Passaic County Technical Institute

Wayne, NJ

Physics Honors 2 Curriculum

August 2015

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I. Course Description

Physics Honors 1 is a college level, algebra based general physics course somewhat similar to a introductory level university physics course. It is intended to be a second course taken after a first course in physics or general science. Students taking this course should have also taken and mastered the algebra 2 course. Some trigonometry is required and the necessary topics will be covered in a short the math methods review which will be an integral part of this advanced high school physics course.

The course covers four general areas in physics. They are electricity and magnetism, optics, special relativity, and atomic and nuclear physics.

This course has been approved for a maximum of four (4) college credits through Seton Hall University's Project Acceleration Program. The breakdown is as follows:

General Physics II	PHYS 1702-PPC	3 Credits
Physics Lab II	PHYS 1812- PPC	1 Credit

II. Course Objectives/Outline

Content Area:	Physics Honors 2		Grade(s)	10, 11, 12
Unit Plan 1 Title:	Forces and Interactions	Time Frame	2 Weeks	

Learning Objectives

- Perform calculations involving Pascal's principle, buoyancy and Archimedes principle PS2.A
- Describe fluids in motion and use mathematical representations of mass and volume flow rates, and Bernoulli's principle to calculate quantities such as flow rates, volume, density, pressure and velocity of fluids in motion. PS2.A
- Use mathematical representations of magnetism, Newton's law of gravitation, and Coulomb's law to describe and predict the magnetic, gravitational, and electrostatic forces between objects. PS2.B
- Use appropriate mathematical routines to calculate values for initial or final angular momentum, or change in angular momentum of a system, or average torque or time during which the torque is exerted in analyzing a situation involving torque and angular momentum. PS2-1
- Analyze torque brought on by forces arising from magnetic and electrical interactions between objects and use mathematical representations of both the force and resulting torque. PS2.A
- Use mathematical representations of relativistic mass and to predict the relativistic momentum of an objects travelling at relativistic speeds. PS2-A
- Perform calculations on relativistic addition of velocities. PS2A

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	**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	**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

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-PS2-1),(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	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) **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)	to be defined. (HS-PS2-2) - ***Connections to Nature of Science*** **Science Models, Laws, Mechanisms, and Theories Explain 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)

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. • Apply scientific ideas to solve a design problem, taking into account possible unanticipated effects. (HS-PS2-3		
Common Core		
• **Common Core Writing Standards:** WHST.11-12.7 WHST.11-12.9 • **Common Core Reading Standards:** RST.11-12.1, RST.11-12.7		

Content Area:	Physics Honors 2		Grade(s)	10, 11, 12
Unit Plan 2 Title:	Energy	Time Frame	6 Weeks	

Learning Objectives

- Identify and quantify the various types of energies within a system of objects in a well-defined state, such as elastic potential energy, gravitational potential energy, kinetic energy, and thermal energy and represent how these energies may change over time. PS3.A, PS3.B 2
- Calculate changes in kinetic energy and gravitational potential energy of a system using representations of that system. PS3.A 3
- Construct an explanation, using atomic-scale interactions and probability of how a closed system approaches thermal equilibrium when after energy is transferred to it or from it in a thermal process. PS3.A 4
- 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). PS3A
- Describe the models that represent processes by which energy can be transferred between a system and its environment because of differences in temperature: conduction, convection, and radiation. PS3B
- Predict qualitative changes in the internal energy of a thermodynamic system involving transfer of energy due to heat or work done and justify those predictions in terms of conservation of energy principles PS3B
- Plot of pressure versus volume for a thermodynamic process to make calculations of internal energy changes, heat, or work, based upon conservation of energy principles (i.e., the first law of thermodynamics). PS3B
- Describe emission or absorption spectra associated with electronic or nuclear transitions as transitions between allowed energy states of the atom in terms of the principle of energy conservation, including characterization of the frequency of radiation emitted or absorbed. PS3B
- Mathematically express the changes in electric potential energy of a loop in a multi-loop electrical circuit and justify this expression using the principle of the conservation of energy. PS3B
- Nuclear processes, including fusion, fission and radioactive decay of unstable nuclei involve the release and absorption of energy. PS1-C.

