flows—within and between systems at different scales. (HS-PS4-3) **Stability and Change** • Systems can be designed for greater or lesser stability. (HS-PS4-2) Energy and Matter • Energy cannot be created or destroyed–only moved between one place and another place, between objects and/or fields, or between systems. (HS-ESS1-2) - **Connections to Engineering, Technology, and Applications of Science Interdependence of Science, Engineering, and Technology** • Science and engineering complement each other in the cycle known as research and development (R&D). (HS-PS4-5) **Influence of Engineering, Technology, and Science on Society and the Natural World** • Modern civilization depends on major technological systems. (HS-PS4-2),(HS-PS4-5) • Engineers continuously modify these technological systems by applying scientific knowledge and engineering design practices to increase benefits while decreasing costs and risks. (HS-PS4-2) - **Connections to Engineering, Technology, and Applications of Science Interdependence of Science, Engineering, and Technology** • Science and engineering complement each other in the cycle known as research and development (R&D). Many R&D projects may involve scientists, engineers, and others with wide ranges of expertise.

merits of arguments. (HS-PS4-3) **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in 9–12 builds on K–8 and progresses to evaluating the validity and reliability of the claims, methods, and designs. • Evaluate the validity and reliability of multiple claims that appear in scientific and technical texts or media reports, verifying the data when possible. (HS-PS4-4) • Communicate technical information or ideas (e.g. about phenomena and/or the process of development and the design and performance of a proposed process or system) in multiple formats (including orally, graphically, textually, and mathematically). (HS-PS4-5) **Constructing Explanations and Designing Solution** Constructing explanations and designing solutions in 9–12 builds on K–8 experiences and progresses to explanations and designs that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. (HS-ESS1-2)	**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, and 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) **ESS1.A: The Universe and Its Stars** • The study of stars' light spectra and brightness is used to identify compositional elements of stars, their movements, and their distances from Earth. (HS-ESS1-2) • The Big Bang theory is supported by observations of distant galaxies receding from our own, of the measured composition of stars and non-stellar gases, and of the maps of spectra of the primordial radiation (cosmic microwave background) that still fills the universe. (HS-ESS1-2) • Other than the hydrogen and helium formed at the time of the Big Bang, nuclear fusion within stars produces all atomic nuclei lighter than and including iron, and the process releases electromagnetic energy. Heavier elements are produced when certain massive stars achieve a supernova stage and explode. (HS-ESS1-2) **PS4.B: Electromagnetic Radiation** • Atoms of each element emit and absorb characteristic frequencies of light. These characteristics allow identification of the presence of an element, even in microscopic quantities. (secondary to HS-ESS1-2)	(HS-ESS1-2**)** **Connections to Nature of Science Science Models, Laws, Mechanisms, and Theories Explain Natural Phenomena** • A scientific theory is a substantiated explanation of some aspect of the natural world, based on a body of facts that have been repeatedly confirmed through observation and experiment and the science community validates each theory before it is accepted. If new evidence is discovered that the theory does not accommodate, the theory is generally modified in light of this new evidence. (HS-PS4- 3) **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** • Scientific knowledge is based on the assumption that natural laws operate today as they did in the past and they will continue to do so in the future. (HS-ESS1-2) • Science assumes the universe is a vast single system in which basic laws are consistent. (HSESS1-2)
NJSLS		

WHST.9-12.2, WHST.11-12.8
RST.9-10.8, RST.11-12.1, RST.11-12.7, RST.11-12.8
See Appendix I

III. Methods of Student Evaluation

Assessment can be divided into two general categories: formal (graded) and informal/classroom-based (both graded and ungraded). The key to effectively assessing a student's mastery of skills is to match the assessment method to the learning objective.

Formal Assessments

- Evaluation
- Class participation
- Creative assignments
- Homework and classwork assignments
- Reports and presentations
- Research methodology
- Technological applications
- Unit tests
- Various speaking and listening assignments
- Multiple choice exams
- Quizzes (announced and unannounced)
- Essays
- Formal lab reports
- Scientific journal reviews
- Projects
- Short answer and problem solving tests
- Tests and quizzes on blackboard
- Case Study analysis

Informal Assessments

- Instructor's observations of note-taking, and organization of notebooks and assignments
- Cooperative learning activities, including labs
- Creative project assignments
- Laboratory behavior
- Observing citizenship and appropriate social responses
- Instructor's observations of time management skills

IV. Instructional Strategies Based on Instructional Goals

- Graphs and other visuals
- Engaging in discussions
- Reading silently and aloud
- Listening and speaking activities
- Watching and responding to media
- Brainstorming
- Listening
- Mapping
- Revising and editing
- Participating in small and large groups
- Researching to make connections to texts and classroom discussions
- Collaborative projects
- Answering questions (oral and written)
- Summarizing
- Debating
- Analyzing texts, discussions, etc.