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	**PS2.B: Types of Interactions** • Newton's law of universal gravitation and Coulomb's law provide the mathematical	**Patterns** • Different patterns may be observed at each of the scales at which a system is studied and can provide

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 Thinking**	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)	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)

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)		

Common Core
• **Common Core Writing Standards:** WHST.11-12.7, WHST.9-12.9 • **Common Core Reading Standards:** RST.11-12.1, RST.11-12.7

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

Learning Objectives

- Apply mathematical routines to determine the magnitude and direction of the electric field at specified points in the vicinity of a small set (2–4) of point charges, and express the results in terms of magnitude and direction of the field in a visual representation by drawing field vectors of appropriate length and direction at the specified points. PS2B
- 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. PS3-5 2
- Use mathematical representations of Coulomb's Law to describe and predict the electrostatic forces between objects. PS2-4 3
- Construct an explanation of a model of electric charge, and make a qualitative prediction about the distribution of positive and negative electric charges within neutral systems as they undergo various processes. PS2.B 5
- Calculate the magnitude and determine the direction of the electric field between two electrically charged parallel plates, given the charge of each plate, or the electric potential difference and plate separation. PS2B
- Construct an explanation of the function of a simple electromagnetic device in which an induced emf is produced by a changing magnetic flux through an area defined by a current loop (i.e., a simple microphone or generator) or of the effect on behavior of a device in which an induced emf is produced by a constant magnetic field through a changing area. PS2B
- Make predictions about the redistribution of charge during charging by friction, conduction, and induction. PS2.B 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. PS2-5
- Describe AC circuits and use mathematical representations of electrical resistance and the reactance of inductors and capacitors to calculate the impedance of a steady state LRC circuit. PS2B
- Use right-hand rules to analyze a situation involving a current-carrying conductor and a moving electrically charged object to determine the direction of the magnetic force exerted on the charged object due to the magnetic field created by the current- carrying

conductor. PS2B

- Communicate scientific and technical information about why the molecular-level structure is important in the functioning of designed materials. PS2-5
- Plan data collection strategies and perform data analysis to examine the values of currents and potential differences in an electric circuit that is modified by changing or rearranging circuit elements, including sources of emf, resistors, and capacitors. 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) **Using Mathematics and Computational Thinking** Mathematical and computational thinking at the 9– 12 level builds on K–8 and progresses to using algebraic	**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:	**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)

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	**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)	

show relationships among variables between systems and their components in the natural and designed worlds. • Develop and use a model based on evidence to illustrate the relationships between systems or between components of a system. (HS-PS3-5)		

Common Core
• **Common Core Writing Standards:** WHST.9-12.9, WHST.11-12.2, WHST.11-12.7, WHST.11-12.8, WHST.9-10.10 • **Common Core Reading Standards:** RST.11-12.1

Content Area:	Physics Honors 2		Grade(s)	10, 11, 12
Unit Plan 5 Title:	Waves and Electromagnetic Radiation	Time Frame	6 Weeks	

Learning Objectives

- Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media. HS-PS4-1 2
- Evaluate the validity and reliability of claims in published materials of the effects that different frequencies of electromagnetic radiation have when absorbed by matter. HS-PS4-4 3
- Distinguish between models of radiant energy, and use the scale of the problem to determine at what regimes a particle or wave model is more appropriate. PS4.B 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. PS4-3 5
- Make claims using connections across concepts about the behavior of light as the wave travels from one medium into another, as some is transmitted, some is reflected, and some is absorbed. PS4
- Plan data collection strategies as well as perform data analysis and evaluation of the evidence for finding the relationship between the angle of incidence and the angle of refraction for light crossing boundaries from one transparent material to another (Snell's

law).PS4B

- Use quantitative and qualitative representations and models to analyze situations and solve problems about image formation occurring due to the reflection of light from surfaces. PS4B
- Use quantitative and qualitative representations and models to analyze situations and solve problems about image formation occurring due to the refraction of light through thin lenses. PS4B
- Predict the dependence of major features of a diffraction pattern (e.g., spacing between interference maxima) based upon the particle speed and de Broglie wavelength of electrons in an electron beam interacting with a crystal. (de Broglie wavelength need not be given, so students may need to obtain it. PS4B

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Asking Questions and Defining Problems Asking questions and defining problems in grades 9–12 builds from grades K–8 experiences and progresses to formulating, refining, and evaluating empirically testable questions and design problems using models and simulations. • Evaluate questions that challenge the premise(s) of an argument, the interpretation of a data set, or the suitability of a design. (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	**PS3.D: Energy in Chemical Processes** • Solar cells are human-made devices that likewise capture the sun's energy and produce electrical energy. (secondary to HS-PS4-5) **PS4.A: Wave Properties** • The wavelength and frequency of a wave are related to one another by the speed of travel of the wave, which depends on the type of wave and the medium through which it is passing. (HS-PS4-1) • Information can be digitized (e.g., a picture stored as the values of an array of pixels); in this form, it can be stored reliably in computer memory and sent over long distances as a series of wave pulses. (HS-PS4-2),(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	**Cause and Effect** • Empirical evidence is required to differentiate between 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

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 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	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 m any 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) 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	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

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-	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)	involve scientists, engineers, and others with wide ranges of expertise. (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)

ESS1-2)		

Common Core
Common Core Writing Standards: WHST.9-12.2, WHST.11-12.8   **Common Core Reading Standards:** RST.9-10.8, RST.11-12.1, RST.11-12.7, RST.11-12.8

Content Area:	Physics Honors 2		Grade(s)	10, 11, 12
Unit Plan 5 Title:	Structure and Properties of Matter	Time Frame	6 Weeks	

Learning Objectives

- Provide evidence that the number of protons determine an element, and that neutrons and electrons do not. PS1A
- Use aspects of particulate models (i.e., particle spacing, motion, and forces of attraction) to reason about observed differences between solid, liquid and gas phases of certain materials. PS1A
- Plan and conduct an investigation to gather evidence to compare the structure of substances at the bulk scale to infer the strength of electrical forces between particles. PS1A
- Describe emission or absorption spectra associated with electronic or nuclear transitions as transitions between allowed energy states of the atom in terms of the principle of energy conservation, including characterization of the frequency of radiation emitted or absorbed. PS1A
- Explain why classical mechanics cannot describe all properties of objects by articulating the reasons that classical mechanics must be refined and an alternative explanation developed when classical particles display wave properties. PS1A
- Articulate the reasons that the theory of conservation of mass was replaced by the theory of conservation of mass–energy PS1C
- Support the photon model of electromagnetic radiation with evidence provided by the photoelectric effect and Compton scattering. PS1C
- Use a graphical wave function representation of a particle to predict qualitatively the probability of finding a particle in a specific spatial region. PS1C
- Use mathematical representations of the uncertainty principle to estimate uncertainties in position and momentum, and energy and time of a particle. PS1C
- Predict the number of radioactive nuclei remaining in a sample after a certain period of time, and also predict the missing species (alpha, beta, gamma) in a radioactive decay. PS1C
- Use mathematical representation of the Q-value to prediction the direction of a nuclear reaction. PS1C

- Describe the nuclear processes of fission and fusion and technological, environmental and safety challenges of each process in production of energy for the society. PS1C