- Peer teaching
- Competing in teams/debating
- Playing games
- Creating games
- Note taking and note making
- Writing

V. Textbook: Holt Mcdougal Physics; 1st Edition; 2012; By: Serway & Faughn; Houghton Mifflin Harcourt Publishing Company; 978-0-547-58669-4

VI. Scope and Sequence

Key: I – Introduced, D-developed in Depth, R-Reinforced

Skill To Be Learned	**11**	**12**
Identify, explain and use SI units of measurement	R	R
Correctly identify and manipulate mathematical formulas	I,D,R	I,D,R
Define velocity and acceleration mathematically and graphically	I,D,R	I,D,R
Distinguish between displacement and distance, speed and velocity	I,D,R	I,D,R
Explain the parameters affecting free fall	I,D,R	I,D,R
Explain the difference between a vector and scalar quantity	I,D,R	I,D,R
Use kinematic equations to solve various two dimensional motion problems	I,D,R	I,D,R
Explain Newton's 1st , 2nd , and 3rd Laws	I,D,R	I,D,R

Understand the nature of gravitational, electromagnetic, weak, and strong forces	I,D,R	I,D,R
Calculate and solve problems involving weight, normal force, friction, and inclined planes	I,D,R	I,D,R
Describe the relationship between energy and work	I,D,R	I,D,R
Explain the Work-Energy Principle	I,D,R	I,D,R
Explain and solve problems using the Conservation of Mechanical Energy	I,D,R	I,D,R
Solve problems involving work and power	I,D,R	I,D,R
Explain the relationship between impulse and momentum	I,D,R	I,D,R
Gain and understanding of conservation of momentum	I,D,R	I,D,R
Explain the difference between elastic and inelastic collisions	I,D,R	I,D,R
Calculate various aspects of circular motion	I,D,R	I,D,R
Explain and be able the calculate problems using the Law of Universal Gravitation	I,D,R	I,D,R
Calculate how objects move in space	I,D,R	I,D,R
Explain the properties of waves	I,D,R	I,D,R
List and explain wave interactions	I,D,R	I,D,R
Demonstrate an understanding of the nature, types and causes of motion	I,D,R	I,D,R
Explain the characteristics of sound waves	I,D,R	I,D,R
Describe sound intensity and resonance	I,D,R	I,D,R
List the characteristics of light	I,D,R	I,D,R
Recognize situations in which refraction will occur	I,D,R	I,D,R

Describe how light waves interfere with each other to produce bright and dark fringes	I,D,R	I,D,R

VII. Pacing Chart

Marking Period 1

- *Unit 1*
  - **Measurements in Experiments:** (1 weeks) Student will be able to define the SI standards of measurement. Student will be able to use common metric prefixes. Student will be able to estimate measurements and solutions to problems. Student will be able to perform arithmetic operations using scientific notation. Student will be able to perform arithmetic operations with significant digits.
  - **Using Vectors to Represent Motion:** (2 weeks) Student will be able to choose coordinate systems for motion problems. Student will be able to differentiate between scalar and vector quantities. Student will be able to define a displacement vector and determine a time interval.
  - **Qualitatively and Quantitatively Describing Motion:** (4 weeks) Student will be able to define velocity and acceleration operationally. Student will be able to relate the direction and magnitude of velocity and acceleration vectors to the motion of objects. Student will be able to solve problems of relative velocity. Student will be able to describe motion in terms of changing velocity. Student will be able to apply kinematic equations to calculate distance, time, or velocity under conditions of constant acceleration. Student will be able to relate the motion of a freely falling body to motion with constant acceleration.
  - **Describing Motion graphically:** (2 weeks) Student will able to construct and interpret graphs of position versus time. Student will be able to compare graphical representations of accelerated and nonaccelerated motion.