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models (pp. 56-59, NRC, 2012) Students use, synthesize, and develop models to predict and show relationships among variables between systems and their components in the natural and designed worlds. • Develop a model based on evidence to illustrate the relationships between systems or between components of a system. (SLO 1, 2) • Use a model to predict the relationships between systems or between components of a system. (SLO 1, 2, & 5) **Planning and Carrying Out Investigations** (pp. 59-61, NRC, 2012) Students plan 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	**PS1.A: Structure and Properties of Matter** (pp. 106-109, NRC, 2012) • Each atom has a charged substructure consisting of a nucleus, which is made of protons and neutrons, surrounded by electrons. (SLO 1) • The periodic table orders elements horizontally by the number of protons in the atom's nucleus and places those with similar chemical properties in columns. (SLO 4, 5 & 6) • The repeating patterns of this table reflect patterns of outer electron states. (SLO 4, 5 & 6) • The structure and interactions of matter at the bulk scale are determined by electrical forces within and between atoms. (SLO 1, 3 & 7) **PS1.B: Chemical Reactions** (pp. 109-111, NRC, 2012) • The fact that atoms are conserved, together with knowledge of the chemical properties of the elements involved, can be used to describe and predict chemical reactions. (SLO 6) **PS1.C: Nuclear Processes** (pp. 111-113, NRC, 2012)	**Patterns** (pp. 85-87, NRC, 2012) • 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. **Stability and Change** (pp. 56-59, NRC, 2012) • Much of science deals with constructing explanations of how things change and how they remain stable. - ***Connections to Nature of Science*** **Scientific Knowledge Assumes an Order and Consistency in Natural Systems** (pp. 96-101, NGSS Appendix H, NRC, 2013) • Science assumes the universe is a vast single system in which basic laws are consistent.

accordingly. (SLO 7) **Analyzing and Interpreting Data** (pp. 61-63) • Analyze data using a model (Periodic table) in order to make a valid scientific claim. (SLO 4) **Constructing Explanations and Designing Solutions** (pp. 67-71, NRC, 2012) Students Construct explanations and design solutions that are supported by multiple and independent student-generated sources of evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on valid and reliable evidence obtained from a variety of sources (including students' own investigations, models, 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. (SLO 3, 6)	• Strong and weak nuclear interactions determine nuclear stability and processes. (SLO 2) **PS2.B: Types of Interactions** (pp. 116-118, NRC, 2012) • Attraction and repulsion between electric charges at the atomic scale explain the structure, properties, and transformations of matter. (SLO 2, 5 & 7)	
Common Core		
• **Common Core Writing Standards:** WHST.9-12.2, WHST.9-12.5, WHST.9-12.7, WHST.11-12.8, WHST.9-12.9 • **Common Core Reading Standards:** **RST.9-10.7**, **RST.11-12.1**		

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

Mastering of the core proficiencies of Biology shall be evaluated in accordance with the general grading policies as listed in the student handbook:

- Tests – 40%
- Laboratory Reports and Projects – 20%
- Quizzes – 20%
- Class Participation – 10%

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. Scope and Sequence

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

SKILLS TO BE LEARNED	11	12
Logically gather order and interpret data through an appropriate use of measurements and tools.	D,R	D,R
Correctly identify and manipulate mathematical formulas	I,D,R	,D,R
Describe and explain vector algebra, trigonometric ratios and simple derivatives and integrals	I,D,R	,D,R
Describe fluid pressure, buoyancy, and viscosity and perform calculations involving buoyancy, Pascal's principle and Archimedes principle.	I,D,R	I,D,R
Describe the behavior of gases on the basis of the kinetic theory and demonstrate an understanding of the gas laws.	I,D,R	I,D,R
Demonstrate an understanding of the four thermodynamic processes and use these along with the laws of thermodynamics to describe heat engines.	I,D,R	I,D,R
Understand Coulomb's and Gauss's laws and use them to evaluate electric force and electric fields respectively.	I,D,R	I,D,R
Describe capacitors and capacitance and explain how dielectrics affect capacitance.	I,D,R	I,D,R
Describe resistor-capacitor (RC) series circuits and solve RC circuit problems.	I,D,R	I,D,R
Demonstrate an understanding of wave motion and apply these principles to electromagnetic waves	I,D,R	I,D,R
Describe geometric optics including the applications of lens, mirrors and	I,D,R	I,D,R

prisms to practical instruments such as microscopes and telescopes.		
Describe the nature of static electricity, magnetism, and electromagnetism	I,D,R	I,D,R
Analyze simple steady-state, direct current (DC) and voltage/resistance (VR) circuits and demonstrate an understanding of the relationships between electric current, voltage and power.	I,D,R	I,D,R
Describe and understand the special theory of relativity and some of its consequences including time dilation, length contraction and simultaneity.	I,D,R	I,D,R
Demonstrate an understanding of the quantum model in describing the behavior of matter at the atomic and sub-atomic levels.	I,D,R	I,D,R
Examine the lives and contributions of important scientists.	I,D,R	I,D,R
Describe radioactivity and the three types of radioactive decay and perform calculations on half life and radioactive decay rates.	I,D,R	I,D,R
Describe the nucleus and the basic concepts of thermonuclear power.	I,D,R	I,D,R

VI. Pacing Chart

<u>Marking Period 1</u>

- *Unit 1*
  - **Fluids:** (3 weeks*)* Student will be able to distinguish between the different phases of matter. Student will be able to solve problems on density and specific gravity. Student will be able understand pressure in fluids and solve problems involving pressure in the atmosphere and in liquids. Student will be able perform calculations involving Pascal's principle, buoyancy and Archimedes principle. Student will be able to describe fluids in motion and solve problems involving flow rate and Bernoulli's principle.
- *Unit 2*
  - **Heat and Temperature:** (3 weeks) Student will be able to understand the atomic theory of matter. Student will be able to understand temperature and how it is measured. Student will be able to describe thermal expansion and

solve related problems. Student will be able to understand gases and concept of an absolute temperature. Student will be able to solve problems involving the ideal gas law. Student will be able to understand the kinetic theory and use it explain some of the properties of matter. Students will be able to understand heat as energy transfer. Student will be able to describe specific heat and solve calorimetric problems. Student will be able to describe heat transfer and solve problems involving heat transfer by conduction and radiation.

- **Thermodynamics: (**3 weeks**)** Student will be able to define to understand the zeroth, first and second laws of thermodynamics. Student will be able to describe thermodynamic processes and the first law. Student will be able to describe heat engines and solve problems involving heat engines. Student will be able describe the operation of heat engines in reverse (such as air conditioners). Student will be able to understand and solve problems involving entropy.

Marking Period 2

- *Unit 3*
  - **Electric Potential and Fields**: (3 weeks) Student will be able to calculate electric force using Coulomb's law for an array of electric point charges. Student will be able to describe electric fields and calculate the electric field due to an array of electric point charges. Student will be able to describe electric fields inside and outside of conductors. Student will be able to understand Gauss's law and the concept of an electric flux. Student will be able to use Gauss's law to relate electric charge to electric field. Student will be able to understand the relationship between electric potential and electric field. Student will be able to calculate the potential difference at a point due to an array of electric point charges. Student will be able to describe capacitors and dielectrics. Student will be able to describe electric energy storage in capacitors.
  - **Electric Current and Direct Current Circuits**: (3 weeks) Student will be able to describe Ohm's law and understand the color coding of resistors. Student will be able to analyze parallel and series arrangements of resistors. Student will be able to analyze parallel and series arrangements of capacitors. Student will be able to analyze direct current circuits consisting of voltage sources, resistors and switches using Kirchhoff's rules. Student will be able to understand resistivity and calculate the resistivity of materials. Student will be able to calculate electric energy and power. Student will be able to describe resistor-capacitor (RC) series circuits and solve RC circuit problems. Student will be able to describe the operation of voltmeters, ammeters and ohmmeters.

- **Magnetism:** (3 weeks) Student will be able to describe magnets and magnetic fields. Student will be able to understand that electric currents produce magnetic fields. Student will be able to use the right hand rule to describe force on a current carrying conductor or on a charge moving in a magnetic field. Student will be able calculate the force between two current carrying wires. Student will be able understand Ampere's law and use it to derive the magnetic fields in simple symmetric cases. Student will be able describe torque on a current loop and solve problems involving torque and magnetic moment. Student will be able understand diamagnetism, paramagnetism and ferromagnetism.