Marking Period 2

- *Unit 1*
  - **Momentum:** (2 weeks) Student will be able to compare the system before and after an event in momentum problems. Student will be able to define the momentum of an object. Student will be able to determine the impulse given to an object. Student will be able to recognize the conditions under which the momentum of a system is conserved. Student will be able to recognize that impulse equals the change in momentum of an object. Student will be able to relate Newton's third law of motion to conservation of momentum in collisions and explosions
- *Unit 2*
  - **Planetary Motion:** (3 weeks) Student will be able to relate Kepler's laws of planetary motion to Newton's law of universal gravitation. Student will be able to calculate the periods and speeds of orbiting objects. Student will be able to describe the method Cavendish used to measure G and the results of knowing G. Student will be able to solve problems involving orbital speed and period. Student will be able to relate weightlessness to objects in free fall. Student will be able to contrast Newton's and Einstein's views about gravitation.
  - **Projectile Motion:** (2 weeks) Student will be to recognize that the vertical and horizontal motions of a projectile are independent. Student will be able to relate height, time in the air, and initial vertical velocity of a projectile using its vertical motion, then determining the range. Student will be able to explain the shape of the trajectory of a moving object depends upon the frame of reference from which it is observed
  - **Circular Motion:** (2 weeks) Student will be able to explain the acceleration of an object moving in a circle at constant speed. Student will be able to describe how centripetal acceleration depends upon the object's speed and the radius of the circle. Student will be able to recognize the direction of the force that causes centripetal acceleration.
  - **Friction** (1 week) Student will be able to represent and describe the two types of forces that a surface can exert on an object- a normal force, and a friction force parallel to the surface and dependent on the normal force and textures of the two surfaces.

Marking Period 3

- *Unit 2*

- **Friction:** (1 week) Student will be able to represent and describe the two types of forces that a surface can exert on an object- a normal force, and a friction force parallel to the surface and dependent on the normal force and textures of the two surfaces.
- **Newton's Second and Third Laws:** (2 weeks) Student will be able to describe an object's acceleration in terms of its mass and the net force acting on it. Student will be able to predict the direction and magnitude of the acceleration caused by a known net force. Student will be able to identify action-reaction pairs..
- **Changes in Motion:** (1 week) Student will be able to describe how force affects the motion of an object. Student will be able to interpret and construct free-body diagrams.
- **Newton's First Law:** (3 weeks) Student will be able to explain the relationship between the motion of an object ant the net external force acting on the object. Student will be able to determine the net external force on an object. Student will be able to calculate the force required to bring an object into equilibrium.

- *Unit 3*
  - **Work and Energy:** (3 weeks) **Student** will be able to describe the relationship between work and energy. Student will be able to display an ability to calculate work done by a force. Student will be able to identify the force that does work. Student will be able to differentiate between work and power and correctly calculate power used. Student will be able to communicate an understanding of mechanical advantage in ideal and real machines. Student will be able to analyze compound machines and describe them in terms of simple machines

Marking Period 4

- *Unit 4*
  - **Electric Fields** (3 weeks) Student will understand the basic properites of electric charge. Student will differentiate between conductors and insulators. Student will be able to calculate electric force using Coulomb's law. Student will be able to compare electric force with gravitational force.
  - **Magnetism** (3 weeks) Student will predict whether magnets will repel or attract each other. Student will be able to describe the magnetic field around a permanent magnet. Student will be able to describe the orientation of the Earth's magnetic field.
- *Unit 5*.
  - **Waves:** (3 weeks) Student will be able to demonstrate knowledge of the nature of sound waves and the properties sound shares with other waves. Student will be able to solve problems relating the frequency,

wavelength, and velocity of sound. Student will be able to define the Doppler shift and identify some of its applications. Student will be able to recognize that light is the visible portion of an entire range of electromagnetic frequencies. Student will be able to define luminous intensity, luminous flux, and illuminance. Student will be able to explain the formation of color by light. Student will be able to explain the cause and give examples of interference in thin films. Student will be able to describe methods of producing polarized light. Student will be able to explain the damaging effects on living tissue that some frequencies have.