<u>Marking Period 3</u>

- *Unit 3*
  - **Electromagnetism and Alternating Current:** (3 weeks) Student will be able describe an induced emf. Student will be able describe Faraday's Law of induction and Lenz's law. Student will be able understand the concept of magnetic flux and solve problems involving changes in magnetic flux. Student will be able understand that a changing magnetic flux produces and electric field. Student will be able understand the operation of electric generators and motors. Student will be able understand the concept of a back emf and counter torque. Student will be able describe mutual and self inductance and the operation of transformers. Student will be able to describe the LR series circuit. Student will be able to describe AC circuits and the reactance of inductors and capacitors. Student will be able understand LRC series circuits and be able to solve problems involving this circuit.
- *Unit 4*
  - **Electromagnetic Waves and Geometric Optics** (3 weeks) Student will be able understand that electromagnetic waves can be can be produced by an oscillating charge. Student will be able describe the propagation of electromagnetic waves through empty space. Student will be able to understand that light is an electromagnetic wave and part of the electromagnetic spectrum. Student will be able calculate the energy, momentum transfer and pressure in electromagnetic waves. Student will be able use the ray model of light and ray diagrams describe the images formed by plane and spherical mirrors. Student will be able understand reflection and refraction of visible light and carry out calculations using Snell's law. Student will be able to describe total internal reflection and fiber optics. Student will be able use the ray tracing and ray diagrams describe the images formed by thin lenses.

- **Physical Optics** (3 weeks) Student will be able to understand Huygens principle, diffraction and the wave nature of light. Student will be able to describe interference patterns of light through a double slit and a single slit or disk. Student will be able to describe the dispersion of visible light. Student will be able to understand the interference and dispersion patterns produced by a diffraction grating. Student will be able to describe the interference patterns produced by thin films, the air wedge and Newton's rings apparatus. Student will be able to describe polarization and polarizers.

<u>Marking Period 4</u>

- *Unit 1*
  - **The Theory of Special Relativity**: (2 weeks) Student will be able to understand Newtonian-Galilean Relativity and the postulates of the special theory of relativity. Student will be able to understand the consequences of the special theory of relativity; simultaneity, time dilation and length contraction. Student will be able to understand four dimensional space-time and relativistic momentum and mass. Student will be able to perform calculations involving the special theory of relativity.
- *Unit 5*
  - **Atomic Physics**: (3 weeks) Student will be able to describe the properties of the electron. Student will be able to understand Planks quantum hypothesis including Black body radiation and Wien's law. Student will be able to describe the particle properties of light through the photoelectric and Compton effects. Student will be able to describe the properties of the photon. Student will be able to understand the wave-particle duality of light. Student will be able to understand the wave nature of matter. Student will be able to describe the early models of the atom. Student will be able to understand Heisenberg's uncertainty principle. Student will be able to perform calculations involving the photoelectric and Compton effects, atomic spectra and energy levels, and photon energies and interactions.
  - **Nuclear Physics**: (3 weeks) Student will be able describe the structure and properties of the nucleus. Student will be able to describe nuclear forces and calculate binding energy. Student will be able to describe radioactivity and the three types of radioactive decay. Student will be able to understand and perform calculations on half life and radioactive decay rates. Student will be able to describe radioactive decay series and radioactive dating. Student will be able to understand nuclear stability and tunneling. Student will be able to describe the detection of

radiation. Student will be able to balance nuclear reactions calculate Q-values. Student will be able to describe nuclear fission, fusion and their role in energy production.

VII. Proficiencies

1) Demonstrate an understanding of forces and fields such as gravitation, electrical and magnetic and how they relate to potential and kinetic energy, and power.
2) Demonstrate an understanding of wave motion and apply these principles to electromagnetic waves.
3) Describe geometric optics including the applications of lens, mirrors and prisms to practical instruments such as microscopes and telescopes
4) Analyze simple steady-state, direct current (DC) and voltage/resistance (VR) circuits and demonstrate an understanding of the relationships between electric current, voltage and power
5) Describe nature of static electricity, magnetism, and electromagnetism
6) Describe and understand the special theory of relativity and some of its consequences including time dilation, length contraction and simultaneity.
7) Demonstrate an understanding of the quantum model in describing the behavior of matter at the atomic and sub-atomic levels