Student Handout

Course Description

Physics deals with the principles upon which the advances in modern technology are based. The major fields of mechanics, sound, and light are covered. As the year progresses, students will discover how unrelated phenomena can be explained with the help of a few fundamental unifying laws, and how a huge body of unrelated information can become unified. For example, out of the many motions of various bodies from the smallest nuclear particle to the giant planets the student will discover a few simple laws that describe all motion. Students will also gain an understanding of Newton's Universal Law of gravitation and Einstein's theory of gravity. An emphasis will be given to physics applications and related careers.

Proficiencies

1. Logically gather order and interpret data through an appropriate use of measurements and tools.
2. Students will evaluate the importance of curiosity, honesty, openness, and skepticism in science. Students will use standard safety practices for all classroom laboratory and field investigations. Students will identify and investigate problems scientifically.
3. Students will use tools and instruments for observing, measuring, and manipulating scientific equipment and materials.
4. Students will demonstrate the computation and estimation skills necessary for analyzing data and developing reasonable scientific explanations.
5. Students will communicate scientific investigations and information clearly.
6. Students will analyze how scientific knowledge is developed.
7. Students will understand important features of the process of scientific inquiry.
8. Demonstrate an understanding of the nature, types and causes of motion.
9. Demonstrate an understanding of the nature of gravitational, electromagnetic and nuclear forces.
10. Explain the law of conservation of energy and relate it to energy transformations.
11. Demonstrate an understanding of the characteristics of work and energy.
12. Describe and identify the components of the electromagnetic spectrum
13. Students will analyze the relationships between force, mass, gravity, and the motion of objects. Students will evaluate the significance of energy in understanding the structure of matter and the universe.
14. Students will evaluate the forms and transformations of energy.
15. Students will analyze the properties and applications of waves.

16. Students will evaluate relationships between electrical and magnetic forces.
17. Students will analyze the properties of electric fields.
18. Examine contributions of important scientists to the development of physics principles.

APPENDIX I:

WHST.9-10.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

A. Introduce a topic and organize ideas, concepts, and information to make important connections and distinctions; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.
B. Develop the topic with well-chosen, relevant, and sufficient facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.
C. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among ideas and concepts.
D. Use precise language and domain-specific vocabulary to manage the complexity of the topic and convey a style appropriate to the discipline and context as well as to the expertise of likely readers.
E. Establish and maintain a style and tone appropriate to the audience and purpose (e.g. formal and objective for academic writing) while attending to the norms and conventions of the discipline in which they are writing.
F. Provide a concluding paragraph or section that supports the argument presented.

WHST.9-10.9. Draw evidence from informational texts to support analysis, reflection, and research.

WHST.9-10.10. Write routinely over extended time frames (time for reflection and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences.

WHST.11-12.2. Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.

A. Introduce a topic and organize complex ideas, concepts, and information so that each new element builds on that which precedes it to create a unified whole; include formatting (e.g., headings), graphics (e.g., figures, tables), and multimedia when useful to aiding comprehension.
B. Develop the topic thoroughly by selecting the most significant and relevant facts, extended definitions, concrete details, quotations, or other information and examples appropriate to the audience's knowledge of the topic.

C. Use varied transitions and sentence structures to link the major sections of the text, create cohesion, and clarify the relationships among complex ideas and concepts.
D. Use precise language, domain-specific vocabulary and techniques such as metaphor, simile, and analogy to manage the complexity of the topic; convey a knowledgeable stance in a style that responds to the discipline and context as well as to the expertise of likely readers.
E. Provide a concluding paragraph or section that supports the argument presented.

WHST.11-12.7. Conduct short as well as more sustained research projects to answer a question (including a self-generated question) or solve a problem; narrow or broaden the inquiry when appropriate; synthesize multiple sources on the subject, demonstrating understanding of the subject under investigation.

WHST.11-12.8. Gather relevant information from multiple authoritative print and digital sources, using advanced searches effectively; assess the strengths and limitations of each source in terms of the specific task, purpose, and audience; integrate information into the text selectively to maintain the flow of ideas, avoiding plagiarism and overreliance on any one source and following a standard format for citation.

WHST.11-12.9. Draw evidence from informational texts to support analysis, reflection, and research.

RST.9-10.8. Determine if the reasoning and evidence in a text support the author's claim or a recommendation for solving a scientific or technical problem.
RST.11-12.1. Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.
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.
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.